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Abstract

This paper evaluates the sustainability of the main energy sources in Egypt. In its attempt to reach this evaluation, the paper reviews Egypt's energy map, highlighting the features of the energy sector in the Egyptian economy in general and petroleum sector in particular. To assess the effectiveness of government policies in a broader sustainability framework, the resource rent as a measure of sustainability is conducted for oil and gas. The paper estimates the current value of oil and natural gas reserves, predicts the future revenues from consuming these non-renewable resources, and calculates the net present value of Egypt's wealth from such natural resources. These calculations are being applied under different scenarios, where different relative future prices movements and extraction rates for both oil and natural gas are considered.

ملخص

تقوم هذه الورقة بتقييم استدامة مصادر الطاقة الرئيسية في مصر. وفي سعيها للوصول إلى هذا التقييم، تستعرض هذه الورقة خريطة مصر في مجال الطاقة وتبرز ملامح قطاع الطاقة في الاقتصاد المصري بشكل عام وقطاع النفط بصفة خاصة. ويستخدم تأجير الموارد كمقياس للاستدامة للنفط والغاز لتقييم فعالية السياسات الحكومية في إطار أوسع للاستدامة، تقدر الورقة القيمة الحالية لاحتياطيات النفط والغاز الطبيعي ، وتتوقع العائدات المستقبلية من هذه الموارد المستهلكة غير المتجددة ، وتحسب صافي القيمة الحالية لثروة مصر من هذه الموارد الطبيعية. ويجري تطبيق هذه الحسابات وفقا لسيناريوهات مختلفة، حيث تعتبر مختلف تحركات الأسعار النسبية المستقبلية ومعدلات الاستخراج لكل من النفط والغاز الطبيعي.

1. Introduction

In modern economies, it is unforeseen for any country to develop or even to survive without sources of energy. Energy can be generated using two types of sources; renewables, such as solar, wind and hydropower; and non-renewables, such as crude oil, natural gas and coal. For decades, oil with its products has been the most usable source of energy for almost every country. In this regard, countries can be categorized as either net oil exporters or net oil importers. Taking into account crude oil price, its impact on the ability of a country to accelerate economic growth and enhance the level of prosperity broadly varies among these two categories. For instance, when the international price of crude oil drastically increased during the last couple of years to exceed $145 per barrel, such as in the first half of 2008, major oil exporters in the Middle East witnessed huge surpluses, which led to higher levels of GDP. Meanwhile, net oil importers, especially those who subsidize the price of oil products in their domestic markets, have faced a serious fiscal problems.

Considering the case of Egypt, which has recently become a net oil importer; it is observed that its low capability to pass changes in international oil price to its domestic market results in high amounts of subsidies. The Egyptian government had to finance a significant increase in its public spending to continue subsidizing the domestic price of petroleum products. Hence, oil products subsidy reached LE 62.7 billion in year 2008/2009 compared to LE 40 and LE 60.2 billion in 2006/2007 and 2007/2008 respectively (Ministry of Finance Statistics 2008). This implies that spending on oil subsidies increased by one-third in just two years. Furthermore, the subsidy of LE 62.7 billion accounts for 17.8 percent of total public expenditure in 2008/2009. After registering a relatively low level of international oil prices, which have recently fallen, the effect of such noticeable reduction in international prices on the domestic prices is nil. So far, the Egyptian government has not announced that there will be a cut in the domestic fuel prices.

This situation raises an important question regarding the price threshold that reflects the minimum level of social costs the Egyptians should pay to maximize their current level of welfare. Additionally, this price should indirectly include the depletion cost as it negatively affects the right of coming generations from these natural resources. The decline in the Egyptian proven oil reserves over the last twenty years has highly confirmed this idea. It was 4.7 billion barrel at the end of1987; however, it stood at about 3.7 billion barrels by the end of 2006. For this reason, the Egyptian government had to find a way out; hence, the recently adopted energy strategy addressing the challenges Egypt's energy sector is facing and introducing the solutions from the government viewpoint. The energy strategy for Egypt aims at supplying the economy with the needed energy over fifteen years, starting 2007, and mapping the level of dependency on different energy sources up to 2022. The strategy involves, in one of its major dimensions, switching local market supply from oil to natural gas. In this regard, switching from one non-renewable resource to another, namely from petroleum to gas, is one of the policy issues that should be revisited, taking into consideration that Egypt is known to be a net natural gas exporter.

Due to the fact that there are other renewable sources of energy, the opportunity cost should be also considered. That is, global vision should take into account not only the availability and direct extraction and production costs of non-renewable resources, but it should also incorporate indirect social costs of depleting such natural resources. Thus, a proper Egyptian policy mix for energy, providing lowest costs and maximum benefits, should be developed in order that a clear plan of how different sources of energy should be managed. Accordingly, comprehensible vision can finally help policy makers to adopt an appropriate and acceptable level of domestic oil products prices. For instance, more flexible domestic prices can be achieved by applying a formula that takes into consideration the different factors affecting these prices, similar to many other countries that cannot afford their subsidies bills.

Therefore, developing a sustainability analysis can be considered as one of the inputs that are highly important to ensure the quality of policy making process related to managing the non-renewable energy resources in Egypt.

To achieve such an aim, this paper attempts to review Egypt's energy map and compute sustainability measures, namely resource rents, of fossil fuels in order to ensure the effectiveness of government policies in managing the non-renewable energy sources Egypt has. First of all, the next section gives an overview of Egypt's current situation concerning oil and natural gas, as well as an analytical review of the oil and gas market in Egypt. Then, section three presents a comprehensive description of the energy strategy of Egypt. Section four introduces the literature on the topic of sustainability. Section five applies sustainability measures in the case of Egypt's oil and natural gas. Lastly, section six concludes.

2. Non renewable Resources in Egypt

Depending on fossil fuels as its foremost source of energy, Egypt has witnessed an increasing level of oil and natural gas consumption. Those two main energy sources represent most of the energy consumption in Egypt, accounting for more than 90% of total energy consumption (Table 1). Such an undiversified energy mix among other market distortions has left the Egyptian government with a challenging situation, where energy sustainability is significantly unforeseen. The level of oil reserves and production has been continuously declining throughout the second half of 1990s and early 2000s; in contrast, consumption has been persistently increasing. Public finances have been dramatically affected by the subsidized domestic prices for oil products and natural gas, resulted in an inefficient end-use of these natural resources.

2.1. Crude Oil: Reserves, Consumption, and Trade Balance

Egypt is considered a significant oil producer, where crude oil production has continued to witness a substantial increase over a long period of time since 1980,reaching its peak in 1996. As shown in Figure (1), in 1980, Egypt's production of crude oil was 595,000 barrels per day, which increased to 887,000 barrels in 1985 and remained relatively stable over a decade to reach its peak in 1996 with a record of 922,000 barrels per day. However, Egypt's production of crude oil has continued to decline from its peak in 1996, reaching 768,000 barrel per day in 2000, 658,000 barrels and 602,000 barrels in 2005 and 2008 respectively.

Historically, domestic oil consumption remained almost flat until 1995, ranging from 430,000 barrels in 1985 to 458,500 in 1995. Starting 1996, data reveals a steep increase in domestic oil consumption amounting to more than 702,000 barrels per day in 2008, compared to 552,800 barrels per day in 2000, around 260,000barrels in 1980, and 465,000 barrels in 1990 (Fig. 1).

Clearly, the rate of growth of oil production steadily exceeded that of oil consumption. The growth in consumption over the period 2000 to 2008 exceeded 27%; whereas production decreased by around 22%. Therefore, the substantial increase in domestic oil consumption has changed the features of the relation between production and consumption, leading to a gap that is currently covered through imports. The sharp increase in petroleum products consumption could be mainly attributed to the current energy subsidy scheme. Moreover, Egypt's GDP increased substantially over this period of time where growth rate ranged between 3.4% in 2000/2001 and 7.2% in 2007/2008. This high growth rate has definitely accelerated the consumption of energy products.

On the other hand, proven oil reserves have run into a positive trend ever since 1980 and in 1994 amounted to around 6.4 billion barrels, as depicted in Figure 2. However, these reserves declined sharply in 1995 to reach 3.26 billion barrels. In 2003, Egypt's proven oil reserves stood at 3.7 billion barrels, remaining at the same level ever since.

The steep increase in oil domestic consumption had negatively affected the quantity available for exports, turning Egypt from a net exporter during the period 1980 to 2006 to a net importer in 2007, shown in Figure 3. Egypt's exports of crude oil reached 353,000 barrels per day in 1980, recording an overall positive trend till 1996 where it reached 432,571 barrels per day. This was in turn reflected in petroleum trade balance which increased by more than 22% over the same period. Nevertheless, the sharp increases in domestic demand on petroleum products lead to a decline in exports of crude oil of more than 87% over the period extending from 1996 to 2008.

2.2. Natural Gas: Reserves, Consumption, and Trade Balance

The adverse effects and negative repercussion of the decrease of oil production were partially tolerated by the substantial increase in the production of natural gas, whose sector is considered one of the most rapidly growing sectors in Egypt. Egypt's proven reserves have sharply increased over last decade to reach 58,500 billion cubic feet in 2008, compared to 20,356 billion cubic feet in 1997, and less than 3,000 billion cubic feet in 1980, as depicted in Figure 4. The vast reserves of natural gas represented a strong source of attraction for a number of foreign oil companies, whose exploration activities resulted in significant discoveries of natural gas deposits. These deposits are mainly located in the western desert, Nile Delta, and under the Mediterranean Sea. It is worth noting that Egypt's reserves of natural gas constitute around 1% of world reserves.

Due to the major discoveries of natural gas over the last decade, production has more than tripled over the same period of time, increasing from 476.752 billion cubic feet in 1997 to more than 1,677 billion cubic feet in 2007 as illustrated in Figure 5. Consumption of this abundant resource has been almost identical to those of production up until 2003. However, as of 2004, amounts produced started to exceed those consumed, reaching 1,123 billion cubic feet in 2007.

