Egyptian-German Joint Committee on Renewable Energy, Energy Efficiency and Environmental Protection

Impact of Energy Demand on Egypt's Oil and Natural Gas Reserves

Current situation and perspectives to 2030

gtz

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and Environmental Protection

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Cairo, June 2010

JCEE

Egyptian German Joint Committee
on Renewable Energy, Energy Efficiency
and Environmental Protection

The Governments of Egypt and Germany agreed in 2007 to establish an Egyptian-German High Level Joint Committee for cooperation on Renewable Energy, Energy Efficiency, and Environmental Protection.

The overall objectives are, according to the Memorandum of Understanding, to “help to promote an environmentally sustainable economic development, based on the contribution of securing energy supplies, improving living conditions and conserving the natural environment.”

The JCEE is supported by a bilateral technical cooperation project, executed by the Ministry of Electricity and Energy of the Arab Republic of Egypt and GTZ. The German contribution is financed by the Federal Ministry of Economic Cooperation and Development (BMZ).

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Foreword

This analysis of future oil and natural gas reserves in Egypt is based on quantitative simulations of the country's energy sector. In the course of the analysis, the extreme dependency of the current energy strategy on natural gas becomes evident. This strategy is viable for approximately 15 years before the falling reserves-to-production (R/P) ratio indicates its coming end. Not only Egypt's energy strategy, but also much of the country's economic and social development scheme, is based on access to low-cost natural gas and petroleum; thus, the end of the oil and gas era in Egypt would deprive the country of one of its fundamental resources. This period coincides with increased shortages of other critical resources, such as water.

Egypt must use the grace period of 10 to 15 years to transform itself from a fossil fuel-based economy to one built on more sustainable resources. The country's remaining oil and gas reserves could be used to finance a transition to an economy that is based on human and renewable energy resources and appropriate for the age of climate-induced risks and exhausted fossil energy resources. This would require a change in the allocation and pricing system for oil and gas in order to generate financial resources for education, health, and other factors of human development.

Renewable energy and energy efficiency are key technological options for fostering this transition. Rather than burning up fossil energy reserves in a spurious industrial competition that has no future, Egypt could build on its engineering and industrial base and become a competitive player and regional leader in the "new" energy economy of the 21st century.

I want to thank the report's author, Francisco Figueroa de la Vega, who is an experienced energy planner with many years in the oil and gas industry as well as research institutes and other think tanks, for providing us with this study. This research reflects some of the concepts and models he developed and applied during our collaboration in the Latin American and Caribbean regional energy organization OLADE and the regional UN Economic Commission ECLAC, in a joint project with GTZ called "Energy and Sustainable Development in Latin America and the Caribbean," with financing from the Federal German Ministry for Economic Cooperation and Development (BMZ). I also appreciate the insights of peer reviewer Roberto Gomelsky, former Policy Director of OLADE and key consultant for private sector power development projects in Latin America.

The present work has been conducted as a background study of the Egyptian German Joint Committee for Renewable Energy, Energy Efficiency and Environmental Protection (JCEE), with financing from BMZ. We are grateful for the material and information received to conduct the scenarios from the partners in the JCEE, in particular the Ministry of Electricity and Energy, the Egyptian Electric Utilities and Consumer Protection Regulatory Agency, and others.

Responsibility for the work lies with the author and myself, representing GTZ. Apart from providing JCEE with a background paper for orientation of the activities and assessing the impacts, we hope to be able to contribute to the current strategy discussion in Egypt.

Paul H. Suding
GTZ Egypt Energy Program Director, Cairo
March 2010

Executive Summary

Egypt is currently the world’s 25th largest oil producer and is home to 4.5 billion barrels of crude reserves, 0.3 percent of the global total. With diminishing production, however, the country is losing significance in the rankings and is projected to have only 1.5 billion barrels of remaining reserves by 2030, a marginal quantity compared to the 800 billion barrels of global reserves.

Egypt could still produce approximately 280,000 barrels per day by 2030, but it would need to import another 400,000 barrels, or 20 million tons of oil equivalent (mtoe), of crude per day to run its refineries at current capacity. To supply its total energy consumption, Egypt would also need to import an additional 22–45 mtoe (net) of petroleum products by 2030.

If Egypt wishes to maintain high economic growth, only a strict energy efficiency and renewable energy policy will be able to keep total petroleum imports at around 42 mtoe. In contrast, a lax energy policy and economic growth would elevate net imports to 65 mtoe by 2030.

Egypt is in a more favorable situation with natural gas than it is with oil. With 76 trillion cubic feet of remaining reserves, the country ranks 7th among non-OPEC countries, and 16th worldwide. Egypt may continue to expand its natural gas production to meet demand for exports, which could increase slightly from the current 630 billion cubic feet to 800 billion cubic feet by 2030, and also meet rising domestic demand.

However, here too the current policy to expand natural gas usage in all sectors as a substitute for petroleum products leads to rapid growth in consumption. Together with exports, this will increase production and cause the remaining reserves to diminish rapidly, even if discoveries increase the reserve base. Within approximately 20 years, Egypt’s natural gas production will face the same fate that domestic oil production has encountered since the mid-1990s: stagnation and decline in production. Sluggish economic growth would postpone this exhaustion. With desired rapid economic growth, however, Egypt’s extensive gas strategy is bound to reach its limits during the 2020s.

A clear decision to promote renewable energy in the electricity sector can ease the pressure, maintaining natural gas as the preferred fuel for environmental reasons. To maintain its high use of natural gas, Egypt will need to reconsider gas exports and successively replace domestic with imported natural gas between 2025 and 2030. The strategic shift in Egypt’s energy future would be to complement natural gas as much as possible with wind and later solar energy, as this will reduce the burden from oil and petroleum-product imports and prolong the natural gas age.

This assessment provides a purely quantitative analysis of energy flows and directly calculated carbon dioxide emissions in Egypt. It is not an economic evaluation; however, it does provide a clear indication of policy options, specifically in the areas of renewable energy and energy efficiency. It is clear that the choice of such options, represented in the study as the “S&E” (substitution and efficiency) scenario, will affect Egypt’s external economic account very positively. The important condition for this economic advantage is that investments in efficiency and renewable energy have a high domestic content, which is perfectly possible in light of Egypt’s existing industrial structure and the quality of its engineering and work forces.

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Abbreviations and Acronyms

BAU	Business-As-Usual (scenario)
bbl	barrel (volume of 159 liters)
BMZ	Federal German Ministry for Economic Cooperation and Development
BP	British Petroleum Corporation
CEPAL	United Nations Economic Commission for Latin America and the Caribbean (also: ECLAC)
CHP	Combined Heat and Power
CC	Combined-Cycle Gas Power Generation Technology
cf	cubic foot (volume of 28.3 liters)
cfd	cubic feet per day
CNG	Compressed Natural Gas
CO_{2eq}	Carbon Dioxide Equivalent
EEHC	Egyptian Electric Holding Company
EIA	US Energy Information Administration
ENI	Ente Nazionale di Idrocarburos (Italian Oil Company)
GDP	Gross Domestic Product
GOR	Gas-to-Oil Ratios
GTL	Gas to Liquids
GTZ	Deutsche Gesellschaft fuer Technische Zusammenarbeit (GTZ) GmbH
GWh	GigaWatt-hours (1000 MWh)
GWP	Global Warming Potential
HDI	United Nations Human Development Index ()
HEG	High Economic Growth (scenario).
IEA	International Energy Agency
JCEE	Egyptian-German Joint Committee on Renewable Energy, Energy Efficiency, and Environmental Protection
kW	kilowatt (capacity unit)

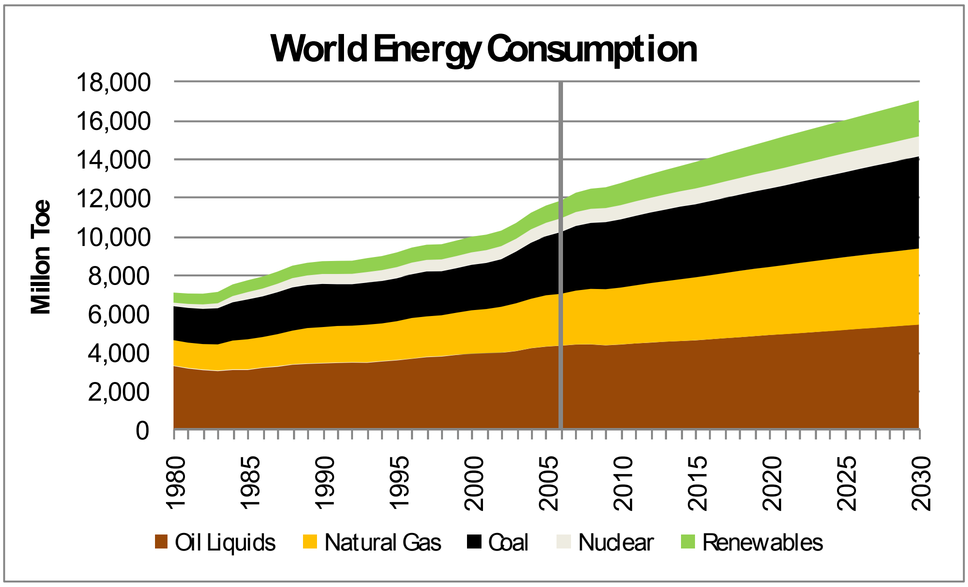
kWh	kilowatt-hours (energy unit)
LEAP	Long-range Energy Alternatives Planning System
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MWh	Megawatt hours (1000 kWh)
NGL	Natural Gas to Liquids
oe	oil equivalent (energy conversion factor 1 kgoe = 11630 kWh)
OECD	Organization for Economic Cooperation and Development
OLADE	Organisation Latinoamericana de Energia
OPEC	Organization of Oil Exporting Countries
PPP	Purchasing Power Parity
ROI	Return on Investment
R/P	Reserves/Production (ratio)
S&E	Substitution and Efficiency (scenario)
SEI	Stockholm Environment Institute
USGS	US Geological Survey
WB	World Bank
WEC	World Energy Council

1. World Oil and Natural Gas Consumption and Reserves

1.1 World Energy Consumption

The U.S. Energy Information Administration's 2009 "reference case" projects that the annual growth in world energy consumption will decreae from 2.0 percent in the period 1980–2006 to 1.4 percent in the period 2008–2030.[i] (See Figure 1.) While the current economic downturn is expected to slow the growth in world energy demand in the short term, it is assumed that the growth rate will pick up again after 2010 as most nations resume their earlier growth trends.

Figure 1. World Energy Consumption, 1980–2030



Note: Liquids including biofuels and excluding from renewables.
Source: DOE/EIA, May 2009

In the EIA reference case, consumption of all energy sources increases over time. Assuming that world oil prices remain relatively high through most of the projection period, liquid fuels and other petroleum products are the world's energy sources that grow most slowly in this scenario, increasing at an average annual rate of 1.0 percent from 2008 to 2030.[ii] (See Table 1.) Renewable resources are the fastest growing energy sources, with consumption increasing 2.7 percent per year. Projected increases in oil prices, rising concern about the environmental impacts of fossil fuel use, and strong government incentives to increase the penetration of renewables in most countries, improve the prospects for renewable energy worldwide.

Although liquid fuels are expected to remain the largest source of energy, their share of marketed world energy consumption declines in the reference case from 35.3 percent in 2008 to 31.8 percent in 2030. This scenario assumes that rising world oil prices lead many energy users, especially in the industrial and electric power sectors, to switch from liquid fuels and other petroleum products when feasible. Between 2008 and 2030, liquid fuel consumption in the residential, commercial, and electric power sectors declines worldwide.

In the transportation sector, liquid fuel consumption remains relatively unaffected by projected world oil prices in the 2009 reference case. World oil prices in this case are US$99.7 per barrel from US$130 in 2030. In the absence of significant technological advances, liquid fuels continue to dominate world transportation markets.
In the industrial sector, growth in liquid fuel consumption is slower because of efficiency gains and fuel substitution, especially in non-OECD regions where there are more opportunities for fuel

switching. World liquid fuel consumption for energy in the industrial sector increases by 0.7 percent per year.

Table 1. Growth and Structure of World Energy Consumption, 1980–2030

Year(s)	Liquids	Natural Gas	Coal	Nuclear	Renewables	Total
	Annual Average Growth					
1980-2006	1.1%	2.7%	2.3%	5.1%	2.2%	2.0%
2006-08	0.8%	3.4%	3.3%	1.2%	6.2%	2.5%
2008-30	1.0%	1.4%	1.5%	1.6%	2.7%	1.4%
	Structure					
1980	46.2%	19.0%	24.7%	2.7%	7.4%	100.0%
2008	35.3%	23.3%	27.4%	5.7%	8.4%	100.0%
2030	31.8%	23.3%	28.0%	5.9%	10.9%	100.0%

Source: DOE/EIA, 2009

Natural gas remains an important fuel for electricity generation worldwide, being more efficient and less carbon-intensive than other fossil fuels. In the reference case, total natural gas consumption increases 1.4 percent annually on average from 2008, and its use in the electric power sector increases 2.1 percent per year. As world oil prices presumably rebound following the current economic downturn and then rise through 2030, consumers are expected to choose less-expensive natural gas to meet their energy needs whenever possible, particularly in the industrial sector where, for example, newly constructed petrochemical plants are expected to rely increasingly on natural gas as a feedstock.

In the reference case, world coal consumption increases 1.5 percent per year on average from 2008 to 2030 and accounts for 28 percent of world energy consumption in 2030. In the absence of policies or legislation that limit growth in coal use, the United States, China, and India are expected to substitute coal for more expensive fuels. Together, these three nations account for 88 percent of the projected net increase in coal consumption from 2008 to 2030. The only decreases in coal consumption are projected for OECD-Europe and Japan, where populations are either growing slowly or declining, electricity demand growth is slow, and renewable energy sources, natural gas, and nuclear power are likely to be chosen over coal for electricity generation.

Net electricity generation worldwide totals 31.8 trillion kilowatt-hours (kWh) in 2030 in the reference case, 77 percent higher than the 2006 total of 18.0 trillion kWh. The strongest growth in electricity generation is projected for non-OECD countries, where generation increases by 3.5 percent annually as rising living standards increase the demand for home appliances and commercial services, including hospitals, office buildings, and shopping malls. In the OECD countries, where such infrastructure is well established and population growth is relatively slow, much lower growth in electricity generation is expected, averaging 1.2 percent per year from 2006 to 2030.

Currently, natural gas and coal together account for the largest share of world electricity generation, at more than 60 percent. They are projected to remain the most important sources of supply in 2030, with a 64-percent share of total generation. In non-OECD Asia, where coal resources are ample, higher prices for oil and natural gas make coal a more economical source of energy for electricity generation.

Electricity generation from nuclear power increases from 2.7 trillion kWh in 2006 to 3.8 trillion kWh in 2030 in the reference case, as concerns about rising fossil fuel prices, energy security, and increased greenhouse gas emissions support the development of new nuclear generating capacity. Higher capacity utilization rates have been reported for many existing nuclear facilities, and it is expected that most older plants now operating in OECD countries and in non-OECD Eurasia will be granted extensions to their operating lives. There is still considerable uncertainty about the future of nuclear power, however. Public concerns about plant safety, radioactive waste disposal, and the proliferation of nuclear weapons may hinder plans for new installations, and high capital and maintenance costs may keep some countries from expanding their nuclear power programs.

Most of the projected expansion of installed nuclear power capacity is in non-OECD countries. China, India, and Russia account for almost two-thirds of the projected net increase in world nuclear power capacity between 2006 and 2030. In the reference case, China adds 47 gigawatts (GW) of nuclear capacity between 2006 and 2030, India 17 GW, and Russia 21 GW. Several OECD nations with existing nuclear programs also add new net capacity, including South Korea (13 GW), Japan (8 GW), and the United States (12 GW).

Renewable energy sources are the fastest growing energy source for world electricity generation in the reference case, increasing by an average of 2.7 percent per year from 2008 to 2030. Much of the growth is in hydroelectric power and wind power. Of the 3.3 trillion kWh of new renewable generation added by 2030, 1.8 trillion kWh (54 percent) is attributed to hydropower and 1.1 trillion kWh (33 percent) to wind power. Other than hydropower, most renewable technologies are not able to compete economically with fossil fuels over the projection period, except in a limited number of niche markets, according to the EIA scenario. Government policies and incentives are typically the primary drivers for the construction of renewable generation facilities.

As renewable energy use increases worldwide, the mix of fuels in the OECD and non-OECD regions differs in the reference case. In OECD nations, the majority of economically exploitable hydroelectric resources have already been developed, and with the exception of Canada and Turkey, few large-scale hydro projects are planned for the future. Instead, most renewable energy growth in OECD countries is expected to come from non-hydro sources, especially wind and biomass. Many OECD countries, particularly in Europe, have government policies, including feed-in tariffs, tax incentives, and market-share quotas, that encourage the construction of renewable electricity facilities.

In contrast to OECD countries, hydropower is expected to be the predominant source of renewable energy growth in non-OECD nations. Strong growth in hydroelectric generation, primarily from mid- to large-scale power plants, is expected in Brazil, China, India, Laos, and Vietnam. Growth rates for wind generation also are expected to be high in non-OECD countries, with the largest increase in China, which accounts for 88 percent of the total increase in non-OECD wind generation. Generation from wind plants in China increases from 2 billion kWh in 2006 to 315 billion kWh in 2030. Still, the total increase in China's wind generation is only about half the expected increase in the country's hydroelectric generation.

1.2 World Oil Resources

Meeting future liquid fuel demands will depend mostly on existing oil and gas resources and to a much smaller degree on biofuels, taking into account potential conflicts between biofuels and food production in places where appropriate land use regulations are not yet implemented.

The distribution of total oil resources between OPEC and non-OPEC producers is important.[iii] (See Table 2.) Whereas OPEC members agree on supply quotas to sustain their profit margins and market penetration strategies, for non-OPEC producers the economic rationale is related to competition and maximizing the return on investment (ROI) by entering accessible market segments. Within this context, the oil market cannot be called a competitive market.

The availability of oil is also a limiting issue, although world oil resources are continually being reevaluated in light of new data and discoveries.[iv] The fact is that oil is an exhaustible natural resource, and there are situations in which the remaining reserves decline or are simply exhausted and there is a need to substitute the use of oil with alternative energy; in these cases, investment cannot necessarily secure new discoveries.

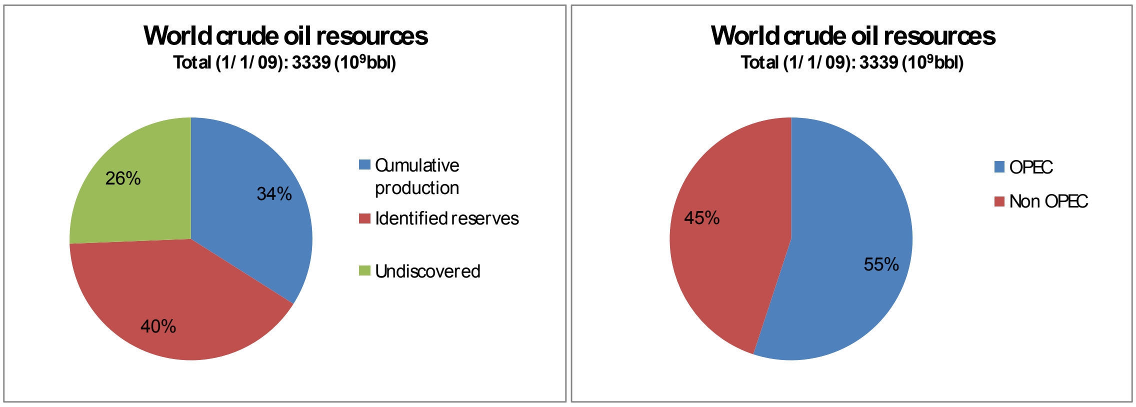
Table 2. World Conventional Crude Oil Resources, 2009*

Country	Cumulative Production	Identified Reserves	Original Reserves (Cumulative Production plus Identified Reserves)	Undiscovered Oil	Total Resources (Original Reserves plus Undiscovered Oil)
			billion barrels		
Saudi Arabia	122.5	266.7	389.2	136.0	525.2
Iran	63.6	150.6	214.2	67.1	281.3
Iraq	32.0	116.1	148.1	51.3	199.4
United Arab Emirates	29.8	100.8	130.6	10.1	140.6
Venezuela	61.8	105.1	166.8	24.2	191.1
Kuwait	38.0	102.4	140.4	4.0	144.4
Nigeria	28.1	38.0	66.1	43.2	109.3
Libya	27.0	44.4	71.4	9.2	80.6
Qatar	9.5	31.0	40.5	5.4	45.9
Algeria	20.6	14.8	35.4	9.9	45.3
Indonesia	23.3	5.3	28.6	10.2	38.8
Other (**)	14.7	17.3	32.0	4.1	36.1
TOTAL OPEC	**470.8**	**992.5**	**1463.3**	**374.7**	**1838.0**
Russian Federation	173.9	102.3	276.3	115.3	391.6
United States	208.2	43.9	252.1	83.0	335.1
Mexico	39.6	13.0	52.6	23.3	75.9
China	36.3	16.1	52.4	23.2	75.6
Canada	32.2	31.5	63.7	3.7	67.4
Norway	23.3	9.1	32.4	22.7	55.2
United Kingdom	24.8	4.5	29.3	7.1	36.4
Oman	8.8	5.8	14.6	5.2	19.8
Egypt	10.7	4.6	15.3	4.2	19.5
Malaysia	7.0	6.5	13.5	4.4	17.9
India	7.8	6.2	14.0	3.2	17.2
Other	91.6	104.7	196.3	186.0	382.2
TOTAL Non-OPEC	**664.5**	**355.5**	**1020.0**	**481.3**	**1501.3**
WORLD	**1135.3**	**1348.0**	**2483.3**	**856.0**	**3339.3**

(*) Includes natural gas-to-liquids (NGL) (**) Gabon and others
Source: Masters et al 1994, BP 2009, USGS 2001

By early 2009, the world had produced 34 percent of the conventional crude in existing fields.[v] (See Figure 2.) Identified reserves totaled 40 percent with a 100-percent probability of recovery, assuming the necessary investments in development and extraction. Resources still to be discovered represented 26 percent, and the typical recovery probability is estimated at 5–10 percent depending on the technology, crude API gravity, on-shore or offshore profundity, and proximity to the Earth's poles.

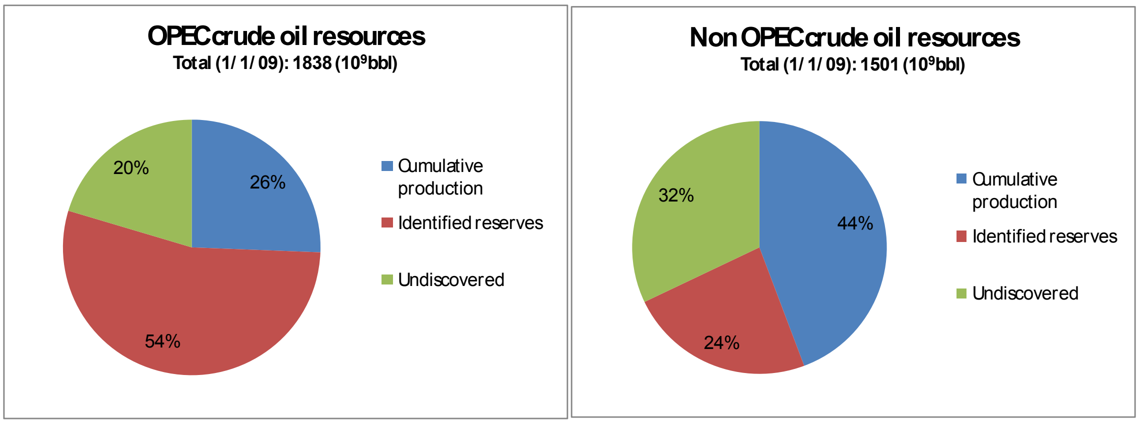
Figure 2. World Crude Oil Resources, 2009



Source: Masters et al 1994, BP 2009, USGS 2001

The world's cheap oil is located mainly in the Middle East but is sold at market prices based on an agreed supply regulation between OPEC producers seeking a profit margin on sales close to 100 percent. OPEC controls 55 percent of total crude oil resources, while the remaining 45 percent is owned by large numbers of non-OPEC producing countries of varying sizes. (See Figure 2.) OPEC has produced 26 percent of its resources while the non-OPEC countries have produced 44 percent of theirs, spurred on by the 1979 oil shock which stimulated exploration and exploitation in areas that were by then considered "non-profitable."[vi] (See Figure 3.)

Figure 3. OPEC and Non-OPEC Crude Oil Resources, 2009

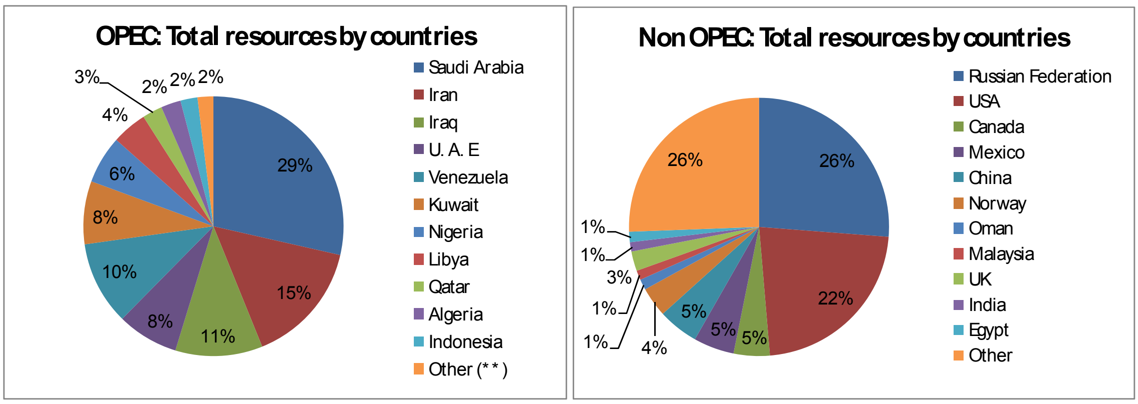


Source: Masters et al 1994, BP 2009, USGS 2001

Currently, some 54 percent of the world's total identified reserves (that are mostly proven) remain available to OPEC producers, compared with 24 percent for Non-OPEC producers. This means that, in the short term, OPEC has a better and stronger reaction capacity in the face of future world oil demands. But the cost of this huge availability of oil resources is immobilized assets, particularly given that the economic rationale of non-OPEC producers leads them to use the most cost-effective surface technologies, which significantly increases the possibility of converting undiscovered resources into proven reserves.

Over the medium term, it is possible that dominant positions may be diluted and that supply perspectives will be more balanced between the two oil-producing blocs. The recovery of undiscovered resources will rely on technology at higher prices, as it is more expensive to confirm marginal identified reserves.

Figure 4. OPEC and Non-OPEC Crude Oil Resources, by Country, 2009



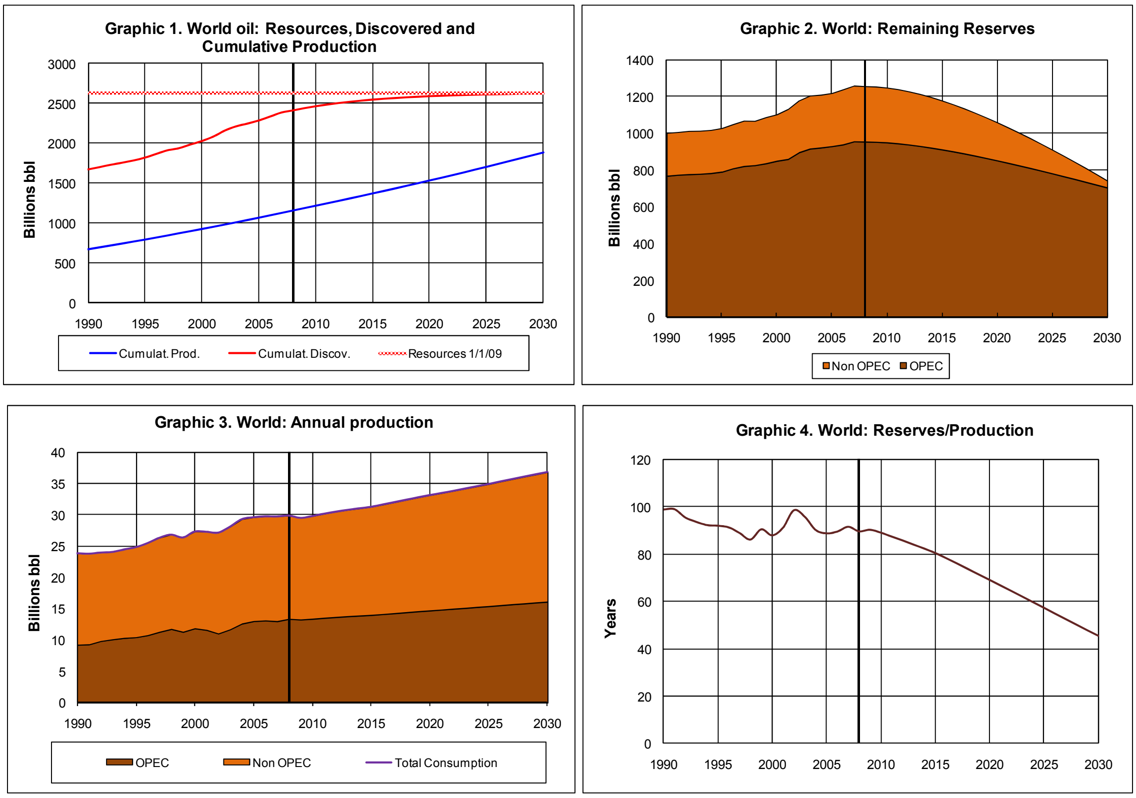
Source: Masters et al 1994, BP 2009, USGS 2001

As of 2009, OPEC represented 14 oil-producing countries.[vii] (See Figure 4.) Of these, six are major oil producers, and four of these six (Saudi Arabia, Iran, Iraq, and Venezuela) account for at least 10 percent of world oil resources. Non-OPEC countries are far more numerous, with 11 producers accounting for 74 percent of production and many more countries accounting for the remaining 26 percent of production. The Russian Federation and the United States dominate non-OPEC production, together representing 48 percent of those resources, with the United States being a net importer.

1.3 World Oil Market in Perspective

Between 1990 and 2008, world oil discoveries increased steadily.[viii] (See Figure 5, Graphic 1.) This was driven by the long-term increase in crude oil prices on the international market, despite short-term fluctuations that originated from speculation by traders through inventory accumulation.

Figure 5. World Crude Oil Reserves and Production, 1990–2030



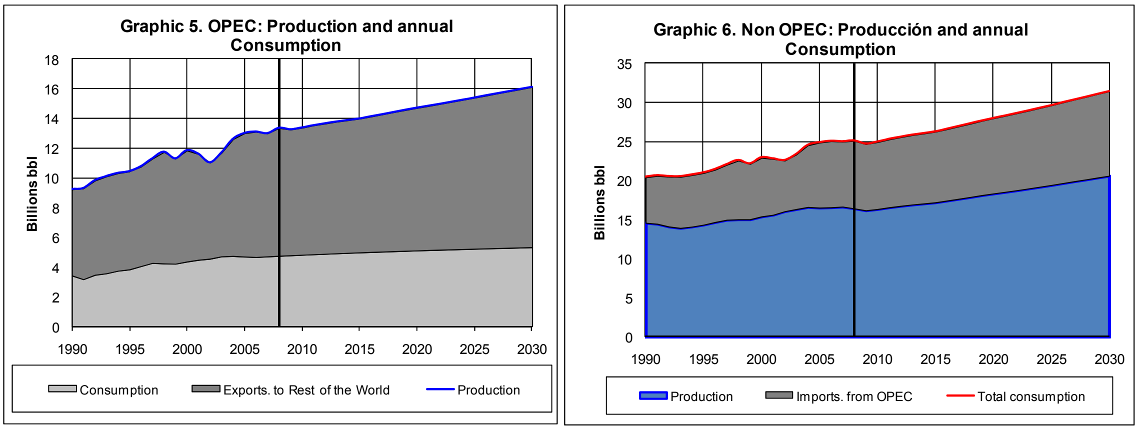
Source: Author's analysis based on USGS and BP information

Cumulative production increased steadily because of rising oil demand in both industrialized countries and large emerging economies such as China and India. The difference between the cumulative production and reserves curves (Figure 5, Graphic 1) is explained by the remaining reserves volume, which appears to have reached its peak around 2007 (2006 for OPEC countries and 2007 for non-OPEC). With production required to meet world demand for refined products growing at 0.9 percent to 2030 (see Table 1), remaining reserves in conventional oil fields under exploitation (both in operation and new) will decline, exhausting resources for both OPEC and non-OPEC producers (see Table 2).

On the demand side, while projected consumption growth rates to 2030 in OPEC countries are low based on historical trends (0.5 percent), those in non-OPEC countries are double (1.0 percent), particularly in emerging economies.[ix] (See Figure 6.) This is because these countries have less flexibility, due to insufficient investments, to adapt to new technologies in transportation, energy efficiency in industry, and the use of renewable energy in power generation.

According to the EIA, world demand for liquid fuels has dampened in the near term as a result of the global economic recession that began in 2008 and continued into 2010. However, a return to growth is expected over the long term as national economies recover. In particular, the developing economies of non-OECD Asia and the Middle East are expected to return to strong economic growth, accompanied by growing demand for energy to fuel transportation and industrial activity.