Monitoring natural gas consumption patterns reveals that the electricity sector, industrial sector, and petroleum sector constitute 58.8%, 28.6% and 9.8% respectively of total consumption in 2006/2007 as shown in Figure 6. In spite of the government efforts to expand the utilization of natural gas, in an attempt to shift energy demand from oil to natural gas, utilization of this resource is still very limited in several sectors, namely; transportation and household sectors whose consumption represents 0.9% and 1.9% only of total consumption, respectively. The low level of consumption in some sectors can be explained by tracing the degree of substitutability between oil and gas, which varies among different economic sectors. For instance, the fixed costs of switching from oil to gas are very high in the transportation sector, resulting in a slower rate of substitution.

The above mentioned facts have led to a rapid increase in Egypt's exports of natural gas. In 2003, Egypt's exports stood at 12.36 billion cubic feet, growing rapidly to reach more than 598 billion cubic feet in 2008; making Egypt a net exporter of natural gas.

2.3 Crude Oil and Natural Gas: Pricing Mechanism and Subsidy

Energy subsidy is considered an important issue because of the political and social aspects associated with it. It accounts for the highest fiscal burden on the Egypt’s state budget, among other types of subsidies the government introduces, including food subsidies and a social safety net. Energy subsidies amounted to 17.8% of total government expenditure in 2008/2009, and more than 66.8% of total subsidy expenditures in the same year (People's Assembly 2010). Furthermore, the rapid increase in consumption of petroleum products, associated with the sharp increases in international prices for most of these products at different points of time, has contributed to raise the absolute value of petroleum products subsidies substantially. In this regard, the substantial increases in the value of energy subsidies in Egypt are mainly induced by the limited pass through from international to domestic prices.

According to Egypt's state budget end of year accounts for the fiscal year 2008/2009, oil products subsidies reached LE 62.7 billion, compared to only LE 1.2 billion in 1997/1998 (Figure 7). The Egyptian government worked on absorbing any increase in the international prices of these products for a long period of time. Even the adjustments that were adopted in prices at several points of time were made on an ad hoc basis; a fact that intensifies political pressures with any attempt by the government to adjust energy prices at any point of time.

Historically, energy prices in Egypt remained constant from 1990 to 2004, when the Egyptian government started to move the prices of some products at different points of time. The latest move in energy prices was adopted in May 2008. Law no. 114 of 2008 included the increase of Gasoline (90-octane, 95-octane), diesel oil, kerosene, and natural gas prices, shown in Table (2).

According to the Ministry of Petroleum, the latest price movements are expected to reduce the fiscal burden of energy subsidies by realizing additional savings of LE 7.5 billion. Concerning natural gas domestic prices, the Egyptian government decided to phase out subsidies currently granted to energy intensive industries over three years to cut inefficiencies in the market and help reduce budget deficit. However, natural gas for households is still subsidized (Table 2); and the government announced that such subsidy policy is essential and cannot be touched in the short term.

Despite domestic price movements, oil products prices in Egypt do not follow international oil price fluctuations. During the nineties, for example, International crude oil price changes were not reflected in the Egyptian oil products market. Also, since early 2000s, the upward trend in international oil prices was not consistently shown in the domestic prices. Crude oil prices increased by almost 50% in 2000, while domestic oil products prices were stable. From 2001 to 2003, international prices have steadily increased to reach US$25 per barrel. Afterwards, in 2004 crude oil price started escalating to reach US$38.27 per barrel. The crude oil price boomed witnessed in 2008, to reach US$97.26 per barrel. In 2009, a severe drop occurred to the crude oil price, reaching US$61.7 per barrel, as shown in figure (8).

In 2008, the Egyptian government reacted to the jump in international oil prices by adapting most of petroleum products domestic prices, illustrated in table (2); however, many of these products remain heavily subsidized. In this context, the subsidy is defined as the difference between the cost of providing the domestic market with the relevant product; including all direct and indirect costs, such as the costs of refining, transportation, storing, import duties and taxes; and the sales revenue from that product . Noticeably, the natural gas for high intensity energy industries is the only unsubsidized energy product; where its domestic price is greater than its cost by more than 30%. Such price surpluses can be perceived as an implicit tax the government imposes only on these industries (table 3).

The enormous fiscal burden of oil products subsidies threatens the sustainability of the oil sector in Egypt. On one hand, petroleum products subsidies undermine the government's ability to increase public spending on other vital sectors, such as education and health, or to enhance infrastructure. This is partly reflected in the fact that spending on these subsidies has over-valued spending on public investments in Egypt for the last three years, though the government is still a major investor in many infrastructure activities. For this reason, the Egyptian government gives up the share of state budget on the revenue attained by the Egyptian General Petroleum Corporation (EGPC) [1] and taxes on its profits to compensate the

[1] is the public entity being responsible for developing, organizing, planning and managing all the petroleum-related activities in Egypt through petroleum companies working in producing crude oil and natural gas,

costs of oil products subsidies. However, the financial position of the EGPC is threatened due to the continuous financial burden that should be covered to meet the growing domestic demand on oil products.

To sum up, highly distorted energy prices, along with a poor pricing mechanism create greater pressures on Egypt's energy future. It undermines the Egyptian government's ability to run a sound energy strategy that takes into consideration different opportunity costs arising from the depletion of these resources. Furthermore, the lack of transparency in dealing with energy subsidies, in addition to its huge value, has further complicated the situation; as it entails greater concerns on the sustainability of EGPC itself on one hand, and its ability to handle its role, as well as accelerating the depletion rate of these resources on the other hand. Additionally, EGPC doesn't take into consideration meeting commercial objectives; this is mainly attributed to the pressures it faces due to its obligation to sell petroleum products to domestic consumers at subsidized prices. This has encouraged EGPC, like many other national oil companies in developing countries that face the same factors (Eller et al 2010), to under-invest in reserves and shift extraction of resources away from the future toward the present.

3. Egypt’s Energy Strategy

As a main source of energy as well as economic growth, fossil fuel has always attracted the attention of economists and policy makers in Egypt (Choucri and Shafei 1984; Choucri et al 1990; Alami 2006; Selim 2006). However, the high level of dependency on such depleteable natural resources has drawn attention to the issue of sustainability[2]. In addition, subsidizing oil products and natural gas within the domestic market highlighted the public finances challenge to continue introducing these products with low prices, regardless of their production[3]cost . Moreover, it is claimed that the subsidized end-user prices for energy are a significant factor contributing in an inefficient use of non-renewable sources of energy. To maintain efficiency, restructuring the energy sector generally and liberalizing the oil sector specifically are a necessary condition to meet the requirements of competitive markets.

On the other hand, installing new capacities to utilize the abundant renewable resources to generate energy has always been a potential policy alternative to the depletion of non-renewables. For these reasons, the Egyptian government recently initiated its long-term energy plan aiming at sustaining energy supply in the economy over fifteen years. This plan was first announced in 2007 and is perceived, from the government's viewpoint, as a comprehensive energy framework containing all dimensions that should be taken into consideration. The plan mainly consists of six strategic dimensions; some of them are not

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transferring crude oil, oil refinement and marketing (for more details on subsidy treatment and EGPC’s financial analysis, see annex 1).

[2] Alami (2006) showed that there is a development of natural gas market in Egypt, which moved the country from a dependency on oil to gas in order to meet almost half of its energy needs. They recommended that Egypt should reach a balancing point that takes into consideration different factors including crude oil production, domestic consumption and export revenue. Selim (2006) suggested that Egypt would become a net importer of oil by 2007/2008, and the shortages would reach 300,000 barrel per day (bpd) in 2015, and 600,000 bpd in 2025. Moreover, Selim's estimates showed that Egypt's proven natural gas reserves of 66 trillion cubic feet (tcf) would be depleted by 2020, and that the economy would need an additional 60 tcf of reserves by 2025.

[3] Focusing on subsidy issues in Egypt between 1970s and 1980s, Choucri and Shafei (1984) and Choucri *et al* (1990) argued that government cannot sustain subsidizing energy prices in its domestic market. Stressing the idea of uncertainties concerning reserves and production, they highlighted the importance of such variables for Egyptian policy makers as more investments should be injected in the field of exploration. On the other hand, consuming oil domestically implies decreasing Egyptian oil exports and results in losing more foreign exchange. The authors recommended that Egypt should reach a balancing point that takes into consideration different factors including crude oil production, domestic consumption and export revenue.

new policy components, but their targets were clearly identified and/or quantified (National Democratic Party 2006, 2007, 2008, 2009).

The first dimension is related to oil and natural gas production and reserves, targeting to keep oil production at its current level, attain an annual growth in natural gas production of 5% on average, and intensify discovery activities to develop new fields. On the production side, the accelerated rate of depleting oil coincided with a successive chain of natural gas discoveries. These two factors forced the Egyptian government to adopt a policy aiming at switching the country's energy consumption from petroleum products to natural gas, so that the increase in gas production can offset decline in oil production.

The government was primarily successful in terms of slowing-down the depletion rate of oil and, hence, achieving a steady state of proven oil reserves, keeping it at 3.7 billion barrels. Given the planned oil production level, however, the share of the EGPC, the Egyptian partner in corporations responsible for downstream oil activities, was not sufficient to meet the increasing level of domestic oil consumption since the beginning of the 20th century. Therefore, the EGPC has to buy the necessary portion from its foreign partner’s share and build more refinery capacity to meet domestic demand.

Concerning reserves, attracting international companies to invest in exploring oil and natural gas within Egypt's potential sites is one of its strategic targets to develop the proven oil and natural gas reserves. A precondition to achieve this objective is to liberalize oil and natural gas markets. Liberalization includes: i) easing the bylaw dominant position of the EGPC in certain upstream activities; and ii) offer more incentives to investors within the applied production sharing system in Egypt. In this regard, there have been no significant steps taken so far.

Second, having storage areas namely on the Red and Mediterranean Seas, production facilities, and refinery capacity encourages the government to think of investing in new discovery projects abroad to sustain crude oil supply from foreign sources. This represents a strategic dimension within Egypt’s long-term energy plan, and mainly driven by the fact that it is centrally located among Arab oil and natural gas net exporters and European energy net importers. The government realized that such a location can be employed to obtain additional crude oil storage as well as attracting international investments to connect European consumers with Arab producers through pipelines transporting oil and natural gas. Consequently, Egypt can become a regional hub in the Euro-Mediterranean area in the future.

Third, Egypt’s energy plan is also tackling the issue of subsidy, which required to be re-prioritized in order to reduce its strain on public accounts provided that the lower income social groups enjoy the same level of subsidy. In general, energy subsidy system in Egypt implicitly involves significant opportunity costs in terms of foregone government revenues. The fiscal burden resulting from oil subsidies is noticeably enlarged. The loss in government revenue is mainly due to selling its share in domestic oil production at below-market prices to citizens. Also, it purchases some of the share of its foreign partner at a much higher prices, specified in the production sharing contract price, and sells the final petroleum products at the same subsidized retail prices in the domestic market.

Like many other price-regulated developing economies, one of main social security policies in Egypt is to keep domestic energy prices less than its free market value. Oil subsidy is available for the whole of society regardless of the level of household consumption or income. Moreover, this open-ended oil subsidy system entails subsidizing both producers and consumers at the same percentage per unit. In contrast, subsidies on natural gas are sold at progressive prices in accordance with different household’s consumption brackets. Nowadays, natural gas is sold at unsubsidized prices to domestic heavy-energy intensive industries as well as large enterprises. So far the only exception is the small and medium enterprises (SMEs); however, it is planned to gradually phase-out this subsidy on a three-stage basis.

In addition, price distortion risks attracting investment into sectors because of its harmful effect on EGPC's financial position. Consequently, Egypt may gradually lose its comparative advantage over time. Historically, the government has planned to phase out energy subsidies. However, increases in oil products' domestic prices were gradual, but on an *ad hoc* basis. A number of Prime Ministerial and Ministerial Decrees that have been issued gradually increasing retail prices for different types of energy in an attempt to at least cover their production costs.

In 2008, petroleum product prices were raised by 30% to 40% for high-octane gasoline, leaving low-octane at its original price, and by 46% for kerosene and diesel. This was done by issuing a law that increased the excise sales tax on those petroleum products. At the same time, according to a Prime Ministerial decree, industrial natural gas price were increased; except for SMEs, whose selling prices were totally liberalized at U$3 per BTU. In 2009, the decision to increase natural gas prices sold to SMEs was postponed as one of the measures taken to overcome the negative effect of the global economic crisis.

Fourth, energy conservation, as one of the strategic dimensions, aims at promoting rational use of conventional energy resources and saving 20% of total energy consumption in 2007 over fifteen years ending 2022. The 20% energy saving is an overall rate in the whole economy, but the rate will differ from sector to another. Industry is the major targeted group, where it should reduce its energy consumption by 9.4% of the 2007 total energy consumption over fifteen years. This amounted to 20% of the total industry consumption during 2008. The following sectors in energy conservation list are household, commercial activities, and electricity sector. Those sectors will contribute in saving around 9.7% of total energy consumption. The rest is minor and the responsible sectors for it are civil service, public utility, and agriculture and irrigation.

To this end, the Ministry of Industry established a Committee on Energy Efficiency in Industry whose duties are assessing the potential for energy efficiency and suggesting applied mechanisms to realize that potential. Measures were taken to enforce domestic manufacturers to produce appliances that meet certain minimum standards and then labeling them according to their performance when it exceeds the standard. Standards for some home appliances have been developed; however, so far compliance with such standards is voluntary.

Fifth, within the framework of Egypt’s energy plan, the strategy of the power sector has focused on the diversification of the use of fuel resources, promoting the use of renewable energy. Egypt is endowed with abundance of wind energy resources, especially in Suez Gulf area, as well as its potential to generate electricity by utilizing solar energy. Therefore, in 2007 the Supreme Energy Council in Egypt adopted a resolution on an ambitious plan aiming at increasing the contribution of renewable energy to reach 20% of total energy generated by 2020. The government started to set the appropriate incentive packages to encourage private sector participation in financing, building, and operating wind farms in Egypt.

Egypt started promoting to install wind farm capacities. The expected two projects with both the Danish and German governments would generate electricity amounting to equivalent to 8,200 tons of oil equivalent (toe) per year. The plan is to expand these wind farms installed capacity to 3,000 MW by 2020. The plan for solar thermal electricity generation is to be implemented in phases; the first one will be 150 MW hybrid solar thermal power plant in Kuraymat, to be increased to 750 Mw by the end of 2020.

Sixth, nuclear power has historically been one of Egypt’s policy alternatives. In 2007 the government declared that Egypt will enter into the era of generating electricity using nuclear power, where the first power station will start in 2019, gradually followed by three other stations, reaching their full capacity by 2022 to account for the generation of 7 million tons of oil equivalent (toe).

4. Literature on Non-Renewable Resources Sustainability

In his seminal article, Hotelling (1931) highlighted the scarcity of exhaustible resources to pave the road to the development of non-renewable resource theory. He clearly expressed the issue by saying:

> "The feeling that these products [minerals, forests, and other exhaustible assets] are now too cheap for the good of future generation, that they are being selfishly exploited at too rapid a rate, and that in consequence of their excessive cheapness they are being produced and consumed wastefully…"

The emphasis on his argument, however, did not attract enough attention from scholars and policy makers until the early 1970s. Since then, Hotelling's rule has been perceived as the basic rule of non-renewable resources, and represented in almost all papers tackling the scarcity of exhaustible resources. According to Hotelling's rule, the shadow prices of non-renewable resources should significantly increase by the rate of interest on other capital investments. This rule reflects the opportunity cost of decreasing the future availability of natural resources.

Hartwick (1977) presented Solow's definition of intergenerational equity, namely per capita consumption, and stated that countries should invest all net returns from exhaustible resources in reproducible capital. According to Hartwick' rule, sustainability can be achieved only if the accumulation of capital over time compensates the total non-renewable natural resources depletion. If this condition holds, the arguable future declining consumption can be prevented.

That is, equitability of exhaustible resource extraction requires that the rate of return from a unit of reproducible capital equals the rate of return from owning a unit of deposits of the exhaustible resource. In this case, the *in situ* value of resources, reflecting the value of the resource stock in place, implies that a country is indifferent between consuming the resource and leaving it to the future generations. These concepts entail the concern of intergenerational equity from the utilization of flows from the stock of exhaustible resources.

Following the aforementioned theoretical framework, many studies have considered the issue of environmental degradation owing to the use of non-renewable energy as a source of fuel. The resource rent approach, which is defined as a "surplus value", is measured as the difference between the price at which a resource can be sold and its respective extraction or production costs, including normal returns. Basically, resource rent method designed to ensure a sufficient, fair return to the owner of a resource which avoids the inefficient allocation of such a resource.

The original work by Hicks (1946) identified the key ideas that comprise the concept of income, which in turn indicated the maximum amount a nation can consume for any period without becoming poorer in the subsequent periods. Following Hicks, El Serafy (1989), Adelman (1990) and Mikesell (1994) argued that resource rent or surplus value composed of two values; true income which can be consumed, and a separate depletion cost. The latter should represent the exploration or development cost of additional reserves to replace the extracted amount of such a resource. Also, it is the value that needs to be reinvested in order to provide the future generations with a more sustainable level of consumption to enjoy.

According to El Serafy, the 'user cost' formula for calculating resource rents depends on subtracting only a portion of the total cost of resource depletion. As El Serafy's approach assumes that there is no optimization problem and the total resource rent is constant, Hamilton (1999) called it "the simple present value approach" whilst called Repetto's "the total rent approach." Following Repetto's methodology, any estimated value of the resource rent should reflect by its nature discount rates, future prices and costs, and extraction rates (Repetto et al. 1989). That is to say, Repetto's main assumption is merely the existence of optimal consistency if the price of the capital is rising at an exponential rate.

Despite the foremost deviation of the two approaches in estimating the resource rents, Hamilton concluded that the difference between estimates depending on these two approaches is insignificant. Lawn (2004) agreed with recommendation of Neumayer (1999) in deducting partial rather than total cost of non-renewable resource depletion, El Serafy's approach for estimating resource rents.

Black and LaFrance (1998) among others argued that the petroleum resource stocks are not only the discovered up to now, but development of new reserves are also essential. Since without the drilling of new wells, production from developed fields will decline continuously over time in a manner that is determined by geological factors, they discovered that producers are likely to change the current production rate for the existing wells, in response to a change in output price and new technological innovations.

According to Babusiaux and Bauquis (2007), if the cost of production is not negligible, it is the rent that must increase at a rate equal to the discount rate. Thus, if the price of the resource is stable (or increases at a rate less than the discount rate), it would be in the interest of producers to produce goods as quickly as possible, which would cause the price to drop. If it increases at a higher rate, producers would delay production to take advantage of a higher discounted value. The only change that would allow for market equilibrium is, therefore, the one that makes the discounted value of future unit revenues stable, thus an increase at a rate equal to the discount rate. Their conclusion was that a mix of non-renewable and renewable resources should be implemented.

According to Cobb and Cobb (1994), the cost of any non-renewable resource should be its nearest renewable substitute. For example, the cost of a gallon of petrol conventionally produced is estimated from the cost of equivalent fuel produced from renewable sources such as fuel derived from sugar cane. They adjusted figures to be based on a replacement value to every barrel of oil equivalent of energy resources consumed over the period. This value reflects the cost of replacing each barrel of oil equivalent of energy consumed with renewable energy resources.

To sum up, Hotelling and Hartwick rules confirmed the necessity of depleting natural resources in the light of intergenerational equitability. Future generations should enjoy a a certain level of income that is comparable to returns that the current generation gains from depleting the available exhaustible resources. To measure the return on extracting one unit of non-renewable resources, *in situ* value, resource rent, and user cost are the suggested measurements in the literature on non-renewable resources.

5. Egypt's Energy Sector Sustainability

Considering the welfare effect of exhaustible natural resources, the per-capita income is proven to be negatively related to the level of environmental degradation (Guenno and Tiezzi 1998). Although this concluding remark lacks a strong theoretical background, from the applied viewpoint it is used to measure changes in national wellbeing, taking into account the environmental degradation cost (Hamilton 1999). Hence, the wealth of nations' measurements should account for their natural resources degradation to ensure these economies' sustainability. Accordingly, this part analyzes Egypt's energy sector sustainability through utilizing the resource rent methodology to evaluate the current resource rent, forecast the future resource rent, and estimate the net wealth Egypt can gain from depleting its fossil fuel under different levels of degradation.