Figure 6. Oil Production and Consumption in OPEC and Non-OPEC Countries, 1990–2030

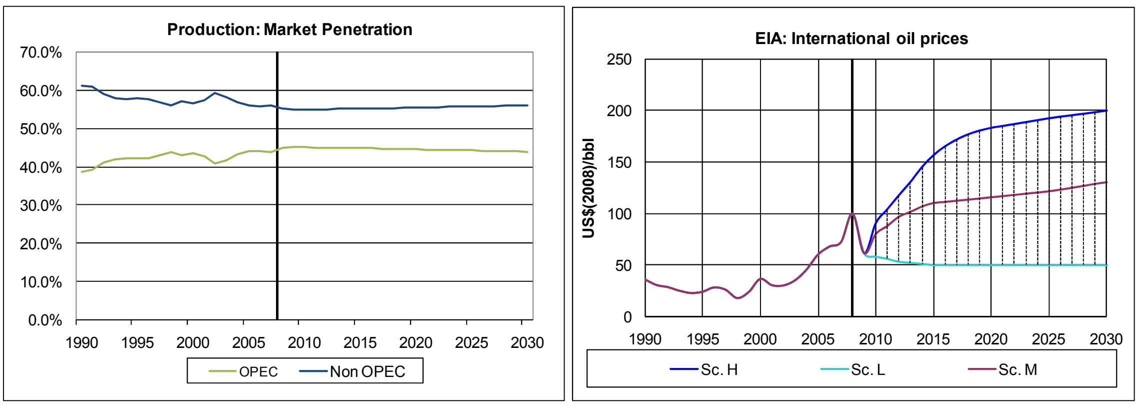


Source: Author's analysis based on USGS and BP information

The increasing cost-competitiveness of other energy sources is leading many current users of liquids outside the transportation sector to switch to other fuels, and as a result the transportation share of total liquid fuel consumption is increasing over time. In 2030, the transportation sector is projected to consume 56 percent of total liquid fuels supplied, with the increase in volume consumed accounting for 78 percent of the total increase in liquid fuels consumption across all sectors from 2006 to 2030.

Strong expansion of liquid fuel use is projected for non-OECD countries, driven by a return to robust economic growth, burgeoning industrial activity, and rapidly expanding transportation use. The largest increase in non-OECD consumption between 2006 and 2030 is projected for non-OECD Asia, at 14.1 million barrels per day. By country, China (8.1 million barrels per day) and India (2.0 million barrels per day) show the largest regional increases in demand, and China's projected demand growth is the largest worldwide. Large increases in liquid fuel consumption are also expected in the Middle East (3.3 million barrels per day) and Central and South America (1.9 million barrels per day).

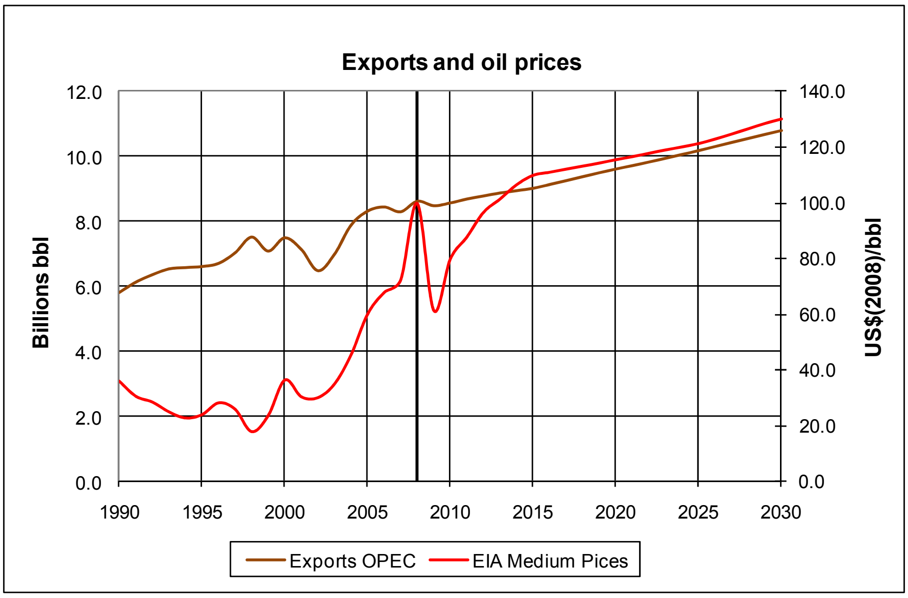
Figure 7. World Oil Market Penetration and Oil Prices, 1990–2030



Source: Author's analysis based on data from EIA, 2009

Liquid fuel consumption in the OECD region is projected to increase more gradually, reflecting expectations of slowly expanding or declining populations and relatively slow economic growth in most OECD nations, as compared with non-OECD nations, over the next two decades. In Japan and OECD Europe, liquid fuel consumption declines by an average of 0.4 and 0.2 percent, respectively, by 2030. The different growth trends projected for the non-OECD and OECD regions mean that total liquid fuel demand in non-OECD countries surpasses that in OECD countries in 2021, when demand in non-OECD Asia exceeds that in North America. In 2030, the United States still consumes more liquid fuel than China does, but this difference is less than one-half the difference in 2006.

Figure 8. Comparison of World Oil Prices and Exports, 1990–2030



Source: Author's elaboration based on information from BP

Table 3. World Oil Balance, 1990–2030

Year	Supply							Demand					
	Production			Net Imports			Total	Consumption			Net Exports		
	OPEC	Non-OPEC	Total	OPEC	Non-OPEC	Total		OPEC	Non-OPEC	Total	OPEC	Non-OPEC	Total
	billion barrels												
1990	9.3	14.6	23.9	0.0	5.8	5.8	29.7	3.5	20.4	23.9	5.8	0.0	5.8
1991	9.3	14.5	23.8	0.0	6.1	6.1	29.9	3.2	20.6	23.8	6.1	0.0	6.1
1992	9.9	14.2	24.0	0.0	6.4	6.4	30.4	3.5	20.5	24.0	6.4	0.0	6.4
1993	10.1	14.0	24.1	0.0	6.5	6.5	30.6	3.6	20.5	24.1	6.5	0.0	6.5
1994	10.4	14.1	24.5	0.0	6.6	6.6	31.1	3.8	20.7	24.5	6.6	0.0	6.6
1995	10.5	14.4	24.9	0.0	6.6	6.6	31.5	3.9	21.0	24.9	6.6	0.0	6.6
1996	10.8	14.7	25.5	0.0	6.7	6.7	32.2	4.1	21.4	25.5	6.7	0.0	6.7
1997	11.3	15.0	26.3	0.0	7.0	7.0	33.4	4.3	22.0	26.3	7.0	0.0	7.0
1998	11.8	15.1	26.8	0.0	7.5	7.5	34.4	4.3	22.6	26.8	7.5	0.0	7.5
1999	11.3	15.1	26.4	0.0	7.1	7.1	33.5	4.3	22.1	26.4	7.1	0.0	7.1
2000	11.9	15.4	27.3	0.0	7.5	7.5	34.8	4.4	22.9	27.3	7.5	0.0	7.5
2001	11.6	15.7	27.3	0.0	7.1	7.1	34.4	4.5	22.8	27.3	7.1	0.0	7.1
2002	11.1	16.1	27.2	0.0	6.5	6.5	33.6	4.6	22.6	27.2	6.5	0.0	6.5
2003	11.7	16.4	28.1	0.0	7.0	7.0	35.1	4.7	23.4	28.1	7.0	0.0	7.0
2004	12.7	16.6	29.3	0.0	7.9	7.9	37.2	4.8	24.5	29.3	7.9	0.0	7.9
2005	13.0	16.6	29.6	0.0	8.3	8.3	37.9	4.7	24.9	29.6	8.3	0.0	8.3
2006	13.1	16.6	29.7	0.0	8.4	8.4	38.2	4.7	25.0	29.7	8.4	0.0	8.4
2007	13.0	16.7	29.7	0.0	8.3	8.3	38.0	4.7	25.0	29.7	8.3	0.0	8.3
2008	13.4	16.5	29.9	0.0	8.6	8.6	38.5	4.8	25.1	29.9	8.6	0.0	8.6
2009	13.3	16.2	29.5	0.0	8.5	8.5	38.0	4.8	24.7	29.5	8.5	0.0	8.5
2010	13.4	16.4	29.8	0.0	8.6	8.6	38.4	4.9	24.9	29.8	8.6	0.0	8.6
2015	13.6	16.6	30.2	0.0	8.7	8.7	38.9	4.9	25.3	30.2	8.7	0.0	8.7
2020	14.8	18.4	33.1	0.0	9.6	9.6	42.7	5.1	28.0	33.1	9.6	0.0	9.6
2025	15.4	19.4	34.9	0.0	10.2	10.2	45.1	5.3	29.6	34.9	10.2	0.0	10.2
2030	16.2	20.6	36.8	0.0	10.8	10.8	47.6	5.4	31.4	36.8	10.8	0.0	10.8
Var % (1990-2008)	2.1%	0.7%	1.2%	-	2.2%	2.2%	1.4%	1.8%	1.1%	1.2 %	2.2%	-	2.2%
Var % (2008-2030)	0.9%	1.0%	1.0%	-	1.0%	1.0%	1.0%	0.5%	1.0%	1.0 %	1.0%	-	1.0%

Source: Author's elaboration based on information from BP

To meet these requirements, it is reasonable to expect that more conservative price scenarios will tend to slow the pace of oil production by non-OPEC producers, which will face increasing costs as new areas are developed, and that OPEC might substitute for this lower relative production. (See Figure 5, Graphic 3.) This means moderately higher market penetration for OPEC, and if OPEC continues with its strategy to maintain profit margins on sales of about 100 percent, oil prices may increase within a range that both groups of producers may desire.[x] (See Figure 7.)

In the EIA reference case, world oil prices begin to rise after 2010 and reach US$130 per barrel in 2030. As a result, liquid fuel consumption is curtailed in countries that have other fuel options available—especially in the electric power sector, where coal and other fuels can be substituted. Worldwide use of liquid fuels for electricity generation falls by 0.8 quadrillion Btu between 2006 and 2030 in the reference case.

Higher market penetration by OPEC producers may increase their exports to the rest of the world and to non-OPEC producers. In this scenario, trade between both groups, including non-oil producing countries, increases at moderate prices, particularly exports to emerging economies.[xi] (See Figure 8 and Table 3.)

1.4 World Natural Gas Resources

Natural gas holds significance as a key substitute for oil products in residential, road transportation, industry, and power generation, having higher efficiencies and lower environmental impact than oil. Unlike in the case of oil, available non-OPEC natural gas resources are double those of OPEC member countries.[xii] (See Table 4.)

Nevertheless, natural gas is also an exhaustible resource and represents only a bridge during the transition to renewable energies that can commercially substitute fossil fuels. The availability of gas resources presents a limiting factor, even though most information revisions indicate that reserves continue to increase.[xiii]

As of early 2009, the world had produced 32 percent of [assumed/estimated?] natural gas resources in existing fields.[xiv] (See Figure 9.) Identified reserves stood at 38 percent, with a probability of recovery near 100 percent provided that the required investments in development and exploitation are realized. Resources to be discovered represented 30 percent of the total, with a typical recovery probability of 5–10 percent depending on the technology, on the Gas-Oil Ratio (GOR) index (if gas is associated with oil production) or if it is free gas, on the depth of gas fields and if they are on-shore or offshore developments, and if productive fields are closer to the Earth's poles.

OPEC controls 33 percent of world gas resources, and the remaining 67 percent is located in a large number of Non-OPEC producers of varying sizes. (See Figure 9.) OPEC has produced 13 percent of its own resources while Non-OPEC countries have produced 41 percent of theirs, incentivized by the successive energy crises that have led to high oil prices, which in turn have stimulated exploration and exploitation in areas that did not previously have good economic prospects. (See Figure 10.) Nevertheless, an estimated 58 percent of identified reserves (as opposed to total, which includes undiscovered), which are mostly proven reserves, are located in OPEC member countries.

This indicates that, over the short and medium term, OPEC has a better capacity to meet future international demand for natural gas. However, OPEC's availability of gas resources brings the cost of immobilized assets, particularly given that the economic rationale of non-OPEC producers is to use the most cost-effective surface technologies, which significantly increases the possibility of converting undiscovered resources into proven reserves.

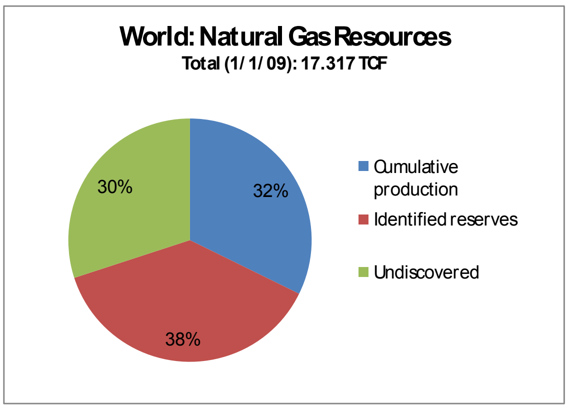
Over the medium term, it is possible that the dominant positions may be diluted and that supply perspectives will be more balanced between the two blocs. The recovery of resources to be discovered will rely on technology at higher prices, as it is more expensive to confirm marginal identified reserves.

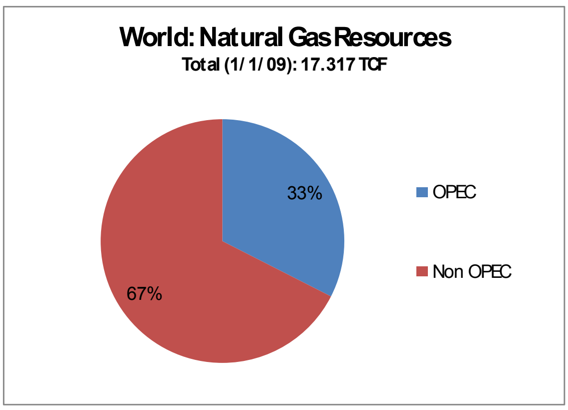
Table 4. Estimated World Natural Gas Resources, 2009

Countries	Cumulative Production	Identified reserves	Original reserves (Cumulative Production plus Identified reserves	Undiscovered Natural Gas	Total Resources (Original Reserves plus Undiscovered Natural Gas
			Trillion cubic feet (10^{12})		
Saudi Arabia	98.4	267.3	365.7	681.0	1046.7
Iran	120.6	1045.7	1166.3	314.6	1480.8
Qatar	51.8	899.3	951.1	41.1	992.2
Algeria	138.4	159.1	297.4	49.0	346.4
Indonesia	122.1	112.5	234.6	107.7	342.3
Nigeria	24.9	184.2	209.1	123.2	332.3
United Arab Emirates	70.4	227.1	297.5	44.5	342.1
Venezuela	59.9	170.9	230.7	101.2	332.0
Iraq	1.8	111.9	113.7	120.0	233.8
Kuwait	20.0	62.9	82.9	5.9	88.8
Libya	17.7	54.4	72.1	21.1	93.2
Other	0.1		0.1		0.1
TOTAL OPEC	**726.1**	**3295.1**	**4021.2**	**1609.4**	**5630.6**
Russian Federation	1006.3	1529.2	2535.5	1168.1	3703.6
United States	1624.4	237.7	1862.1	526.9	2389.0
Canada	351.7	57.7	409.3	24.5	433.9
Norway	104.3	102.7	207.0	183.0	390.0
China	69.7	86.7	156.4	85.8	242.2
Malaysia	75.2	84.3	159.5	50.2	209.7
United Kingdom	165.4	12.1	177.5	23.4	200.9
Mexico	83.5	17.6	101.1	49.3	150.4
Egypt	45.5	76.6	122.2	20.4	142.6
India	42.3	38.5	80.8	30.3	111.1
Oman	19.8	34.6	54.5	33.7	88.2
Other	1273.0	961.0	2234.0	1391.4	3625.4
TOTAL Non-OPEC	**4861.0**	**3238.9**	**8099.8**	**3587.0**	**11686.9**
WORLD	**5587.0**	**6534.0**	**12121.1**	**5196.4**	**17317.4**

Source: Masters et al 1994, BP 2009, USGS 2001

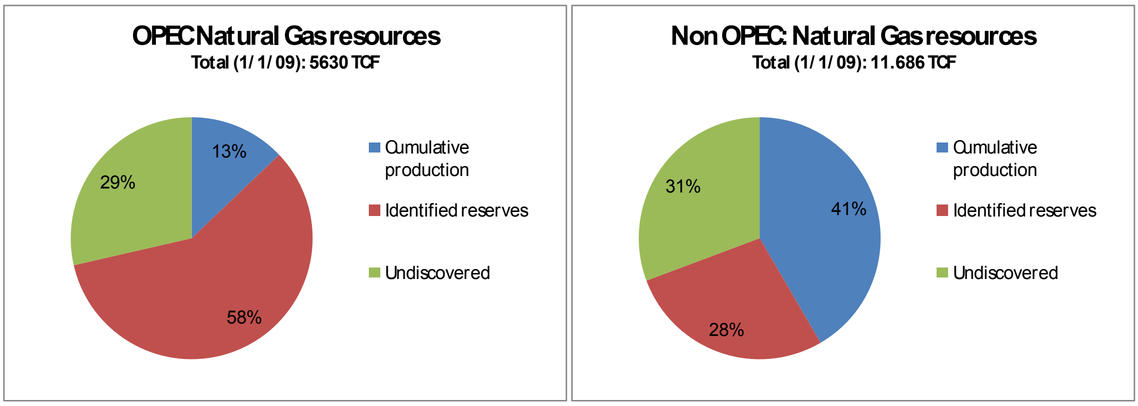
Figure 9. World Natural Gas Resources, 2009