According to the World Bank (1998), the estimates of Egypt's oil and gas resource rents showed that the first half of 1990s witnessed an average of $4-4.5 billion a year. However, oil resource rent fluctuated between $3 and $4 billion, and gas rent was increasing to reach $1 billion in mid-nineties compared to $500 million in 1991. The World Bank's projections of resource rent over the period (1996-2016) indicated that there would be a continuous increase up to the seventh year following 1995, the base year, reaching its highest point at $800 million more than the value of 1995. After 18 years, according to the World Bank scenario, this trend would be reversed and the resource rent level would fall below the 1995-level. At a slower rate of decline in oil production and higher real oil prices, the peak would amount to $400 million after six years; and the rent would be fallen below the 1995-level within eight years.

5.1 Valuation Method

Following the World Bank methodology, the current resource rent will be calculated to estimate the revenues from oil and gas, and total wealth will be estimated as well. The paper follows Repetto et al (1989) recommendation to measure the resource rent by stock valuation as a more suitable methodology in the cases of state-owned energy enterprises in emerging markets or transitional economies. And this is the case of Egypt, where the EGPC is in a dominant position. According to the World Bank Guide to valuing natural resources wealth, the estimates of resource rents and wealth involves the following steps:

1. Estimation of current rents: these are obtained by multiplying the quantity of the resource produced or extracted by the unit rent. Unit rent is the difference between the price of the resource and the cost of making it available at the domestic market.
2. Forecast of future rents: to project rents over the future, assumptions on the growth rate of rents are needed. Future rents are calculated as the product of current rents by a (usually constant) growth factor:

$$R_{t_n} = R_{t_0} ¿ (1+g)^n$$

Where:

R_t: resource rent at time t;

R_{t0}: resource rent at the initial time t_0;

g: growth rate (constant) of the rent;

$t_n = t_0 + n$;

1. Estimation of wealth: wealth is estimated as the present value of future rents over the lifetime of the resource. For any given discount rate r and resource lifetime T, the wealth at time (t_n), W_{t_n} is:

$$W_{t_n} = \sum_{t=t_n}^{t_n+T-1} \frac{R_t}{(1+r)^{t-t_n}}$$

The aforementioned calculations rely on the following key parameters:

- *Growth rate of rents*: the estimation of future rents requires specific assumptions regarding the evolution of demand and supply over time. It is assumed here constant growth rates in the case of sub-soil assets, which depends on the growth rate of the unit rent (the interest rate from Hotelling) and the growth rate of the resource supply.

- *Time to exhaustion of the resource*: the life span of a resource depends on several factors, including the total stock available, the rate of extraction of the resource and general market conditions.

- *Discount rate*: the Social Rate of Return on Investment (SRRI) is used. SRRI is the discount rate that a government would choose in allocating resources across generations. The SRRI in general differs from country to country.

The unit rents are, first, estimated for different products as shown in Table (4). These units are calculated as the difference between world price for each item and its costs, including all cost items to make this product available to the consumer. The costs of gasoline are calculated as a weighted average of its products sold on the local market (Octane 80, 90, 92, and 95). The weights represent the share of each product in gasoline total productions.

To estimate the future rents, the required parameters are first determined as follows: Growth rate of rents (g) is assumed to be affected by two components: first component is the social discount rate amounted to 9.2%[4] (Valentim and Prado 2008); and second component is the planned growth rate of producing the non-renewable resources, i.e., the rate by which the society will deplete its natural resources and it is vary according to different scenarios considered.

Baseline estimates represent the government strategy to stabilize oil production at its current level, i.e., growing by 0%, and increase the annual gas production by 5% on average. Hence, the growth rate of rents is assumed to take the value 9.2% for oil and 14.2% for natural gas in the base-case scenario. In this scenario, the present natural gas reserves will be completely depleted within 20 years while crude oil will be depleted over the next 17 years.

5.2 Sensitivity Analysis

In the baseline scenario, production growth rates are taken as given. However, a different assumption could be driven by considering cross elasticity between oil and natural gas. Hereby, we consider different scenarios, where there are different relative future prices movements between oil and natural gas. If international prices decrease today, it is normal for countries to decrease its production so that reserves are saved if prices are expected to potentially increase in the future. However, Egypt cannot follow such a behavior because Egypt is already a net oil importer, i.e., its oil production does not meet the demand; the EGPC is responsible for providing the society with the needed amounts of petroleum products.

In addition, Egypt does not have the luxury, which other countries have, to decide to decrease oil production, because this automatically means depending on more imports. Furthermore, there are some limitations in shifting from oil to gas. These limitations are, for example, limited building capacities and the huge investments required. Unlike crude oil, natural gas cannot be easily transported as it can only exported through pipelines or liquefied, which need large investments. Above all, rents for natural gas is very low compared to oil rents. For these reasons, increasing gas production due to price increases is assumed to be limited in different scenarios. The next part shows three scenarios that are considered.

Based on his sensitivity analysis, Selim (2006) concluded that the cross elasticity between oil and gas is greater than zero, which means they are two substitutes. According to his results, if the price of both oil and natural gas are characterized by the same trend, i.e., their prices

[4] The choice of a discount rate is crucial. The Social Discount Rate (SDR), for example, is as high as 18%, 11% and 9% in Armenia, Argentina and China respectively (Valentim and Prado 2008). The estimated SDR for Egypt at 9.2% is close to the average historical interest rate on the government loans injected in infrastructure and public utility projects.

increase by the same percent, the substitution ratio between oil and gas is 3:4. Therefore, applying this ratio means that the relative change in quantities produced should reach 3.4% when their prices change by the same percentage points, reflecting the same ratio of price increases, i.e., the relative prices will remain one-to-one. Such analysis represents the base for our first scenario.

For simplicity, we assume a 1% change in gas production, which implies a 3.4% growth in crude oil production. In the first scenario, the present natural gas reserves will be completely depleted within 19 years; and the crude oil, however, will be depleted over the next 13 years. In the second scenario**,** we assume that the increase in crude oil prices is as high as double that of the natural gas, and the increase in natural gas production by one percent. This implies that the oil production increases by 1.7%. Therefore, natural gas will deplete in 19 years while crude oil will deplete within 15 years.

In addition, a third scenario, which assumes that crude oil prices increase as low as half that of the natural gas prices is considered. In this last scenario, the increase in natural gas production by one percent means that the oil production increase by 6.8%. This indicates that natural gas will be depleted in 19 years while crude oil will deplete within 11 years. Table (5) summarizes the aforementioned scenarios to show the main differences between them.

The three mentioned variations from the baseline scenario capture upward price changes for both oil and natural gas. The downward prices trend is not taken into consideration because of policy limitations concerning the minimum level of production the Egyptian government should maintain to meet the domestic demand on oil products without facing a crisis. Hence, this minimum level cannot be reduced and is given by the government policy formulated in its energy strategy, i.e., the baseline scenario. Also, the first scenario accounts for the price movements of both oil and gas by the same proportion. The second scenario includes the relative price ratios that are greater than one. Meanwhile, the third scenario incorporates the relative price ratios that are less than one. Furthermore, different elasticities of substitution reflect all replacement directions between oil and gas. High, medium and low replacement rates are covered by the third, first and second scenarios respectively.

5.3 Estimation Results

The total current resource rent amount reached to LE 15.5 billion in 2008 as shown in Table 6. The quantity produced is the main factor determining the final rent for some petroleum products. Due to the huge produced quantity, gasoline oil, represents the top product, accounting alone for more than LE 3.1 billion, though its unit rent is the lowest. Meanwhile, unit rent, amounting to LE 1,600 per ton, is the main driving force of resource rent for fuel oil. The least rental product is the diesel oil, since it is valued at LE 389 million.

As shown before, the level of reserves of Egypt’s natural gas has witnessed a significant increase during the last few years; however, its unit rent is not as high as that of oil products. Consequently, the resource rent of crude oil has a relatively higher weight than natural gas. Thus the crude oil resource rents comprise the major factor affecting the total rents. Considering the baseline scenario results, Table (7) shows that crude oil represents more than 99.9% of the overall fossil fuel resource rents, with a value of LE 14.2 billion, over the comparison period until it has completely exhausted in the seventeenth year, where its resource rent becomes LE 3.5 billion, resulting in total rents comprising of only the natural gas resource rent in the eighteenth, nineteenth and twentieth years.

Table 8 illustrates that the second scenario is the best one for crude oil since it provides the highest resource rent, which is LE 14 billion in the first year and crude oil is expected to be exhausted in year 15. The third scenario is the worst of them all since it provides the lowest resource rent, at LE 13.4 billion and the year of exhaustion is the eleventh. In comparison to the baseline scenario, the result is in favor of this scenario where the resource rent of the first year was slightly higher than the LE 14 billion and it was expected to exhaust by the seventeenth year. Regarding natural gas, it has just one valuation for all the three scenarios because the parameters are assumed to be constant[5], where the highest resource rent is slightly higher than that of the baseline scenario and year of exhaustion is nineteenth, only one year less than the base scenario.

The aforementioned behavior of oil resource rents is also reflected in the total resource rents, as its main driving force. The total future resource rents of both oil and gas show a declining trend over the time span before depleting these non-renewable resources completely. Like the oil resource rents, the future total resource rents of fossil fuel in the second scenario is the superior among the considered three scenarios, but not on the baseline scenario (Figure 9). The gap between the resource rents in the three scenarios and in the baseline estimate during the first decade is not as high as the subsequent one. For example, the highest discrepancy is attached to the third scenario, reaching the lowest value of LE 832 million in 2009 and the highest level of LE 5.4 billion in 2020 then declining to an amount of LE 3.5 billion in 2025. The lowest difference is realized in the case of second scenario, reaching its peak of LE 920 million in 2018 from LE 218 million in 2009. Meanwhile, the first scenario is the intermediate one.

The above sensitivity analysis compiled with baseline estimates confirm that oil is a costly source of energy to depend upon, relative to natural gas, for some reasons. As the rate of substitutability between oil and natural gas increases, the total resource rent is negatively affected. Being the worst case ranked after the governmental planned policy, the third scenario represents the lowest level of resource rent. Such a scenario is mainly motivated by a higher elasticity of substitution, which resulted from the higher gas price increase than that of oil, between the two non-renewable sources of energy Egypt has. In contrast, the second scenario representing the lowest elasticity of substitution due to the low level of gas price increase compared to the oil prices is positioned as the second best policy option after the baseline scenario. Thus, saving more oil reserves to be consumed in the future, forced by the expected high international prices of crude oil, is a better energy policy than accelerating its rate of extraction. That is to say, the less the growth of oil production is, the better is the policy choice for Egypt.

Finally, the estimated present value of oil and gas rents representing total wealth for all the above scenarios are shown in Table (9). The wealth suggests that the best case is the baseline scenario as it maximizes the Egypt's wealth obtained from fossil fuel. Deviation from the baseline scenario varies among the three other scenarios, amounting to 22%, 10% and 42% for the first, second and third scenario respectively. In other words, an accelerated rate of extracting crude oil causes a loss in total wealth. Thus, the higher the rate of production is, the lower the present value of income Egypt can obtain from depleting its fossil fuels. Therefore, the government strategy that aims at keeping oil production at its current level represents the best energy mix among those discussed through different scenarios as it maximizes Egypt's gain from depleting oil and natural gas.

The above mentioned results confirm the necessity of reconsidering the current subsidy system the government adopts. Such a distorted, unfair system wastes Egypt's natural resources without compensating for this wastefulness with reasonable financial and economic returns. Moreover, the subsidy system contributes to the creation of an irrational consumption of non-renewable energy resources, which pushes the government by turn to accelerate the level of extraction of these resources in an attempt to satisfy the society's needs. Therefore, in

[5] Parameters attached to natural gas are constant among the three scenarios so that other parameters, specifically relative prices and therefore production growth rate of oil, are enforced to vary among these scenarios.

order to achieve its goal, the government should take serious steps towards phasing out or, at least, rationalizing the level of subsidy introduced to different oil products. This will not only reduce the fiscal burden on Egypt's state budget, but will also maximize its wealth.

The aforementioned analysis focuses mainly on the sustainability of energy supply; however, other related environmental policy issues can play a complementary role adding to the previous analytical framework. These policy issues include pollution from energy consumption and cost of damage mitigation. The motorized transportation, for example, involves combustion of fossil fuels, which is the reaction of the hydrogen and carbon present in the fuels with oxygen in the air to produce water vapor and carbon dioxide. Carbon dioxide is the principal gas responsible for the greenhouse effect. The more energy consumed, the more carbon dioxide emitted. Hence, the transport sector is a source of pollutant emissions in Egypt. In this regard, measures to promote public passenger transport and encourage a modal shift of cargo transport from road to railways and inland waterways represent one of the policy options to reduce air pollution in Egypt. Eliminating leaded gasoline that can be achieved through using alternative fuels such as natural gas is another policy option on which Egypt's government concentrates. Also, there is a national program for taxis to run on compressed natural gas (CNG) as an increasing number of taxis in Cairo have been modified. To support this project, CNG service stations have been established to support this program.

To generalize, air and water pollutants can be released from energy use, including particulate matter, sulfur dioxide, nitrous oxides, heavy metals such as mercury, and other chemicals. Such pollutants have been known to cause a range of health problems such as premature death, low birth weight, various types of cancer, neurological disorders, asthma and other lung ailments and numerous other illnesses. These negative effects are not usually reflected in energy market prices. Overcoming this market failure can be achieved through governmental interventions in the form of regulations, taxes, fees, tradeable permits, or other instruments that motivate lower damage costs.

The literature provides methods attempting to quantify the negative consequences of environmental polluters, but the estimated figures represent a lump sum number for the overall pollution in the societies. Such figure for Egypt does not add to this research as its scope is the environmental effect of non-renewable energy sources only. The follow up studies can bridge this gap by estimating the damage costs attributed to each environmental polluter separately.

6. Conclusion

For a period of time extending over two decades Egypt has depended on crude oil as its primary source of energy. Nevertheless, since the late 1990's, natural gas started to play a significant role in Egypt's energy mix. Reserve growth for natural gas tended to be much greater than those for oil. At the same time, the accelerated increase in domestic consumption turned Egypt from a net exporter of crude oil to a net importer. These factors have stimulated the Egyptian government to shift its energy mix towards natural gas in an attempt to overcome the relative scarcity of crude oil and maximize its benefits from an abundant source as natural gas. This had definitely contributed positively to preserve Egypt's oil reserves for a longer period of time. However, this shift will result in an accelerated rate of depleting natural gas unless the Egyptian government starts to consider new channels to diversify Egypt's energy mix.

This has induced the Egyptian government motivation to target increasing the electric power generated from renewable resources by 20% over the next 15 years, in addition to electric energy generated through nuclear power. In spite of the apparent optimism and validity of these measures, the high weight oil and natural gas constitutes in Egypt's energy mix deserves much more serious attention by the Egyptian government, as the problem remains partially solved.

Additionally, the high fiscal costs associated with the heavy subsidy characterizing petroleum products' prices in Egypt even imposes further pressures on any attempt targeting a true reform of the energy sector. These pressures even widen to include threatening the financial position of EGPC, creating serious constraints on its ability or incentive to invest and attract new international reputable companies to initiate new discoveries activities in Egypt. Therefore, the overall picture of Egypt's energy sector definitely raises many question marks regarding energy sustainability in Egypt in light of the magnitude of the current constraints.

Despite the intentions adopted by the Egyptian government to restructure this vital sector, implementation remains a step behind. This could be mainly attributed to the fact that the elimination of even badly targeted subsidies can have an adverse impact on low income groups. Therefore, other policy alternatives that incorporate mitigating measure directed towards these groups should be examined. A necessity that faces a number of obstacles in Egypt; among these, the low capacity to define and recognize low income groups, as well as the relative inefficiency of the safety nets currently in place.

These issues have long been subject to research by different scholars. This research has mainly targeted defining and measuring petroleum products' price subsidies, examining pricing policies, and last but not least considering reform options.

This paper contributes to this research; it presents an overall analysis to energy sector in Egypt regarding Egypt's energy mix in general, and the features of the main energy sources in Egypt; namely, oil and natural gas in addition to their level of production, consumption, trade, and reserves. Then, the paper tries to evaluate the wealth through calculating the net present value of resource rent flow under government targeted growth rates for production of both oil and natural gas.

Analyzing different scenarios for depleting oil and natural gas confirm that accelerating the rate of extraction is negatively affecting Egypt’s wealth. Thus, if there are not new discoveries adding to the proven reserves, the best case is the government plan, which involves increasing the production of natural gas on average by 5% while keeping the current level of oil production annually.

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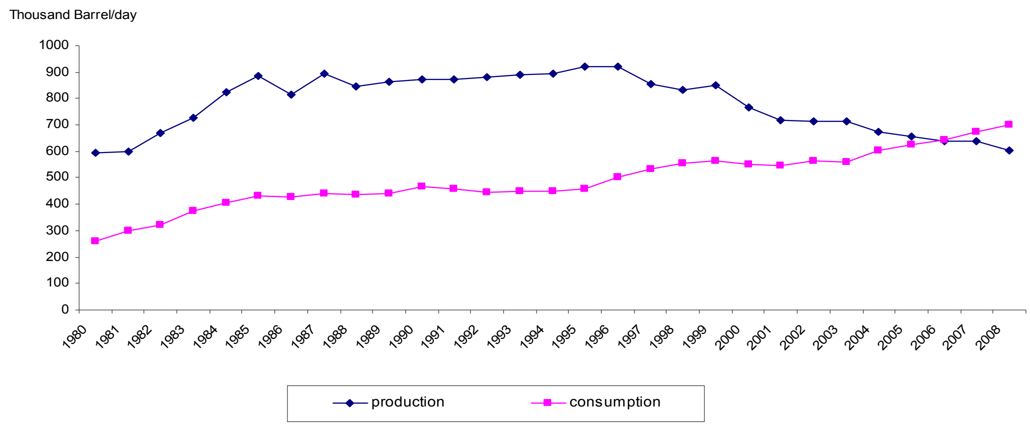
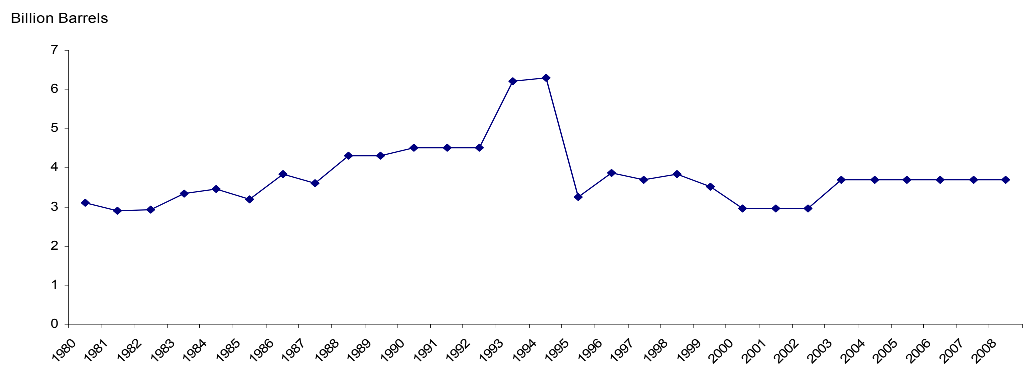
Figure 1: Egypt's Oil Production and Consumption (1980-2008)



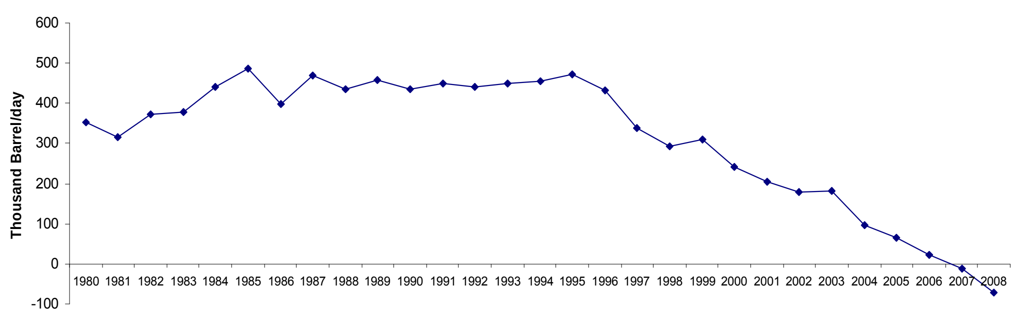
Source: U.S Energy Information Administration, Independent Statistics and Analysis, Country Energy Profile.