Source: Masters et al 1994, BP 2009, USGS 2001

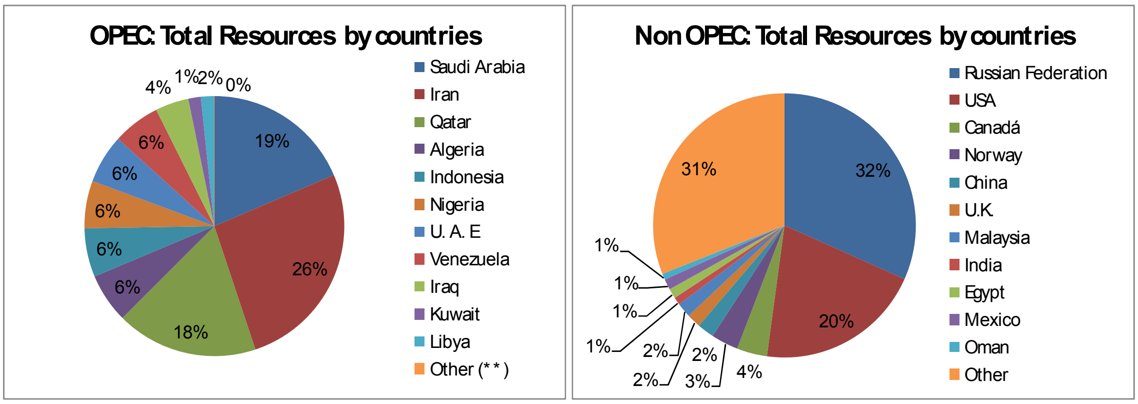
Figure 10. World Natural Gas Demand and Production to 2030



Source: Masters et al 1994, BP 2009, USGS 2001

As of 2009, OPEC had 14 member countries that are natural gas producers.[xv] (See FIgure 11.) Of these, three dominant countries—Saudi Arabia, Iran, and Qatar, all in the Middle East—are home to at least 18 percent of OPEC gas resources. Non-OPEC producers are much more dispersed, with 11 primary producers accounting for 69 percent of production, and a large number of other countries accounting for the remaining 31 percent. The Russian Federation and the United States are home to 52 percent of non-OPEC resources, with the United States being a net importer.

Figure 11. OPEC and Non-OPEC Natural Gas Resources, by Country, 2009



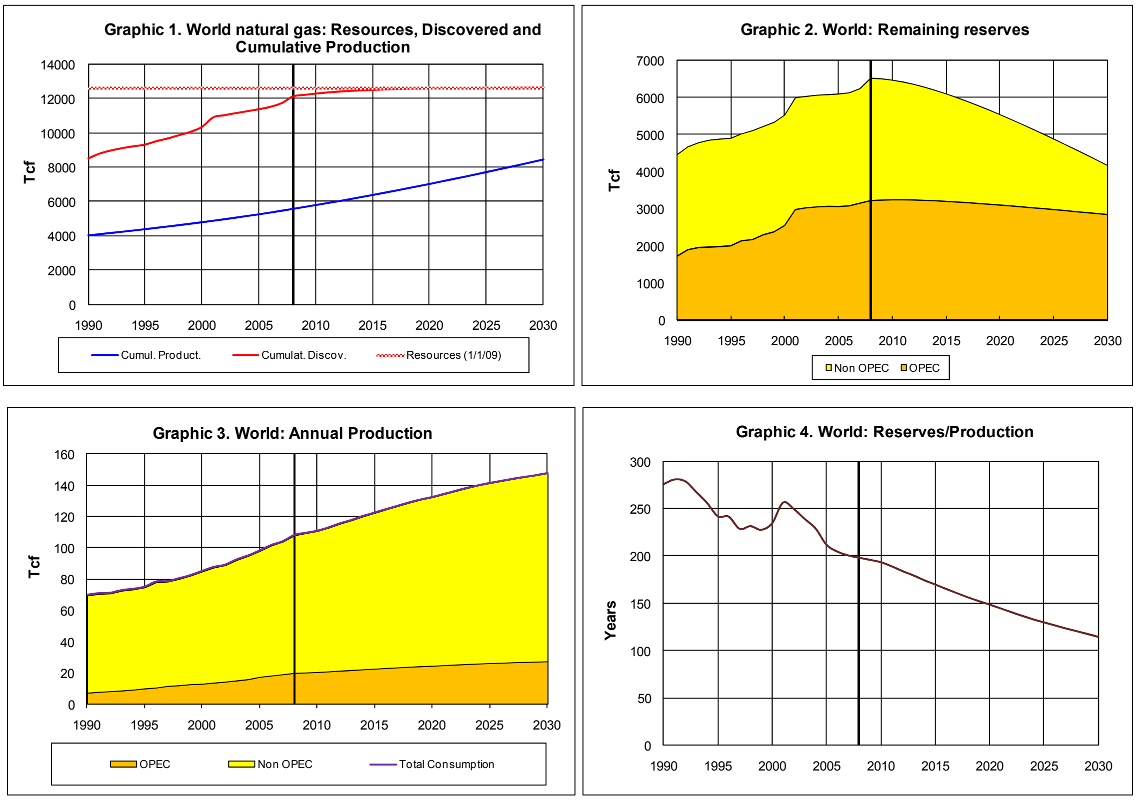
Source: Masters et al 1994, BP 2009, USGS 2001

1.5 World Natural Gas Market in Perspective

Between 1990 and 2008, world natural gas discoveries increased steadily.[xvi] (See Figure 12, Graphic 1.) Investments in natural gas resources were boosted by the long-term increase in crude oil prices on the international market: natural gas became a clear substitute for oil in light of its lower cost. In addition, cumulative natural gas production increased steadily because of rising demand from industrialized countries as well as several emergent economies that need to import gas by pipeline or from overseas as liquid natural gas (LNG) to meet domestic demand.

The difference between the cumulative production and discovery curves (see Figure 12, Graphic 1) is in the volume of remaining reserves, which appear to have peaked in 2008 (2011 in OPEC countries and 2008 in Non-OPEC countries). With the production required to meet world natural gas demand growing at 1.8 percent to 2030 (see Table 1), remaining reserves in gas fields under exploitation (both in operation and new) will decline, exhausting resources for both OPEC and non-OPEC producers (see Table 4).

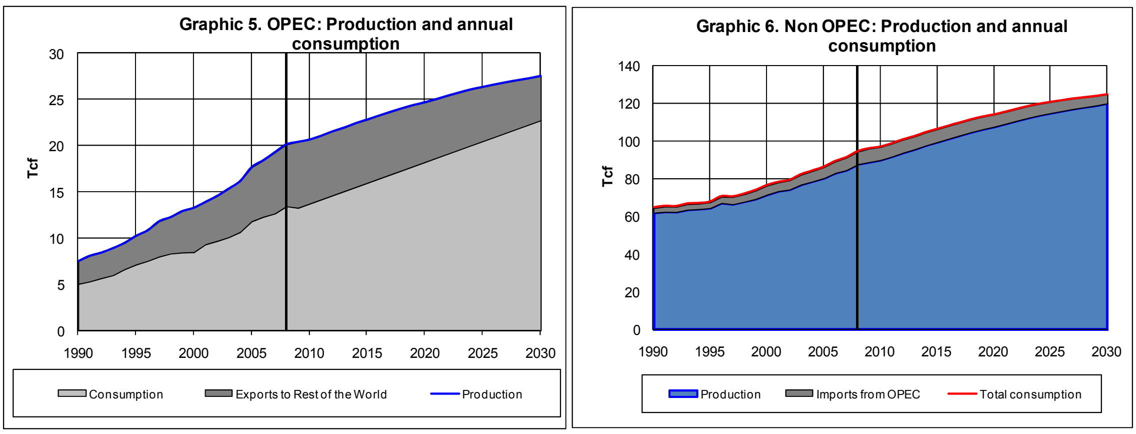
Figure 12. World Natural Gas Reserves and Production, 1990–2030



Source: Author's elaboration based on information from USGS and BP

Whereas OPEC gas consumption is projected to grow to 2030 according to historical trends (2.4 percent), Non-OPEC consumption will grow at almost half this rate (1.3 percent), particularly in OECD countries that may diversify their supply sources, but from a much higher base.[xvii] (See Figure 13, Graphics 5 and 6.)

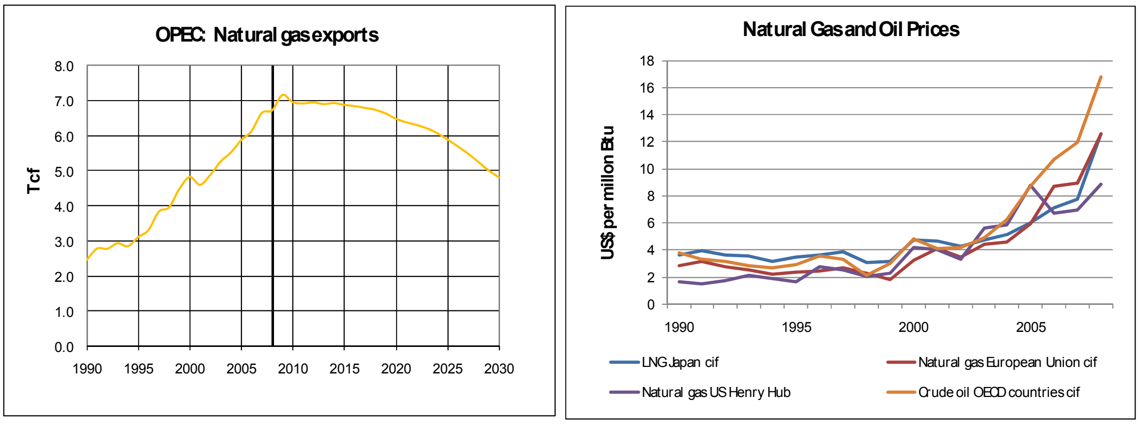
Figure 13. World Natural Gas Production and Consumption, 1990–2030



Source: Authors' elaboration based on information from USGS and BP

Market share of OPEC countries has increased from 10.8 percent in 1990 to 18.7 percent in 2008 while the non-OPEC share diminished from 89.2 percent to 81.3 percent over the same period. Nevertheless, in light of gas resource distribution, this penetration may stay constant because of increasing demands from OPEC countries that might be stimulated to inject more oil in the international market. On the other hand, non-OPEC producers may consider an increase in domestic production to reduce dependence on oil imports from OPEC.[xviii] (See Figure 14 and Table 5.)

Figure 14. World Natural Gas Exports and Price Comparison with Oil, 1990–2030



Source: Author's elaboration based on information from BP and ENERINTER

Prices for natural gas transported by pipeline in 2008 were below those for LNG in Japan and roughly equivalent to those in the European Union.[xix] In all these cases, 2008 gas prices are below those for crude oil in OECD countries.[xx] (See Figure 14.)

Table 5. World Natural Gas Balance, 1990–2030

Year	Supply							Demand					
	Production			Imports			Total	Consumption			Exports		
	OPEC	Non-OPEC	Total	OPEC	Non-OPEC	Total		OPEC	Non-OPEC	Total	OPEC	Non-OPEC	Total
	Trillion cubic feet												
1990	7.5	62.1	69.6	0.0	2.5	2.5	71.7	5.0	64.2	69.2	2.5	0.0	2.5
1991	8.1	62.6	70.7	0.0	2.8	2.8	73.5	5.3	65.4	70.7	2.8	0.0	2.8
1992	8.4	62.5	70.9	0.0	2.8	2.8	73.7	5.7	65.2	70.9	2.8	0.0	2.8
1993	8.9	63.7	72.6	0.0	2.9	2.9	75.5	6.0	66.5	72.5	2.9	0.0	2.9
1994	9.5	64.0	73.5	0.0	2.9	2.9	75.7	6.6	66.3	72.9	2.9	0.0	2.9
1995	10.3	64.6	74.8	0.0	3.1	3.1	78.4	7.1	68.1	75.3	3.1	0.0	3.1
1996	10.9	67.3	78.1	0.0	3.3	3.3	82.2	7.5	71.3	78.9	3.3	0.0	3.3
1997	11.8	66.6	78.5	0.0	3.8	3.8	82.7	8.0	70.9	78.9	3.8	0.0	3.8
1998	12.3	68.0	80.3	0.0	4.0	4.0	84.1	8.3	71.8	80.1	4.0	0.0	4.0
1999	12.9	69.4	82.3	0.0	4.5	4.5	86.5	8.5	73.6	82.0	4.5	0.0	4.5
2000	13.3	71.7	85.0	0.0	4.8	4.8	90.2	8.5	76.9	85.4	4.8	0.0	4.8
2001	13.9	73.6	87.5	0.0	4.6	4.6	91.2	9.3	77.3	86.6	4.6	0.0	4.6
2002	14.6	74.4	89.0	0.0	4.9	4.9	94.2	9.7	79.6	89.3	4.9	0.0	4.9
2003	15.4	77.0	92.4	0.0	5.3	5.3	96.9	10.1	81.6	91.7	5.3	0.0	5.3
2004	16.2	78.7	94.9	0.0	5.5	5.5	100.0	10.7	83.9	94.5	5.5	0.0	5.5
2005	17.7	80.4	98.1	0.0	5.9	5.9	103.7	11.8	86.0	97.8	5.9	0.0	5.9
2006	18.4	83.1	101.6	0.0	6.1	6.1	106.5	12.3	88.1	100.4	6.1	0.0	6.1
2007	19.3	84.7	104.0	0.0	6.6	6.6	110.4	12.7	91.1	103.8	6.6	0.0	6.6
2008	20.2	87.8	108.0	0.0	6.7	6.7	113.0	13.5	92.9	106.3	6.7	0.0	6.7
2009	20.4	89.0	109.4	0.0	7.1	7.1	116.5	13.3	96.1	109.4	7.1	0.0	7.1
2010	20.7	90.0	110.7	0.0	6.9	6.9	117.7	13.7	97.0	110.7	6.9	0.0	6.9
2015	22.9	99.5	122.4	0.0	6.9	6.9	129.3	16.0	106.4	122.4	6.9	0.0	6.9
2020	24.7	107.7	132.4	0.0	6.5	6.5	138.9	18.3	114.1	132.4	6.5	0.0	6.5
2025	26.4	115.0	141.4	0.0	5.9	5.9	147.3	20.5	120.8	141.4	5.9	0.0	5.9
2030	27.6	120.1	147.7	0.0	4.8	4.8	152.5	22.8	124.9	147.7	4.8	0.0	4.8
Var % (1990-2008)	5.6%	1.9%	2.5%	-	5.7%	5.7%	2.6%	5.6%	2.1%	2.4%	5.7%	-	5.7%
Var % (2008-2030)	1.4%	1.4%	1.4%	-	-1.5%	-1.5%	1.4%	2.4%	1.4%	1.5%	-1.5%	-	-1.5%

Source: Author's preparation based on information from USGS and BP

1.6 LNG Trade

World gas liquefaction capacity in 2008 was about 31 billion cubic feet per day (bcfd), and it is expected that LNG production capacity will increase to 43 bcfd by 2012 and 72 bcfd by 2017.[xxi] Re-gasification capacity, meanwhile, totaled 70 bcfd in 2008 and is expected to rise to 98 bcfd in 2012 and 133 bcfd in 2017, suggesting that there may not be enough LNG to be regasified. Some nine new re-gasification terminals are planned along the Atlantic Coast of the Americas, some starting in 2009, based on existing projects in Canada, Brazil, and Argentina.

World demand for natural gas is projected to grow 1.4 percent between 2008 and 2030.[xxii] This increase is associated with liquefaction and re-gasification of LNG to complement national gas production and imports by pipeline.

In 2008, world trade in LNG reached 227 billion cubic meters, compared to an estimated 550 billion cubic meters traded by pipelines.[xxiii] (See Table 6.) Thus, LNG represented about 29 percent of international natural gas commerce that year. LNG supplies are settled by long-term contracts.