Figure 2: Egypt's proved oil reserves (1980-2008)



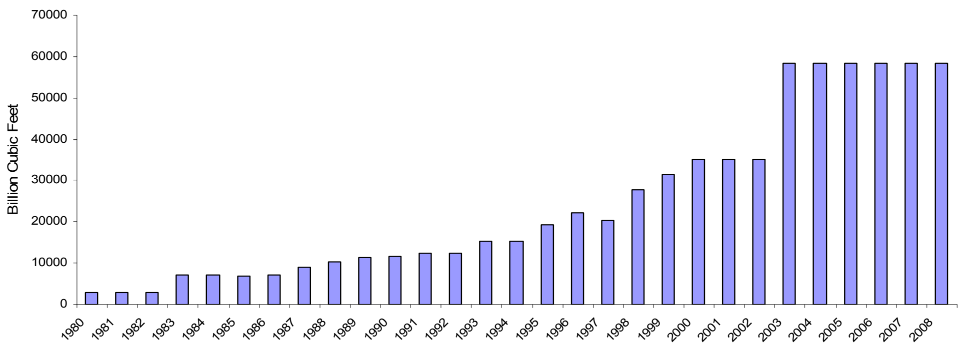
Source: U.S Energy Information Administration, Independent Statistics and Analysis, Country Energy Profile.

Figure 3: Egypt's Net Exports of Crude Oil (1980-2008)



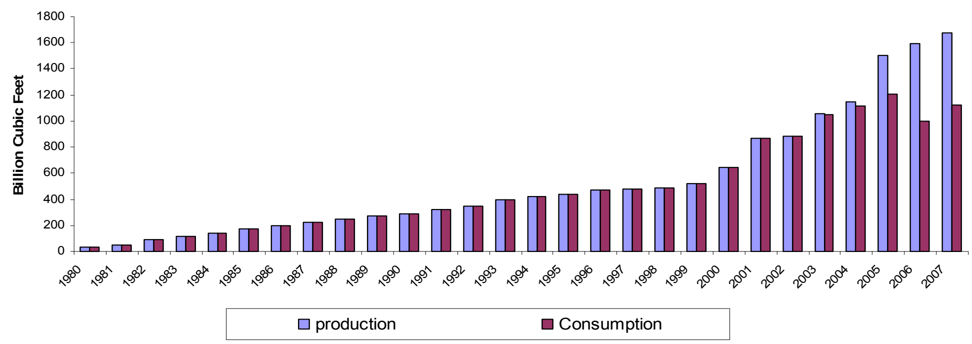
Source: U.S Energy Information Administration, Independent Statistics and Analysis, Country Energy Profile.

Figure 4: Historically Proved Reserves of Natural Gas in Egypt (1980-2008)



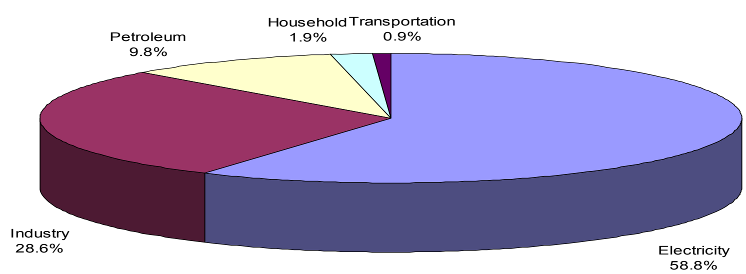
Source: U.S Energy Information Administration, Independent Statistics and Analysis, Country Energy Profile.

Figure 5: Production and Consumption of Natural Gas in Egypt (1980-2007)



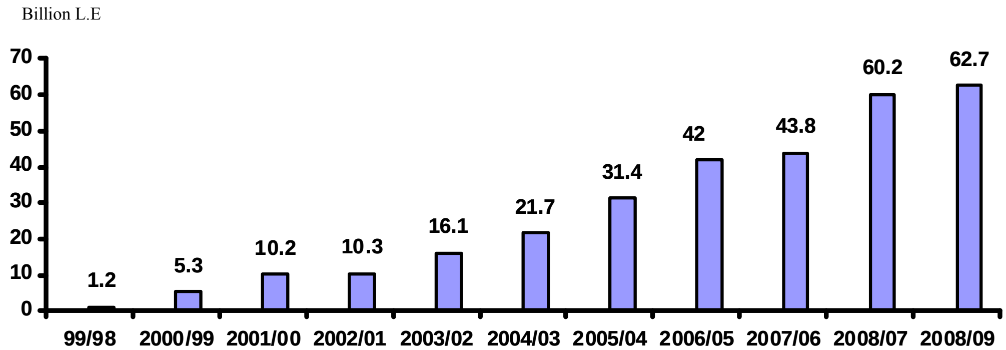
Source: Ministry of Petroleum

Figure 6: Sectoral Consumption of Natural Gas in Egypt (2006/2007)



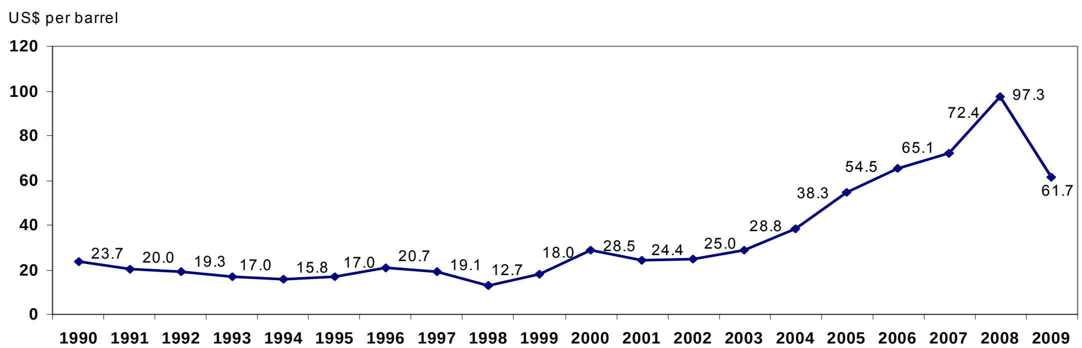
Source: Ministry of Petroleum

Figure 7: Value of Petroleum Products Subsidy in Egypt (1998/99-2008/2009)



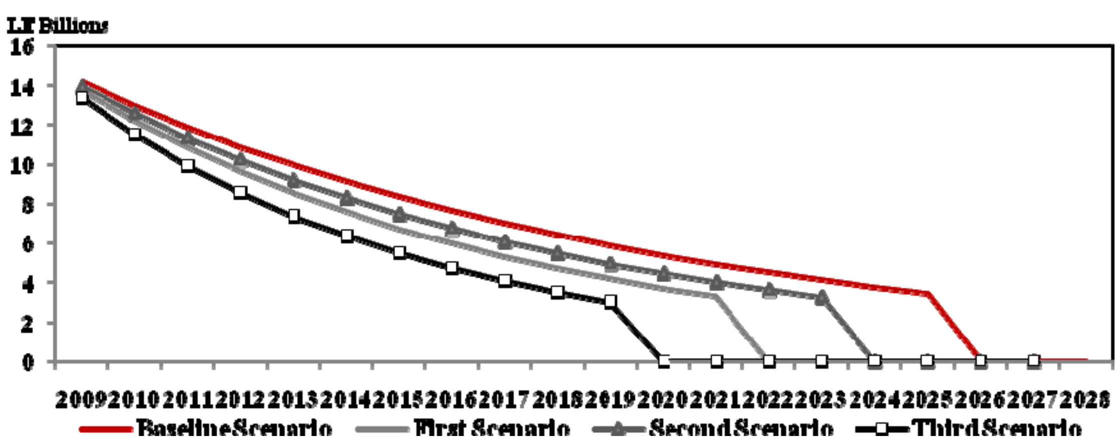
Source: People Assembly, Plan and Budget Committee, Unpublished Data.

Figure 8: International Crude Oil Prices (1998-2009)



Source: BP, Statistical Review of World Energy, 2010, available online at www.bp.com.

Figure 9: Total Future Resource Rents of Fossil Fuel (base year 2008)



Source: Authors' Calculations.

Table 1: Energy Consumption by Source (1990-2008)

Energy Source	Value (in thousands metric tons oil equivalent)				Structure (%)			
	1990	2000	2005	2008*	1990	2000	2005	2007
Fossil Fuels								
Coal and coal products	759	628	895	980	2.4	1.4	1.5	1.3
Oil and petroleum products	22,494	24,556	30,137	32,618	70.5	54.0	48.9	46.3
Natural gas	6,731	17,787	27,765	36,.783	21.1	39.1	45.0	48.1
Nuclear	-	-	-	-	-	-	-	-
Hydroelectric	854	1,178	1,087	3,903	2.7	2.6	1.8	2.0
Other Renewables								
Solar and wind	0	12	321	NA	0.0	0.0	0.5	0.1
Geothermal	0	0	0	0	0.0	0.0	0.0	0.0
Biogas and liquid biomass	0	0	0	0	0.0	0.0	0.0	0.0
Solid biomass[1/]	1,057	1,306	1,431	NA	3.3	2.9	2.3	2.2

Notes: * British Petroleum, Statistical Review of World Energy (2009). [1]includes wood fuel
Source: World Resources Institute, online database, available at: http://earthtrends.wri.org

Table 2: Petroleum Products End User Prices (1990 – 2008)

Time	Gasoline (L.E/ Ltr)				Kerosene (L.E/ Ltr)	Diesel Oil (L.E/ Ltr)	Fuel Oil (L.E/Ton)	Natural Gas* (L.E/m^3)
	Octane 80	Octane 90	Octane 92	Octane 95				
May-1990	0.50	0.55	-	-	0.10	0.10	50	0.047
Sep-1990	0.55	0.60	-	-	0.10	0.10	50	0.047
May-1991	0.90	0.80	-	-	0.20	0.20	80	0.1 – 0.3**
Jan-1992	0.90	1.00	-	-	0.30	0.30	80	0.1 – 0.3**
Jun-1992	0.90	1.00	-	-	0.30	0.30	100	0.094
Dec-1992	0.90	1.00	-	-	0.30	0.30	130	0.12
Jul-1993	0.90	1.00	-	-	0.40	0.40	130	0.12
Sep-1995	0.90	1.00	-	1.75	0.40	0.40	130	0.12
Nov-1996	0.90	1.00	-	1.75	0.40	0.40	130	0.12
Aug-1997	0.90	1.00	-	1.75	0.40	0.40	182	0.14
Apr-2004	0.90	1.00	-	1.75	0.40	0.60	250	0.1-0.3
Sep-2004	0.90	1.00	1.40	1.75	0.40	0.60	250	0.1-0.3
Jul-2006	0.90	1.30	1.40	1.75	0.75	0.75	500	0.1-0.3
Dec-2007	0.90	1.30	1.40	1.75	0.75	0.75	1000	0.1- 0.3
May-2008	0.90	1.75	1.85	2.75	1.10	1.10	1000	0.1-0.3

Notes: * Prices refer to those for household sector, the ministerial decrees after 1997 differentiated between prices according to the purpose of consumption. ** The ministerial decree set different prices according to amount consumed, differentiating between three consumption brackets. *** In March 1995, the price of Natural gas used as for cars was set at LE 0.45/m^3
Source: Ministry of Petroleum, Different Ministerial Decrees.

Table 3: Petroleum Products Prices, Cost, and Percentage of Subsidy in Fiscal Year 2008/2009

Product	Unit	Price	Cost (LE)	Subsidy (LE)	Subsidy (%)
Butagaz	12.5 K	LE 2.5	36.16	33.66	93.1%
	25 K	LE 5.5	72.82	67.32	92.24%
Fuel oil (Mazut)	Ton	LE 1000	1495	495	33.%
Natural Gas					
For homes	3 M	LE 0.1 to 0.3	0.46	From 0.36 to 0.16	35% to 78%
For low intensity energy industries	MBTU	US$ 1.716	2.3	0.584	25.4%
For high intensity energy industries	MBTU	US$ 3	2.3	-0.7	-30.4%
Benzene					
80 octane	Liter	LE 0.9	2.03	1.13	55.%
90 octane	Liter	LE 1.75	2.65	0.9	34%
92 octane	Liter	LE 1.85	3.08	1.23	39.9%
95 octane	Liter	LE 2.75	3.45	0.7	20.3%
Diesel oil	Liter	LE 1.1	2.57	1.47	57.2%
Kerosene	Liter	LE 1.1	2.11	1.01	47.9%

Source: People Assembly, Plan and Budget Committee, Report on State Budget Final Accounts, March 2010.

Table 4: Rent Unit (2008)

Product	Measurement Unit	World prices per unit (In LE)	Costs per unit** (In LE)	Unit Rent
Natural gas	Million BTU	43.20*	14.04	29.16
Diesel Oil	Litre	5.33	2.99	2.34
Gasoline	Litre	3.88	2.82	1.06
Fuel oil	Ton	3,180	1,537	1,643

Notes: *: US Henry Hub Price; **: Fiscal Year.

Sources: - People Assembly, Plan and Budget Committee, Various Reports. - Authors' Calculations

Table 5: Description of the Scenarios

Scenarios		g_y (%)	g (%)	T (years)	Elasticity Substitution	Comments
Baseline Estimates	Oil	0.0	9.2	17		Baseline scenario with a constant oil production.
	Gas	5.0	14.2	20		
1st Scenario	Oil	3.4	12.6	13	3.4	Intermediate elasticity of substitution between oil and gas
	Gas	1.0	10.2	19		
2nd Scenario	Oil	1.7	10.9	15	1.7	Low elasticity of substitution.
	Gas	1.0	10.2	19		
3rd Scenario	Oil	6.8	16.0	11	6.8	Large elasticity of substitution.
	Gas	1.0	10.2	19		

Notes: g_y denotes the planned growth rate of resource production, g is the growth rate of the resource rent and T is the forecasted delay before resource exhaustion. Each scenario considers a social discount rate equal to 9.2%.

Table 6: Current Rent (2008)

Product	Unit	Quantity Produced*	Current Rent (In LE)
Natural gas	Million BTU	1,694	49,403
Diesel Oil	Litre	166,200,000	388,908,000
Gasoline	Litre	2,929,200,000	3,113,739,600
Fuel oil	Ton	7,300,000	11,993,900,000
Total Resource Rent	-	-	15,496,597,003

Notes: *: Fiscal Year.

Sources: - People Assembly, Plan and Budget Committee, Various Reports. - Authors' Calculations.

Table 7: Future Resource Rents in the Baseline Scenario (base year 2008)

Year	No. of Years	Crude Oil (LE million)	Natural Gas (LE thousand)	Total Rents (LE million)
2009	1	14,191	43.26	14,191
2010	2	12,995	37.88	12,995
2011	3	11,901	33.17	11,901
2012	4	10,898	29.05	10,898
2013	5	9,980	25.43	9,980
2014	6	9,139	22.27	9,139
2015	7	8,369	19.50	8,369
2016	8	7,664	17.08	7,664
2017	9	7,018	14.95	7,018
2018	10	6,427	13.09	6,427
2019	11	5,886	11.47	5,886
2020	12	5,390	10.04	5,390
2021	13	4,936	8.79	4,936
2022	14	4,520	7.70	4,520
2023	15	4,139	6.74	4,139
2024	16	3,790	5.90	3,790
2025	17	3,471	5.17	3,471
2026	18	-	4.53	0.005
2027	19	-	3.96	0.004
2028	20	-	3.47	0.003

Source: Authors' Calculations.

Table 8: Future Resource Rents of Crude Oil and Natural Gas (base year 2008)

Year	No. of Years	Crude Oil (LE million)			Natural Gas
		1st Scenario	2nd Scenario	3rd Scenario	(LE thousand)
2009	1	13,762	13,973	13,359	44.83
2010	2	12,222	12,600	11,516	40.68
2011	3	10,855	11,362	9,928	36.92
2012	4	9,640	10,245	8,559	33.50
2013	5	8,561	9,238	7,378	30.40
2014	6	7,603	8,330	6,360	27.58
2015	7	6,753	7,511	5,483	25.03
2016	8	5,997	6,773	4,727	22.71
2017	9	5,326	6,107	4,075	20.61
2018	10	4,730	5,507	3,513	18.70
2019	11	4,201	4,966	3,028	16.97
2020	12	3,731	4,478	-	15.40
2021	13	3,313	4,038	-	13.98
2022	14	-	3,641	-	12.68
2023	15	-	3,283	-	11.51
2024	16	-	-	-	10.44
2025	17	-	-	-	9.48
2026	18	-	-	-	8.60
2027	19	-	-	-	7.80

Source: Authors' Calculations.

Table 9: Natural Resource Wealth (2009)

Scenario	Wealth
Baseline Scenario	83,513
First Scenario	68,687
Second Scenario	75,652
Third Scenario	58,737

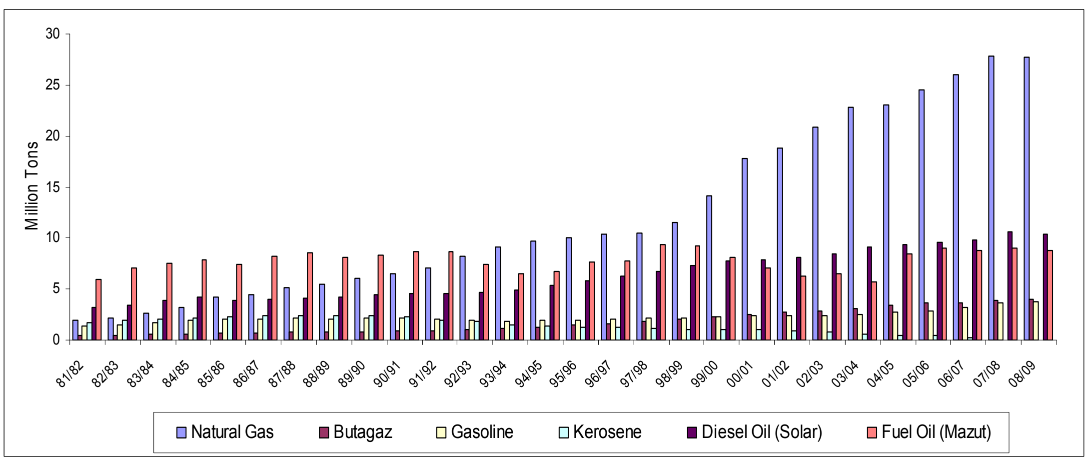
Notes: Values in LE million
Source: Authors' Calculations.

Annex 1

Fundamental features of Egypt's energy profile make it inevitable that crude oil cannot continue to play the vital role it used to have over the last three decades. These features include declining reserves, rising consumption, and low potentiality for new discoveries. Most of these features, if not all, are relatively inflexible; hence, urging the need for the Egyptian government to study other policy options. The viability of these options should be assessed in light of their cost and sustainability. Adversely, the expansion of natural gas sector in Egypt, characterized mainly by significant rising reserve, has anticipated the idea of creating a serious shift in Egypt energy mix. However, this has not been fully realized up to this point in time. Also, there is no clear evidence that this option has been assessed in the light of the rising concerns related to the rate of depletion of these two nonrenewable resources. These concerns could be highly justifiable by the steep increase in energy depletion as a percent of the GNI, which has risen from 5.1% in 2001 to more than 13% in 2007[6].