Table 6. Principal Trade in Liquefied Natural Gas, 2008

To	From: Trinidad & Tobago	Oman	Qatar	UAE	Algeria	Egypt	Nigeria	Australia	Brunei	Indonesia	Malaysia	TOTAL IMP
	Billion cubic metres											
North America												
United States	7.47		0.09			1.56	0.34					**9.94**
Mexico	1.28		0.09			1.12	1.04					**3.61**
South & Central America												
Argentina	0.33					0.08						**0.41**
Dominican Republic	0.47											**0.47**
Puerto Rico	0.81											**0.81**
Europe												
Belgium	0.08		2.65			0.08						**2.49**
France	0.08				7.6	1.06	3.6					**12.59**
Greece	0.08				0.7	0.16						**0.94**
Italy					1.56							**1.56**
Portugal							2.58					**2.63**
Spain	4.32	0.17	5.12		4.9	4.91	7.47					**28.73**
Turkey					4.25	0.08	0.98					**5.31**
United Kingdom	0.47		0.12		0.37	0.08						**1.04**
Asia & Pacific												
China					0.17	0.25	0.24	3.61			0.01	**4.44**
India	0.24	0.35	7.98	0.13	0.65	0.26	0.41	0.16				**10.79**
Japan	0.67	4.25	10.91	7.41	1.12	2.21	2.36	15.94	8.22	18.79	17.47	**92.13**
South Korea	0.84	6.04	11.62		0.47	2.13	0.16	0.53	0.98	4.06	8.31	**36.55**
Taiwan	0.22	0.09	1.1		0.08	0.08	1.36			4	3.61	**12.07**
TOTAL EXP	**17.36**	**10.9**	**39.68**	**7.54**	**21.87**	**14.06**	**20.54**	**20.24**	**9.2**	**26.85**	**29.4**	**226.51**

Source: BP Statistical Review of World Energy, 2009

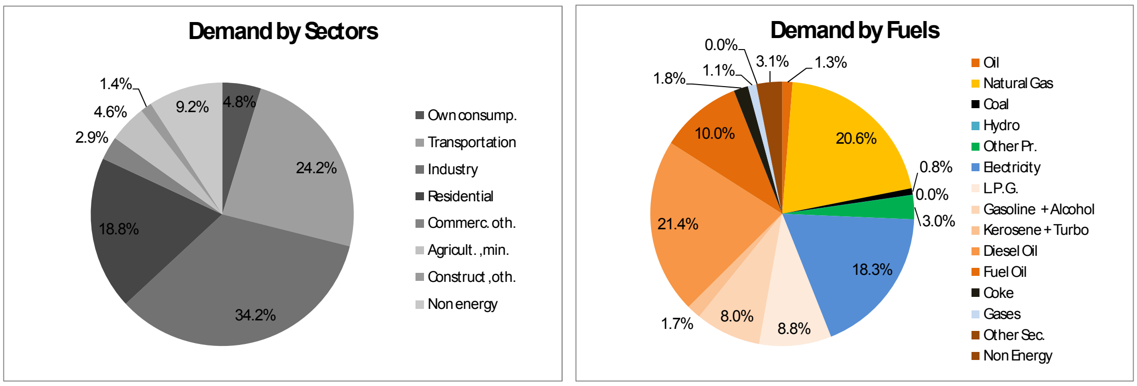
The LNG reference price (Japan) in 2008 was US$12.55 per million Btu, a 13-percent annual increase over 2000. The increase in both liquefaction and re-gasification capacity is attributed to rising natural gas demand and the decline of reserves in countries with lower resources and possible import restrictions by pipelines.

2. Energy Demand Scenarios for Egypt

2.1 Energy Consumption

Egypt's energy balance for 2007 indicates that the largest share of final energy consumption occurs in the industrial sector (34.2 percent), followed by transportation (24.2 percent), residential (18.8 percent), and agriculture and mining (4.7 percent)—together accounting for 81.9 percent of total consumption.[xxiv] (See Figure 15.) By fuel type, oil products account for more than half of fuel consumption (54.1 percent), followed by natural gas (20.6 percent), and electricity (18.3 percent)—together comprising 93 percent of total demand. The remainder is non-energy use.

Figure 15. Share of Egypt's Total Energy Consumption, by Sector and Fuel Type, 2007

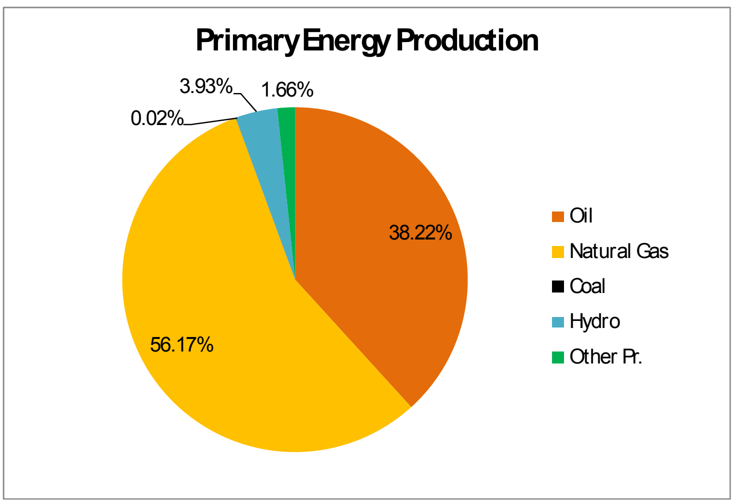


Source: Author's analysis based on data from IEA, 2009

Energy transformation for the internal market occurs mainly via oil-refining activities, natural gas treatment, and power generation (hydro and thermal).

Natural gas (56.2 percent) and oil (38.2 percent) account for the bulk of primary energy supply, representing 94.4 percent of the total.[xxv] (See Figure 16.) The rest is mainly electricity, generated with hydropower (3.9 percent, according to IEA methodology) and other primary sources (1.7 percent).

Figure 16. Share of Egypt's Total Primary Energy Production, by Source, 2007



Source: Author's analysis based on data from IEA, 2009, BP 2009

Table 7, which shows Egypt's energy balance, provides greater detail about the supply and demand flows passing through the country's energy transformation centers.[xxvi] The table shows the interactions between different components of energy demand by fuels with the primary energy offer.

Table 7. Egypt's Energy Balance, 2007

	Oil	Natural Gas	Coal	Hydro	Other Pr.	Total Primary	Electricity	LPG	Gasoline + Alcohol	Kerosene + Turbo	Diesel Oil	Fuel Oil	Coke	Gases	*Other Sec.*	Non Energy	Total Secondary	TOTAL
	Ktoe																	
Production	34,112	50,123	15	3510	1,482	**89,242**	10,762	2,139	4,384	2,699	9,083	10,858	882	533	2,779	1,591	**45,709**	**82,242**
Import	2,446		1,202			**3,648**	22	2,128			1,915					11	**4,075**	**7,723**
Export	2,205	13,556	349			**16,110**	70		366	1,830	166	1,308			2,779	33	**6,552**	**22,662**
Stock changes	-670					**-670**		165									**165**	**-506**
Unused	0	6,811				**6,811**											**0**	**6,811**
Total suply	**33,683**	**29,756**	**868**	**3,510**	**1,482**	**69,299**	**10,714**	**4,431**	**4,018**	**869**	**10,832**	**9,550**	**882**	**533**	**0**	**1,569**	**43,397**	**112,696**
Refinery	-33,052					**-33,052**		655	4,384	2,699	9,083	10,858	423	533	2,779	1,591	**33,004**	**-48**
Power plants		-17,944		-3510		**-21,454**	10,762				-107	-4,523					**10,762**	**-15,322**
Gas plants		-1,484				**-1,484**		1,484									**1,484**	**0**
Coke plants			-459			**-459**							459				**459**	**0**
Other centers						**0**											**0**	**0**
Total transformation	**-33,052**	**-19,428**	**-459**	**-3510**		**-56,449**	**0**	**0**	**0**	**0**	**-107**	**-4,523**	**0**	**0**	**0**	**0**	**45,709**	**-15,370**
Own consumption	631					**631**				142	470	147	459	533			**1,751**	**2,382**
Losses							1,546										**1,546**	**1,546**
Adjustment	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**
Transportation		301				**301**		0	4,018	573	6,730	471					**11,792**	**12,093**
Industry		6,699	409		756	**7,864**	3,186	27	0	39	1,655	4,349					**9,257**	**17,121**
Residential		737			726	**1,463**	3,463	4,403	0	105	0	0					**7,971**	**9,434**
Commerc., other						**0**	1,447										**1,447**	**1,447**
Agricult. , mining						**0**	362	0	0	10	1,869	60					**2,301**	**2,301**
Construction, other						**0**	709										**709**	**709**
Energy consumption	**0**	**7,737**	**409**	**0**	**1,482**	**9,628**	**9,167**	**4,431**	**4,018**	**727**	**10,254**	**4,880**	**0**	**0**	**0**	**0**	**33,900**	**43,528**
Non energy		2,590				**2,590**							423			1,569	**1,992**	**4,582**
Final consumption	**0**	**10,327**	**409**	**0**	**1,482**	**12,218**	**9,167**	**4,431**	**4,018**	**727**	**10,254**	**4,880**	**423**	**0**	**0**	**1,569**	**35,469**	**47.687**

Source: Author's elaboration based on data from IEA, 2009 and BP, 2009

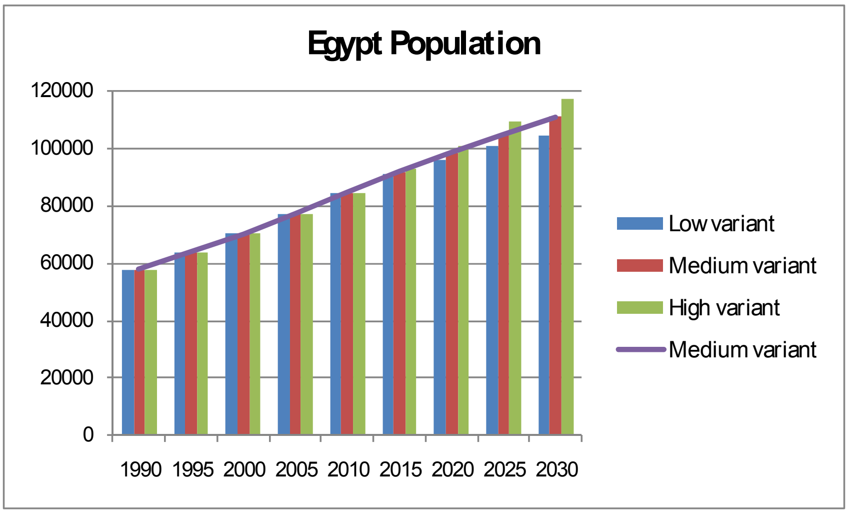
2.2 Drivers of Energy Demand

Several major factors are contributing to the rapid growth in Egypt's energy demand, including population growth, economic growth, and increased motorization. These trends must be considered to understand the present and future dynamics of Egypt's energy economy.

2.2.1 Population

Egypt was home to 81.4 million people in 2008 and is the most populous country in the Arabic Region. The population increased at a relatively high rate of 1.9 percent during the 1990–2008 period but the growth rate is expected to slow in the future, at a rate of 1.56 percent for 2008–2030.[xxvii] (See Figure 17.)

Figure 17. Historic and Future Population Trends in Egypt, 1990–2030



Source: UNdata, United Nations, 2009

The 2007 United Nations Human Development Index (HDI) ranks Egypt 123rd out of 182 countries, with a score of 0.703 on a scale of 0 to 1.[xxviii] The HDI considers such indicators as life expectancy at birth (about 70 years for Egypt), the share of adults above 15 years old (66.4 percent), and per-capita GDP (US$5,349 in PPA-2007). Based on GDP alone, however, Egypt ranks higher (at 103), suggesting that increases in the country's economic resources do not necessarily translate into improvements in health and education.

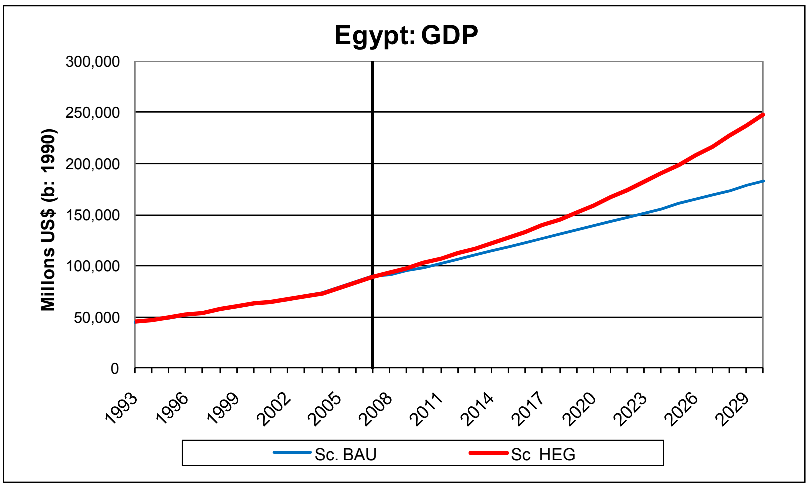
According to World Bank estimates, Egypt's per capita GDP was US$5,349 in 2007 and US$5,460 in 2008, measured in purchasing power parity (PPP).[xxix] The difference illustrates the implicit inflation of the U.S. dollar and the mix of goods and services and their respective prices on the internal market. This places Egypt in a middle position internationally in terms of purchasing power of income.

2.2.2 Economic Development

Egypt's GDP showed a real increase of 5.0 percent annually during 1993–99, which was similar to the average growth rate of 5.2 percent annually during 2000–07. Real per capita growth has been positive throughout the last two decades.

The present study considers two future economic growth scenarios.[xxx] (See Figure 18.) The first, a business-as-usual (BAU) scenario for GDP in 2007–30, assumes an increase of 3.1 percent per year, or roughly half the per capita GDP growth of the past. This scenario also assumes that Egypt will pull out of the current economic crisis relatively slowly. In contrast, the alternative, high economic growth (HEG) scenario assumes that the economy continues to grow dynamically, at an average annual rate of 4.5 percent, on the basis that Egypt will implement important investments in economic and social infrastructure that stimulate the internal market for goods and services and for the domestic labor force.

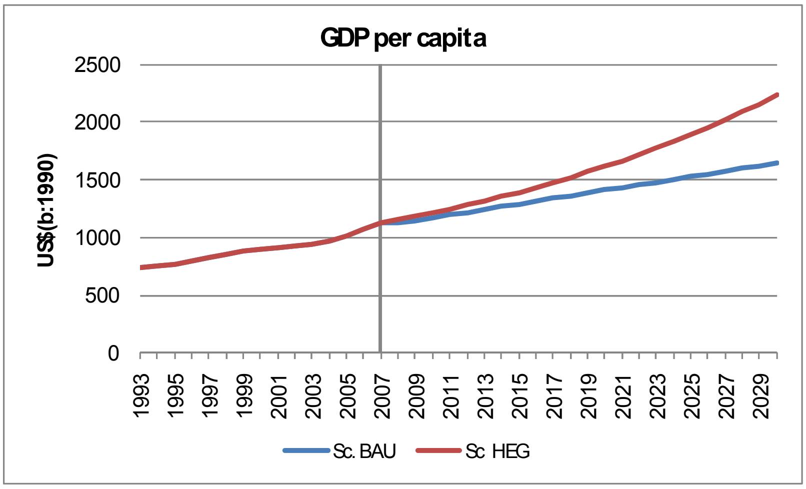
Figure 18. Egypt's GDP Growth, Two Scenarios, 1993–2030



Source: Author's analysis based on data from UNdata, United Nations, 2009

Egypt's real per capita income base (in 1990 dollars) grew 3.1 percent between 1993 and 2007.[xxxi] The BAU scenario results in real per capita growth of 1.7 percent annually from 2007 to 2030, while the HEG scenario results in a 3.0 percent rate, following the historical trend.[xxxii] (See Figure 19.)

Figure 19. Egypt's Real Per Capita GDP, 1993–2030



Source: Author's analysis based on data from UNdata, United Nations, 2009

Table 8 shows the contribution to GDP by economic sector, which has historically been dominated by "Agricultural, Other, and Mining."[xxxiii] In the period 1993–2007, however, "Industry" represented the main source of Egypt's economic growth.

It is assumed that economic growth by sector will show no significant change to 2030, with a modest increase in agriculture and mining, a slight reduction in commerce and construction growth, and higher growth in industry. Nevertheless, there will be an increase in economic activity in all sectors in terms of real GDP growth.

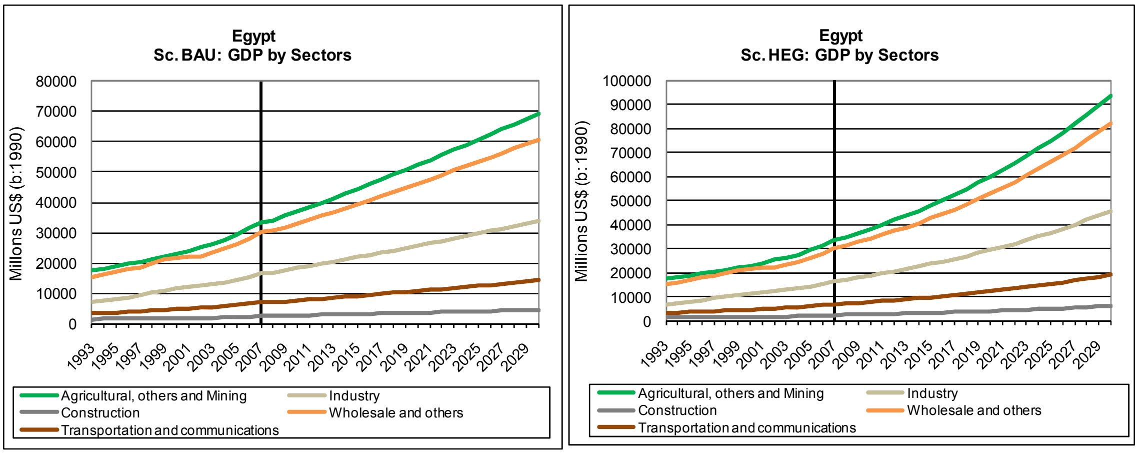
Table 8. Egypt's GDP and Gross Value Added, by Sector, 1993–2007

Years	Gross Value Added by Sector (%)					GDP	
	Agriculture, Others and Mining	Industry	Construction	Trade and other commercial	Transport, Communications	Million US$ (b: 1990)	Annual %
1993	39.0%	15.7%	3.5%	33.9%	7.9%	44979	3.95%
1994	38.6%	16.1%	3.5%	34.2%	7.6%	47029	4.56%
1995	38.1%	16.4%	3.5%	34.4%	7.6%	49436	5.12%
1996	38.0%	16.8%	3.0%	34.5%	7.6%	52151	5.49%
1997	37.4%	17.4%	3.2%	34.4%	7.6%	54249	4.02%
1998	37.2%	17.9%	3.2%	34.2%	7.5%	57564	6.11%
1999	36.6%	18.2%	3.0%	34.8%	7.4%	60663	5.38%
2000	36.6%	18.4%	3.0%	34.4%	7.6%	62801	3.52%
2001	36.7%	18.5%	3.0%	34.3%	7.5%	64801	3.19%
2002	37.8%	18.5%	2.8%	33.0%	7.9%	67478	4.13%
2003	37.5%	18.4%	2.7%	33.5%	7.9%	70258	4.12%
2004	37.3%	18.5%	2.8%	33.6%	7.7%	73436	4.52%
2005	37.5%	18.5%	2.8%	33.4%	7.8%	78462	6.84%
2006	37.4%	18.5%	2.8%	33.5%	7.8%	84023	7.09%
2007	37.4%	18.5%	2.8%	33.5%	7.8%	89890	6.98%

Source: Author's elaboration based on data from UNdata, United Nations, 2009

The inertial BAU scenario maintains historical trends and shows little adjustment in the sectoral structure of growth.[xxxiv] (See Figure 20.) The HEG scenario, in contrast, shows a possible 4.5 percent annual increase in GDP to 2030, based on higher investment in infrastructure and energy by both the government and private sector.

Figure 20. Egypt's Economic Growth by Sector, 1993–2030



Source: Author's analysis based on data from UNdata, United Nations, 2009

2.3 Methodology and Strategic Assumptions for Energy Demand Scenarios

The above analysis of future energy development in Egypt uses a straightforward, quantitative model, which is described in more detail in Annex II. The model starts from an energy balance for the base year 2007. For each future year, final energy consumption estimates are generated in the various sectors. For the supply of the total final demand, the domestic transformation (mainly electricity and petroleum products) is elaborated, including transmission and other losses, which allows for a calculation of the primary energy (PE) domestic supply. The PE balance, including imports and exports and domestic production, is calculated from this domestic PE supply.

A scenario analysis was carried out to study the impacts of potential energy development and different policies on Egypt's oil and gas reserves. This resulted in three scenarios, which are intended not to predict the future but rather to analyze "what if." The three secnarios are:

- **BAU (business-as-usual).** An inertial scenario that assumes a linear growth trend and little structural change.
- **HEG (high economic growth).** Assumes dynamic growth but little change in energy structure and policy. The difference in consumption between the BAU and HEG scenarios is due almost exclusively to varying assumptions about the principle drivers.
- **S&E (substitution and efficiency).** This scenario departs from the HEG scenario and assumes a substitution of energy sources in the consumption and transformation sectors due to a different and more vigorous energy policy, including the implementation of energy efficiency and more renewable energy, as is already in the pipeline.

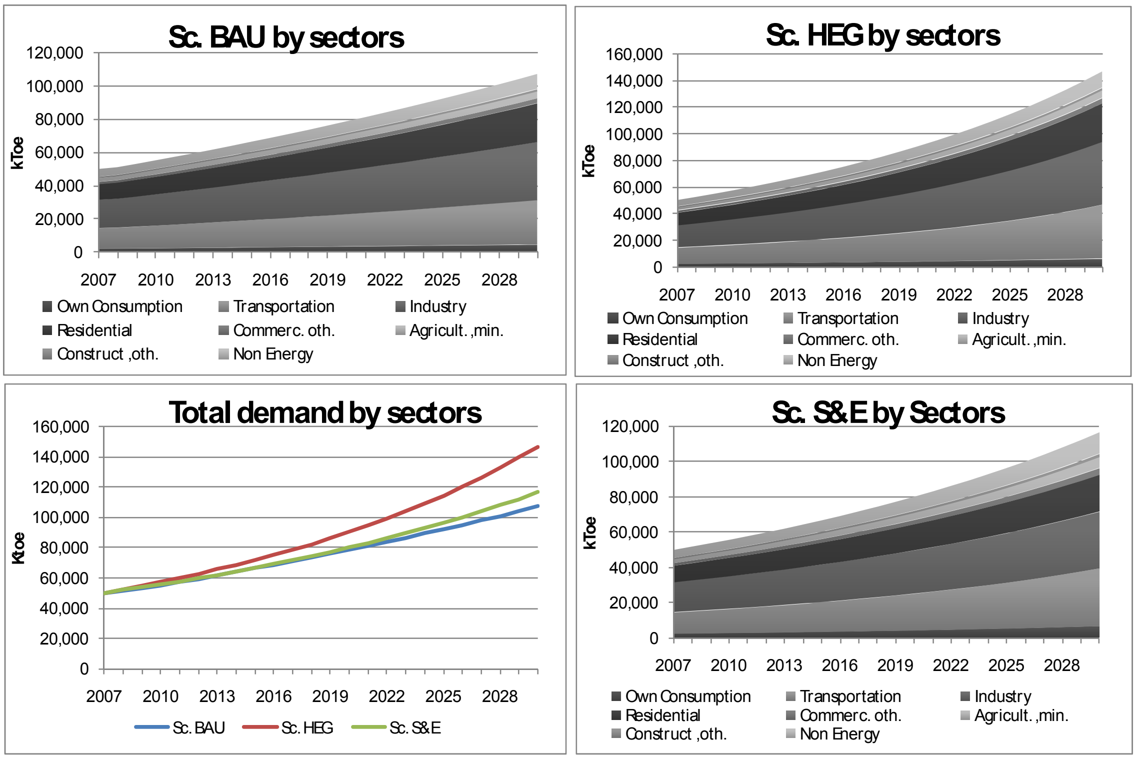
These three scenarios allow for strategic comparison and analysis of the effects of growth, as well as the possible impacts of policies.

2.4 Energy Demand Under Three Scenarios

2.4.1 Final Energy Demand

Figure 21 illustrates Egypt's final energy demand by sector, as well as the energy sector's own consumption for transformation and distribution, under the three scenarios.[xxxv] The BAU scenario results in an annual increase in energy demand of 3.4 percent, and the HEG scenario shows an annual increase of 4.8 percent. The S&E scenario shows growth at 3.7 percent, due to differing assumptions.

Figure 21. Egypt's Energy Demand, by Scenario and Sector, 2007–30



Source: Author's analysis

In all three scenarios, the dominant energy-consuming sectors continue to be industry, transportation, and residential, with industry and residential having a smaller share in the S&E scenario due to greater efficiency and use of decentralized renewable energy.[xxxvi] (See Table 9.)

Table 9. Egypt's Energy Consumption by Sector, 2007 and Three Scenarios for 2030

Sectors	2007	2030		
		BAU	HEG	S&E
Industry	34%	33%	32%	28%
Transportation	24%	25%	27%	28%
Residential	19%	22%	20%	18%
Other	23%	20%	21%	26%

Source: Author's analysis

In 2007, oil products accounted for 54 percent of Egypt's final energy consumption, whereas in 2030 this share declines in all three scenarios.[xxxvii] (See Table 10.) In all three scenarios, natural gas and electricity gain a higher share in final demand.

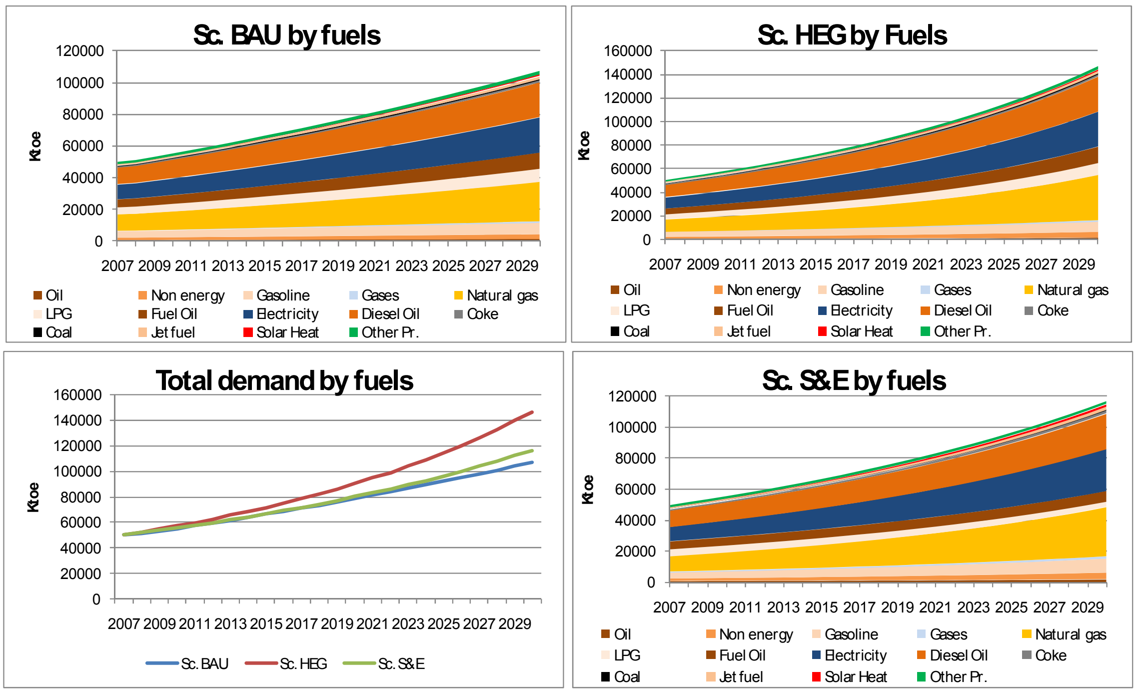
Table 10. Egypt's Energy Consumption by Fuel Type, 2007 and Three Scenarios for 2030

Fuel Type	2007	2030		
		BAU	HEG	S&E
Oil products	54.1%	49.9%	48.3%	42.9%
Natural gas	20.6%	23.1%	26.0%	27.4%
Electricity	18.3%	20.8%	20.0%	23.4%
Other	7.0%	6.2%	5.7%	6.3%

Source: Author's analysis

Among oil products, the shares of diesel, fuel oil, gasoline, and LPG and others do not change significantly over time in the BAU and HEG scenarios. In the S&E scenario, however, the share of LPG decreases in absolute terms and fuel oil and diesel decline in relative terms.[xxxviii] (See Figure 22.)

Figure 22. Egypt's Energy Demand, by Scenario and Fuel Type, 2007–30

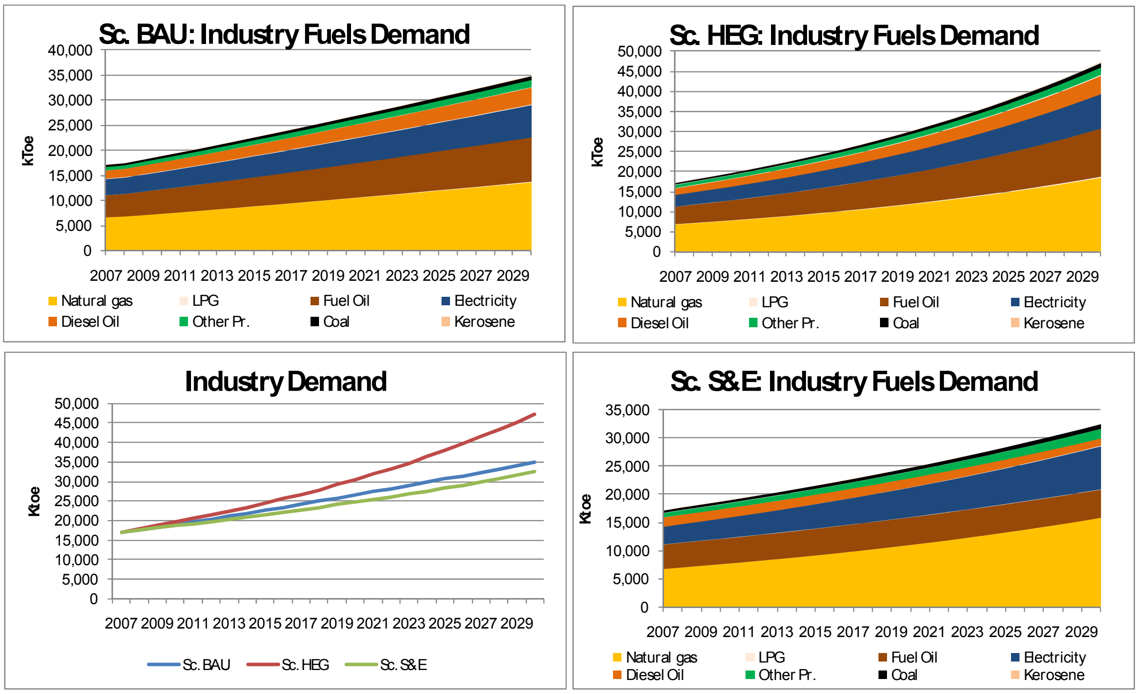


Source: Author's analysis

2.4.1.1 Industry Sector

The industry sector accounted for 34 percent of Egypt's final energy demand in 2007. Annual demand in the sector is projected to increase 3.2 percent in the BAU scenario (to 34.9 mtoe) and 4.4 percent in the HEG scenario (to 47.3 mtoe), up from 17.1 mtoe in 2007.[xxxix] (See Figure 23.) As a result, industrial energy consumption would more than double.

Figure 23. Energy Demand in Egypt's Industry Sector, by Scenario and Fuel Type, 2007–30



Source: Author's analysis

Under the S&E scenario, in contrast, consumption growth is much lower (2.8 percent per year), at 32.4 mtoe, and even smaller than that under the BAU scenario. Thus, the same value added under the HEG scenario could be achieved with approximately 25 percent less energy.

Industry consumes the broadest energy mix as compared with other sectors. The sector's fuel demand structure is 36 percent oil products, 40 percent natural gas, 19 percent electricity, and 5 percent other fuels. These shares remain the same in the BAU and HEG scenarios, whereas In the S&E scenario the mix is 25 percent oil products, 49 percent natural gas, 24 percent electricity, and 3 percent other fuels.

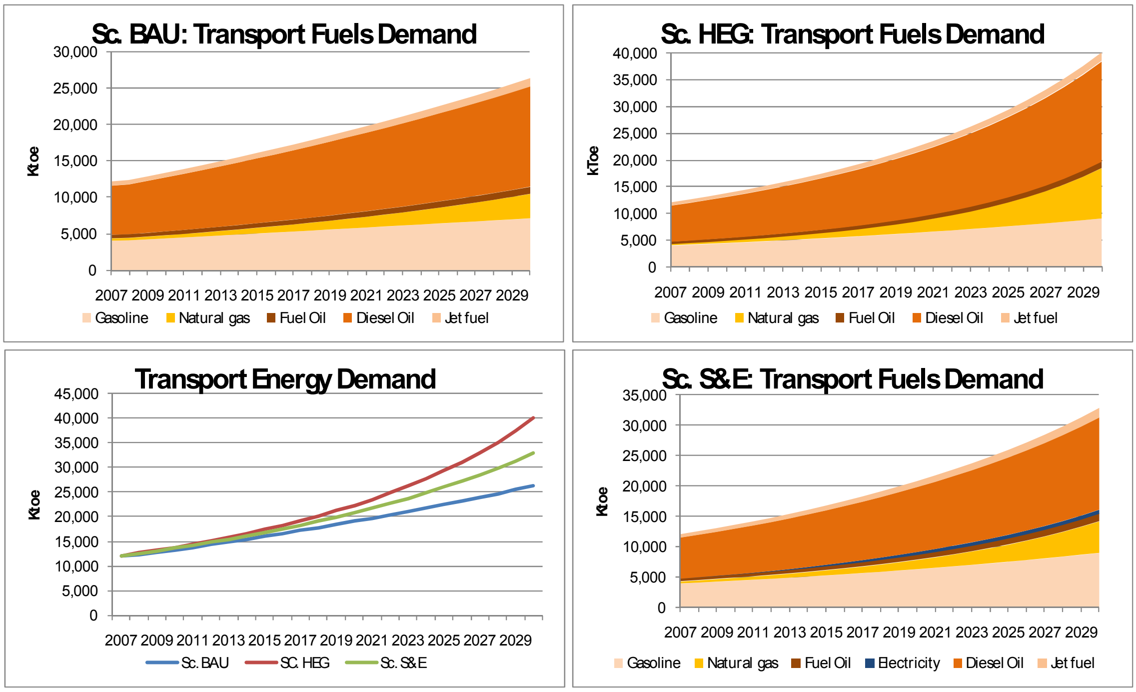
2.4.1.2 Transport Sector

The transport sector accounted for 24 percent of Egypt's final energy demand in 2007. Annual demand in the sector is projected to increase 3.5 percent in the BAU scenario, 5.3 percent in the HEG scenario, and 4.4 percent in the S&E scenario.[xl] (See Figure 24.) In all three scenarios, these growth rates are higher than those in the industry sector.