Generally, consumption growth rates of different energy products ranges from 5% to 10% over the period 1981/1982 to 2008/2009, where natural gas consumption recorded the highest growth rate over this period.

Figure A.1: Historically Consumed Quantities of Petroleum Products in Egypt



Sources: - Ministry of Finance, Egyptian Economic Monitor, September, 2009. - National Democratic Party, Energy Policy Paper, November, 2009

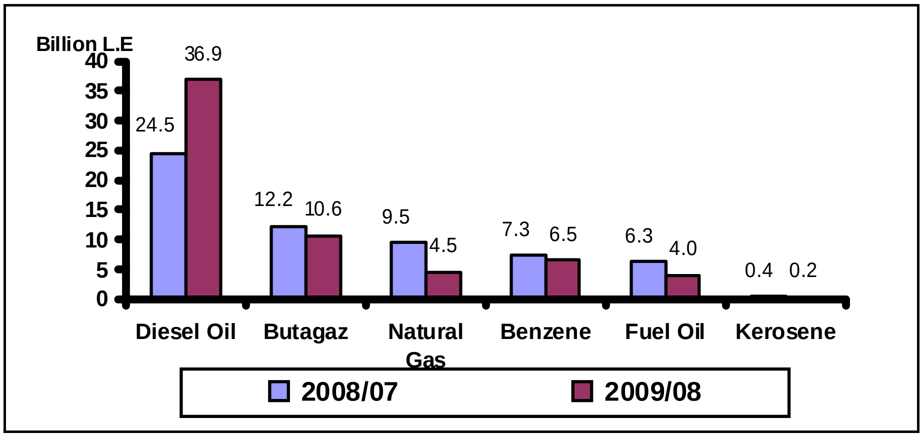
The consumption pattern of various energy products recorded by different sectors over the last two decades puts greater emphasis on the threats Egypt might be facing in the next few years. The present situation highlights serious concerns of energy sustainability of such depleting resources given the aforementioned consumption pattern, along with the currently applied pricing policies adopted by the Egyptian government. These policies are characterized by a heavy subsidy that reaches more than 90% for some of these products; namely, butagaz and fuel oil.

The value of these subsidies are not evenly distributed among different products; it is worth mentioning that subsidies allocated to diesel oil reached EGP 36.9 Billion in 2008/2009; constituting about 58.9% of the total subsidies allocated to petroleum products in this year.

[6] World Bank, World Development Indicators, 2008.

Whereas, natural gas and fuel oil (Mazut) subsidies recorded EGP 4.5 billion and EGP 4 billion, respectively; hence accounting for about 7.2% and 6.4% respectively (Figure 10).

Figure A.2: Value of Subsidy directed to Petroleum Products in 2008/2009 compared to 2007/2008:



Source: People Assembly, Plan and Budget Committee, Report on State Budget Final Accounts for FY 2008/2009, March 2010.

The subsidy value directly brings to attention the argument of the efficiency of subsidy policy in Egypt relative to the fiscal burden it imposes on the Egyptian government. The history and characteristics of energy subsidies in Egypt imposes even greater restrictions and limitations on that issue. Energy subsidies in Egypt tend to be highly inefficient because they are poorly targeted. These subsidies benefit those in the highest income groups more than those in lower income groups. This could be supported by the fact that the higher the income, the larger the quantities consumed of these products. According to Egyptian Ministry of Finance and Ministry of Petroleum, each family in the richest 2% of the Egyptian population benefits with more than EGP 1800 annually from petroleum subsidies. In the meantime, the share of the family in the lowest income quintile is only EGP 234 annually. Moreover, According to the ministry of petroleum, the consumption of industrial, electricity, and transportation sectors constitutes around 63.9% of total quantity consumed of the subsidized petroleum products, while the household consumption represents only 14.3% of total consumption.

Egypt satisfies its domestic demand of the aforementioned products from three main sources, namely; EGPC, which supplies around 44% of the total amount consumed of these products[7], foreign partners of EGPC (where prices of the products are accounted at actual paid price), and imports.

EGPC accounts for high current revenues; as its current revenues constituted about 70.6% from the total current revenues realized by the Egyptian economic authorities in the fiscal year 2009/08 (People Assembly 2010). However, the pressures stemming from the financial burden EGPC is facing due to its commitment to provide subsidized energy products has negatively affected its financial results. EGPC current revenues have decreased from EGP 181.6 billion in 2008/07 to EGP 142.9 billion in 2009/08 with EGP 38.7 billion decrease, which is approximately 21.3%.

Prior to fiscal year 2005/2006, petroleum products subsidy was not explicitly recorded in the state budget, it was treated as an off-budget item. It was subject to an arrangement between Ministry of Petroleum and Ministry of Finance; where EGPC provides these subsidies to the

[7] Estimates of the Ministry of Petroleum for the fiscal year 2007/2008.

consumers from the surplus it achieves and the remainder of this surplus is then transferred to the state budget like rest of economic authorities known as "net transfers." This arrangement has certainly presented a misleading picture on the magnitude of petroleum subsidies, as well as the financial consequences on EGPC, resulting in minor net transfers from EGPC to the state budget and preventing the society as well as policymakers from keeping a close eye on the fiscal costs associated with these subsidies.

Starting fiscal year 2005/2006, petroleum subsidies are recorded as an explicit item in the state budget, and the surplus of EGPC is transferred to the state budget separately, and recorded as net transfers from EGPC. The financial treatment of petroleum subsidies is nothing but a number of accounting records between the Egyptian state budget and EGPC financial statements, without any real cash flows between these two entities. Such treatment of the petroleum subsidies overestimates both public expenditures and revenues sides of the Egyptian state budget, and creates serious pressures on EGPC financial results. In this regard, the Ministry of Finance (MoF) continued to encumber EGPC with the total value of the petroleum subsidy, and in the end of the fiscal year the taxes, fees, and surplus accrued on EGPC for the state treasury.

Like other economic authorities in Egypt, EGPC is committed to transfer the financial surplus resulting from its operations by the end of the fiscal year to the treasury and in return the treasury is committed to cover its deficit, in case it did realize one. It is worth noting that EGPC takes into consideration, when setting petroleum products prices, the social aspect and hence providing sectors and consumers with low prices petroleum products.

Generally, EGPC generates profit through its activities represented in exporting, refining, transferring and distributing crude oil in addition to trading in some imported petroleum products. Moreover, purchasing and selling natural gas generates another portion of profits along with the fees it acquires from services done to other entities. However, the pressures stemming from the financial burden EGPC is facing due to its commitment to provide subsidized energy products has negatively affected its financial results. In the light of EGPC financial statement as of 30/6/2009, a number of facts signify the critical situation it is facing; among these:

- Total liabilities amounted to EGP 113.6 billion, of which EGP 103.5 billion are short run liabilities;
- Working capital continued to record a negative value amounting to EGP 2.3 billion compared to EGP 7 billion in 30/6/2008;
- Total assets have reached EGP 133.4 billion; of which:
  - 69.1% are accounts receivable,
  - 15.6% represents financial investments and lending activities, and
  - 8.2% are fixed assets after deducting the depreciation value.

On the other side, one of the most pressing issues is the continuous need of EGPC to finance its purchases of crude oil, refined products, and natural gas to satisfy domestic demand. According to Ministry of Petroleum data for the fiscal year 2006/2007, more than 40% of refined oil is purchased from foreign partners or imported; also, more than 50% of natural gas domestically consumed is purchased from foreign partners. These have lead to a substantial increase in EGPC accounts payable; it was also forced to obtain short run credit facilities to finance its purchases, in addition to resorting to heavy borrowing.

It is worth noting that most of the central government revenues from the oil and gas sectors are from taxation of and profit transfer from EGPC. The contracts EGPC establishes with its foreign partners are mainly based on two principles; the first is production sharing, and the second is a foreign partner after tax profit retention. Therefore, the main factors that affect the level of government revenues are magnitude of oil and gas production, international oil prices, and domestic petroleum products prices. This entails that setting petroleum products prices below their economic value implies a loss of government revenues.

Table A.1: Taxes from EGPC and Foreign Partners, and Net Transfers from EGPC (2000/01 – 2008/09)

Year	Net Transfers	Taxes from EGPC and Foreign Partner
2000/01	1331.9	4023.1
2001/02	957.3	3562.4
2002/03	100	2563.7
2003/04	-2652.3	4771.5
2004/05	154	4029.6
2005/06	12533.1	23619.7
2006/07	11013.7	25379.8
2007/08	25282.1	29268.4
2008/09	21637.2	34135.2

Source: Ministry of Finance, Egypt's State Budget End of Year Accounts, different years.

The steps of the financial treatment of these subsidies could be summarized as follows:

- EGPC submits to the National Investment Bank (NIB), which acts as MoF representative, the documents concerned with the purchase of the subsidized petroleum products, including the actual cost of purchase, as well as the documents concerned with their sale in the domestic market on quarterly basis. The subsidies value is then calculated on quarterly basis as the difference between the price of selling these products in the domestic market and actual cost borne by EGPC to purchase these products.
- MoF is supposed to compensate EGPC for the above mentioned cost (subsidy value), especially that EGPC purchases most of these products with the international prices. However, this transaction doesn't really take place; as MoF makes a clearance between the value of the subsidies accrued for EGPC for each quarter and the dues eligible for MoF for the same quarter; these dues include:
  - Actual dues: which are related to production activities, sales, dues on foreign partners in the form of sales tax, royalties, customs, and income tax on foreign partners paid by EGPC.
  - Presumptive dues: which includes income tax and treasury surplus, as MoF assumes that EGPC in case provided with cash covering the value of the subsidies will realize a surplus; hence pay the treasury a 40.55% tax of the value of this surplus. It is worth noting that MoF subtracts around 20% of this surplus as reserves and workers' share. The remainder of this surplus is paid to the state treasury.

According to the aforementioned treatment, the financial relation between the state budget and EGPC is nothing but accounting records which do not involve any real cash transfer between the two sides. It is worth noting that although EGPC pays for its purchases from most of the subsidized petroleum products in cash, it sells them on credit for a number of public corporations and institutions. At the same time, EGPC does not receive any cash from MoF; hence affecting the financial results of EGPC negatively.