In the S&E scenario, energy consumption by the transport sector in 2030 exceeds that of industry, at 32.8 mtoe. It might increase to 26.4 mtoe in the BAU scenario and 40.0 mtoe in the HEG scenario. In 2007, transportation required 12.1 mtoe, so consumption is expected to double or triple depending on economic growth. Efficiency could reduce projected consumption by almost 20 percent in 2030.

The transportation sector consumes a larger share of oil products than all others, with oil products meeting 97.5 of the demand and natural gas the remainder. (Note that the energy balance does not include electricity in this sector; both the Cairo metro and tram usage appear to be registered in the public sector. This structure remains the same in both the BAU and HEG scenarios.) The share of diesel oil (55.7 percent) is higher than that of gasoline (33.2 percent). This relationship and dominance remains, although natural gas (CNG) gains importance in all scenarios, reaching over 15 percent in the S&E case.

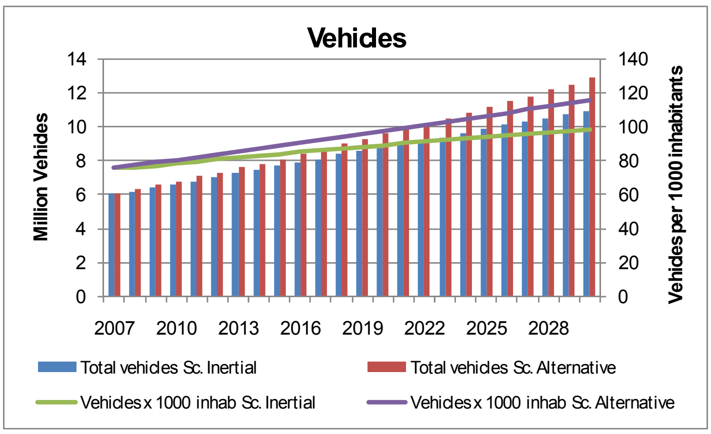
Figure 24. Energy Demand in Egypt's Transportation Sector, by Scenario and Fuel Type, 2007–30



Source: Author's analysis

Egypt's total vehicle fleet neared 6 million units in 2007, including automobiles, light and heavy trucks, motorcycles, and other. There was no information available by type of vehicle or by vehicle engine type, age, average usage, and efficiency. Because of air pollution concerns, Egypt has introduced a policy to use natural gas vehicles for taxis, an initiative that would be intensified under the S&E scenario.

Figure 25. Egypt's Motor Vehicle Fleet, 2007–30



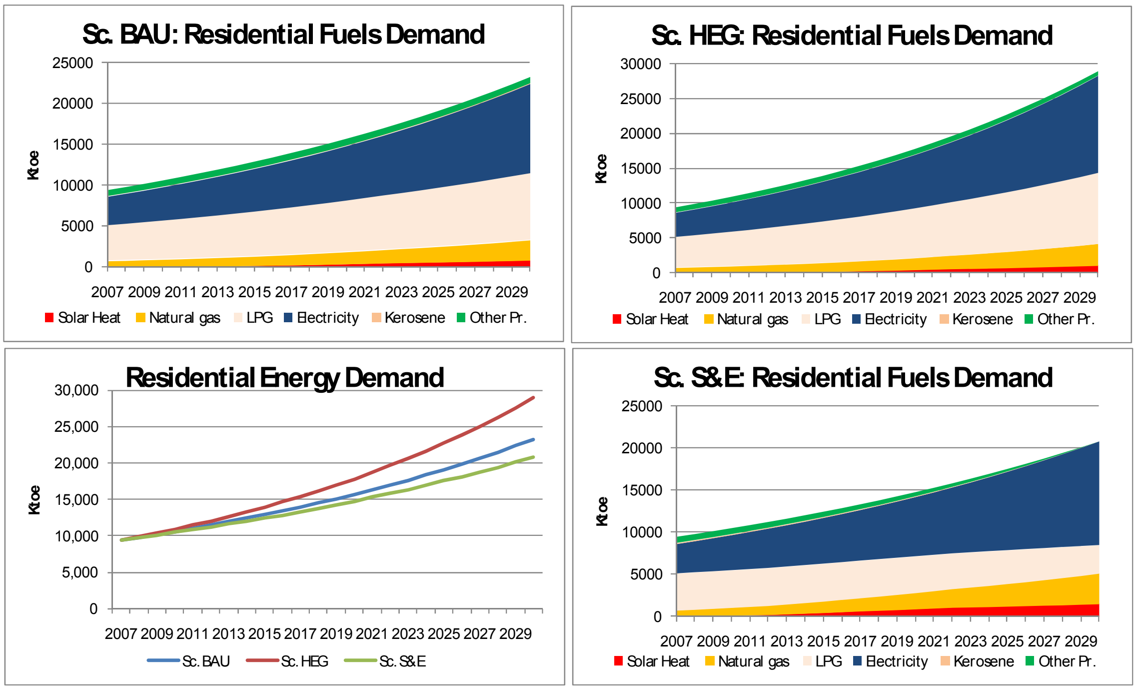
Source: Author's analysis

Total vehicle numbers are projected to increase to 10.9 million units by 2030 in the BAU scenario and to 12.9 million in the HEG scenario, rising alongside per capita GDP. Elasticity will decline as GDP grows, following trends observed globally by countries with different relative economic development.[xli] (See Figure 25.) The number of vehicles per 1,000 inhabitants is expected to rise to 98 in the BAU scenario and 116 in the HEG scenario, up from 76 in 2007.

2.4.1.3 Residential Sector

The residential sector accounted for 19 percent of Egypt's final energy demand in 2007. Annual demand in the sector is projected to increase 4.0 percent in the BAU scenario, 5.0 percent in the HEG scenario, and 3.5 percent in the S&E scenario.[xlii] (See Figure 26.)

Figure 26. Energy Demand in Egypt's Residential Sector, by Scenario and Fuel Type, 2007–30



Source: Author's analysis

This results in residential energy consumption by 2030 of 23.2 mtoe in the BAU scenario, 28.9 mtoe in the HEG scenario, and 20.8 mtoe in the S&E scenario, compared with 9.4 mtoe in 2007. Again, the S&E scenario shows a reduction of approximately 28 percent compared to the HEG scenario; If only fuels and electricity are counted, the "savings" in the S&E case is more than 33 percent.

Table 11. Energy Consumption in Egypt's Residential Sector by Fuel Type, 2007 and Three Scenarios for 2030

Fuel	2007	2030		
		BAU	HEG	S&E
Oil products	51.8%	39.1%	37.8%	16.2%
Natural Gas	8.5%	10.6%	10.6%	17.7%
Electricity	39.8%	46.8%	48.1%	59.1%
Solar Heat	-	3.5%	3.5%	7.0%

Source: Author's analysis

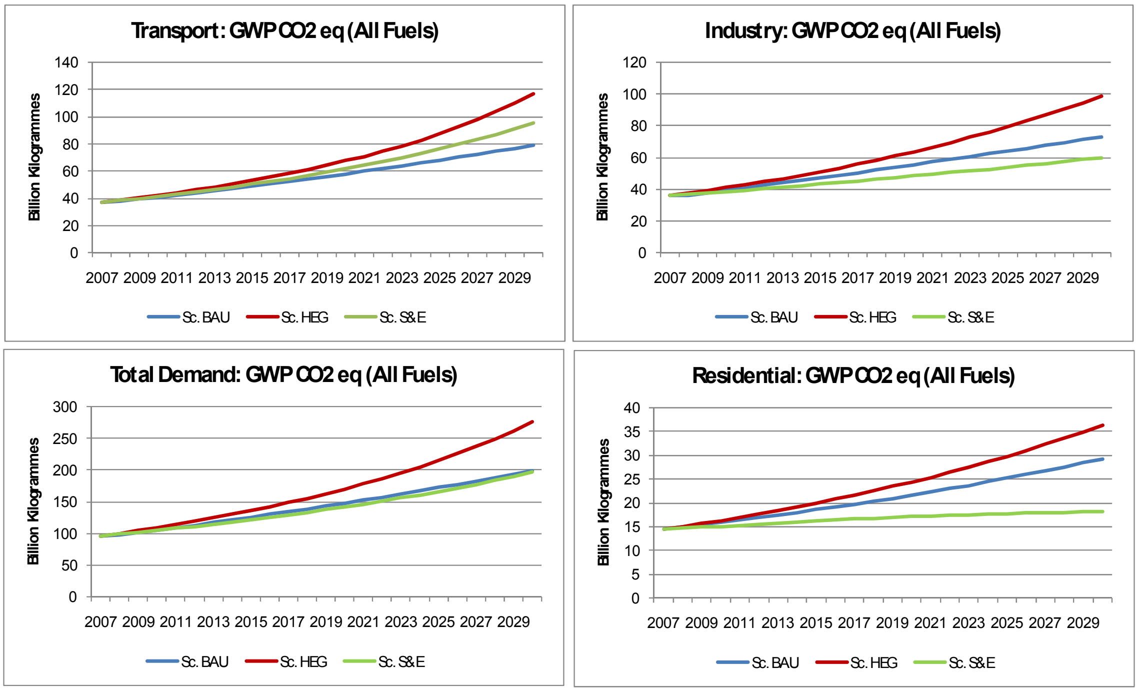
In 2007, most residential energy consumption was in the form of oil products (51 percent GLP, 1 percent kerosene), electricity (40 percent), and natural gas (9 percent). Approximately 98 percent of Egypt's population has access to electricity. Annual per capita residential electricity consumption is an estimated 425 kilowatt-hours (kWh), which is considered rather low compared to European/OECD countries, which average 1,500 kWh.

Electricity is expected to experience the fastest growth in energy demand as household consumers connect to the distribution grid.[xliii] (See Table 11.) Future electricity demand will be marked by changing use patterns as well as increased penetration of residential appliances in households, with the highest growth expected to be from air conditioning systems. This will drive peak load growth.

2.4.1.4 GHG Emissions from Final Energy Demand

Among Egypt's final energy demand sectors, the sector with the largest direct greenhouse gas (GHG) emissions is transport, followed by the industry and residential sectors.[xliv] (See Figure 27.)

Figure 27. Egypt's Global Warming Potential (GWP), by Sector and Scenario, 2007–30



Source: Author's analysis

This picture becomes even more accentuated in the future, as transportation is projected to be directly responsible for 80–120 million tons of carbon dioxide equivalent ($MtCO_{2eq}$) by 2030 (depending on the scenario), compared with 60–100 $MtCO_{2eq}$ for the industrial sector and 19–35 $MtCO_{2eq}$ for the residential sector. However, when GHG emissions from electricity generation are included, both the industry and residential sectors, as well as the commercial and public sectors, contribute a greater indirect share of emissions.

The observed trajectories indicate that the difference between the BAU and HEG scenarios is related to the primary growth drivers (GDP and population), while that of the S&E scenario reflects the relative substitution of energy sources and increased efficiency in the different sectors. (See Figure 27.) The S&E scenario has a more intense impact on Global Warming Potential (GWP) than on energy intensity.

It is very significant that the main emission reduction potentials in both residential and industrial direct emissions are seen with enforcement of the S&E scenario—40 percent in both sectors compared to the HEG scenario. Emission reduction for the transport sector in the S&E scenario is only less than 20 percent. This may reflect the fact that the scenario does not include more radical measures such as a total change of transport mode in Greater Cairo and Alexandria, effectively introducing public rail transport.

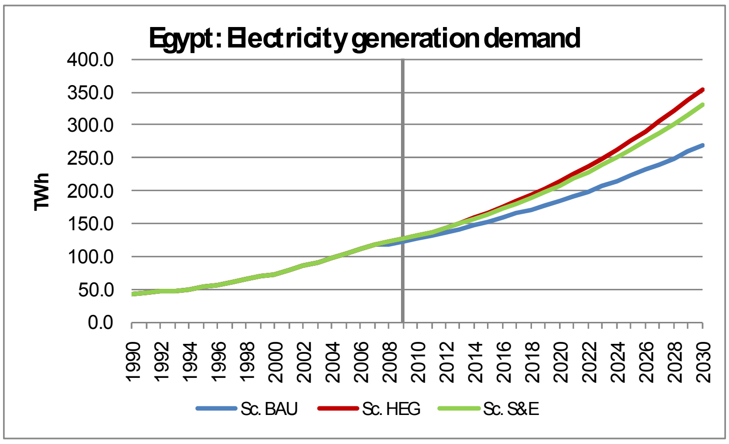
2.4.2. Demand from Energy Transformation

2.4.2.1 Electricity Generation

In 2008, total power generation in Egypt was 125.129 GWh, of which 85 percent was delivered by thermal plants (combined-cycle 35 percent, steam 55 percent, and gas turbines 10 percent), some 14 percent from hydropower, and 1 percent from wind power.[xlv] Total installed electricity capacity was approximately 25 gigawatts (GW). This includes nearly 22 GW of thermal power plants, operated mainly with natural gas; nearly 3 GW of hydroelectric capacity; and 305 MW of wind power capacity.

Annual electricity demand to 2030 increases 3.8 percent in the BAU scenario, 4.9 percent in the HEG scenario, and 4.6 percent in the S&E scenario.[xlvi] (See Figure 28.)

Figure 28. Egypt's Electricity Demand, Three Scenarios, 2007–30



Source: Author's analysis based on BP data, 2009

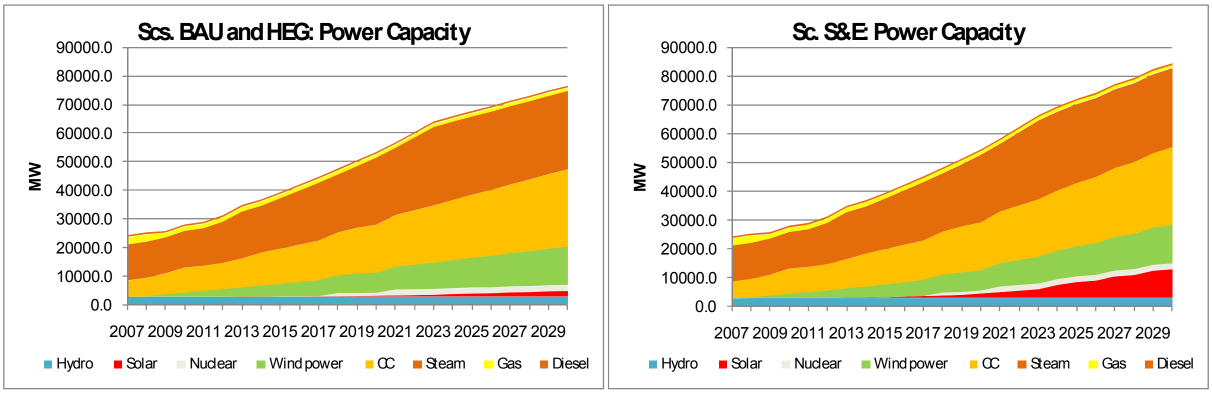
To supply sufficient power, electricity generation rises from 125.156 GWh in 2007 to 287.566 GWh to 2030 in the BAU scenario, 375.652 GWh in the HEG scenario, and 351.719 GWh in the S&E scenario.

The Egyptian Electric Holding Company foresees expanding capacity to nearly 64 GW by 2023. Both the BAU and HEG scenarios assume implementation of this expansion plan. The HEG scenario estimates approximately 78 GW of additional capacity based on power generation required to 2030, whereas in the BAU scenario, some capacity remains idle because of slower growth in electricity demand.[xlvii] (See Figure 29.) In the S&E scenario, total capacity would grow to 68 GW by 2023 and 83 GW by 2030. This higher power capacity exists mainly in a 6.5 GW solar power capacity; new simple gas turbines are not added, and the hydropower increment is small due to the almost complete exploitation of hydro resources of the Nile River with existing capacity.

This means that 56–61 GW of new power capacity will need to enter into operation between 2008 and 2030. Following the direction of the EEHC expansion plan, more than 25 GW would be from combined-cycle (CC) additions and more than 15 GW from additional gas/fuel oil-fired steam turbines. It is assumed that the targeted extension of wind power capacity to 7.2 GW by 2020 will take place in all three scenarios, and that wind capacity will reach over 13.5 GW by 2030. All three scenarios include a nuclear power capacity of 2 GW.

This analysis assumes that the generation will be covered entirely in Egypt, implicitly assuming a zero-sum import-export balance for electricity. It also assumes that hydro, wind, solar, and nuclear plants are, in view of the low operating cost, used to maximum technical availability (95–88 percent), and that capacity factors are as follows: hydro 64 percent, solar 45 percent, and wind 35 percent. The remaining generation is produced by thermal plants, according to merit order and availability (98 percent). The preferred thermal technology would be natural gas combined-cycle, even with increasing gas prices, followed by steam turbines, which could partly run on fuel oil (31 percent) and natural gas (69 percent). Simple gas turbines would be used only for reserve and peak operations.

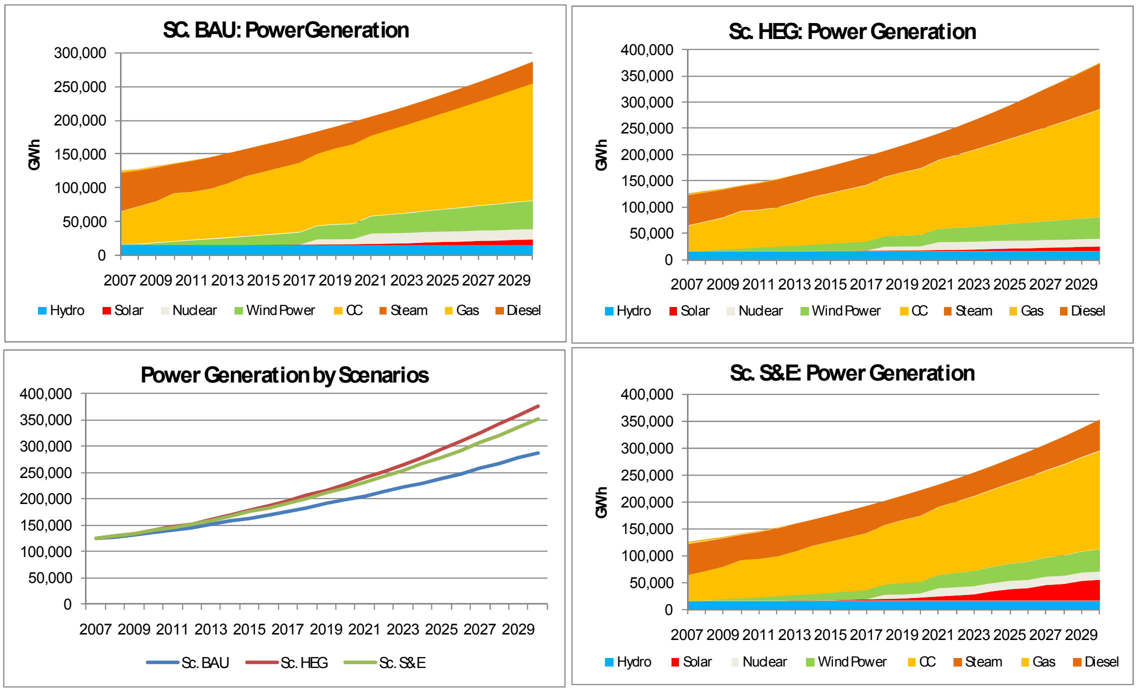
Figure 29. Egypt's Installed Electricity Capacity and Expansion Plans, by Energy Source and Scenario, 2007–30



Source: Author estimates based on EEHC information

This results in varying shares for renewable energy by 2030 under the three scenarios: 23 percent in the BAU scenario, 17 percent in HEG, and 28 percent in S&E.[xlviii] (See Figure 30.)

Figure 30. Power Generation in Egypt, by Scenario and Energy Source, 2007–30



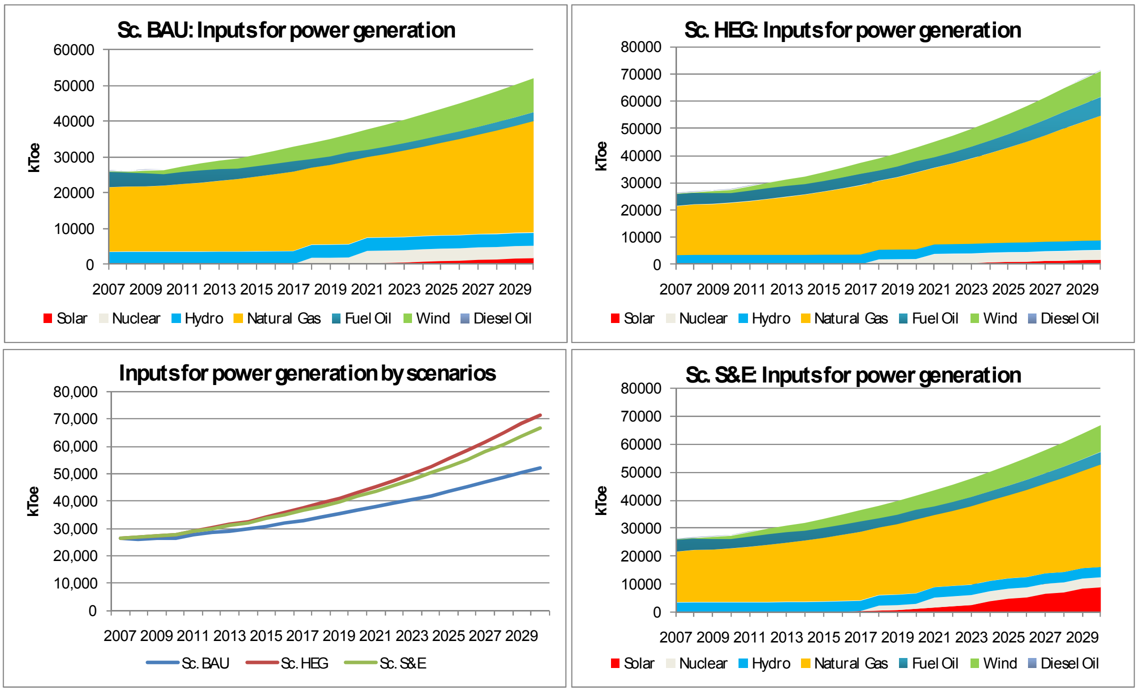
Source: Author's analysis

The energy input of Egypt's power stations in 2007 was 26.2 mtoe. In the three scenarios, it increases by 2030 to 52.1 mtoe for the BAU scenario, 71.4 mtoe for the HEG scenario, and 66.8 mtoe for the S&E scenario.[xlix] (See Figure 31.)

This calculation applies the implicit efficiency factors of Egypt's 2007 energy balance throughout the period (steam turbine 33.6 percent, gas turbine 37.3 percent, combined-cycle 58.7 percent, and diesel 28 percent). Estimates of renewable energy consumption use the BP methodology.[1]

Comparison of the three scenarios provides important insights. The stark difference in demand growth between the BAU and HEG scenarios is met with the same installed capacity structure; fuel oil is the swing fuel. In the BAU scenario, fuel oil would hardly be used, whereas in the HEG scenario it has to deliver all the increment in power from steam turbines. If considerable solar power capacity is available, as assumed in the S&E scenario, this would replace fuel oil.

Figure 31. Inputs for Power Generation in Egypt, by Scenario and Energy Source, 2007–30



Source: Author's analysis

2.4.2.2 Oil Refining

Egypt has the largest oil refining industry on the African continent, with nine refineries that boast a combined crude-oil processing capacity of nearly 726,000 barrels per day.

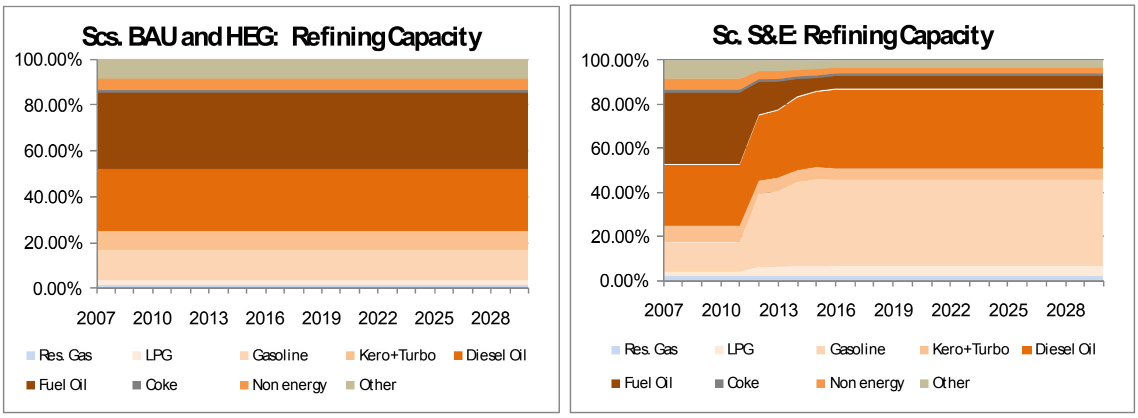
The country currently has a large surplus of heavy fuel oil and a deficit of lighter products. As a result, Egypt has an unfavorable import-export balance, with expensive, lighter products being imported and heavy fuel oil being exported and sold to marine bunkers. Existing plans foresee expanding and upgrading refining capacity to produce more light products and distillates and cut heavy fuel-oil surplus. More than 600,000 barrels per day in new refinery capacity is being planned at both ends of the Suez Canal.

In light of the steady decline in oil production, the present study does not consider any changes in existing refining capacity under the BAU and HEG scenarios. Requirements for refined products will instead be met by increasing imports, as refining capacity becomes insufficient compared with crude oil availability.

[1] The primary energy values of both nuclear and hydropower generation have been derived by calculating the equivalent amount of fossil fuel required to generate the same volume of electricity in a thermal power station, assuming a conversion efficiency of 38 percent (the average for OECD thermal power generation).

The S&E scenario, in contrast, assumes that by 2012, technological improvements in the processing units will be carried out without modifying the total refining capacity.[l] (See Figure 32.) These improvements would increase the efficiency and share of light products in the product mix (gasoline, LPG, and diesel oil).

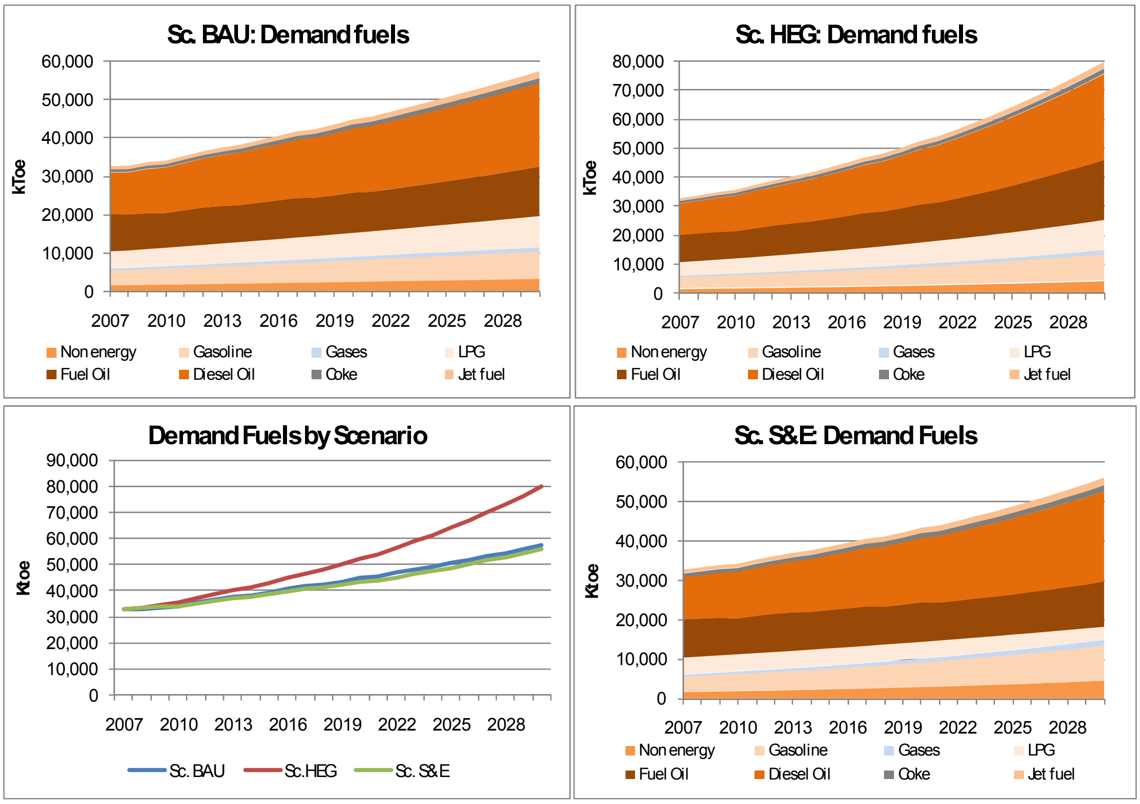
Figure 32. Egypt's Oil Refining Capacity, by Scenario and Fuel Type, 2007–30



Source: Author's analysis

Refineries' demand for oil-refined products in 2007 was 30.6 MToe, including 24.203 kToe for domestic requirements and 6.482 kToe for exports. Domestic demand to 2030 increases to 52.1 mtoe in the BAU scenario, 74.9 mtoe in the HEG scenario, and 49.4 mtoe in the S&E scenario.[li] (See Figure 33.) This is significant as it shows that the S&E strategy substantially reduces the consumption of petroleum products and the need for imports in terms of quantity and quality, i.e., foreign exchange.[lii] (See Figure 34.)

Figure 33. Fuel Demand by Egypt's Refineries, by Scenario and Fuel Type, 2007–30

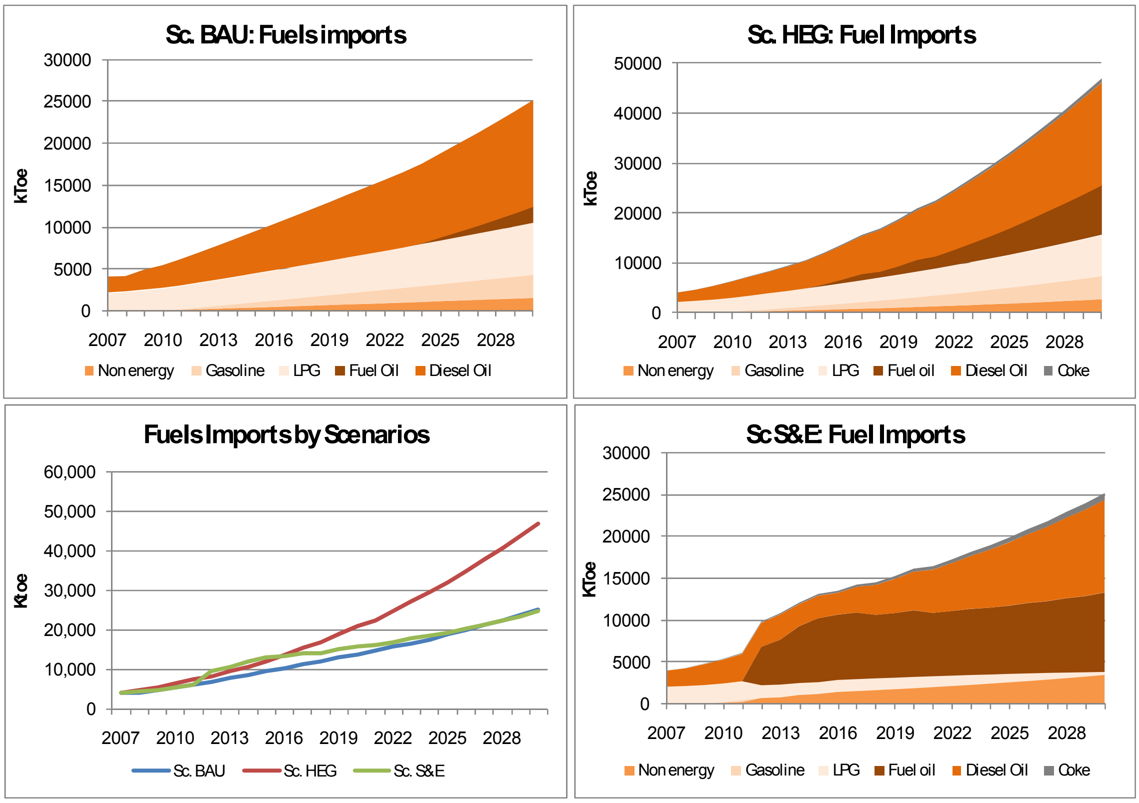


Source: Author's analysis

Fuel demand by refineries increases in the BAU and HEG scenarios due to the different economic growth, without technological improvements in the processing units.

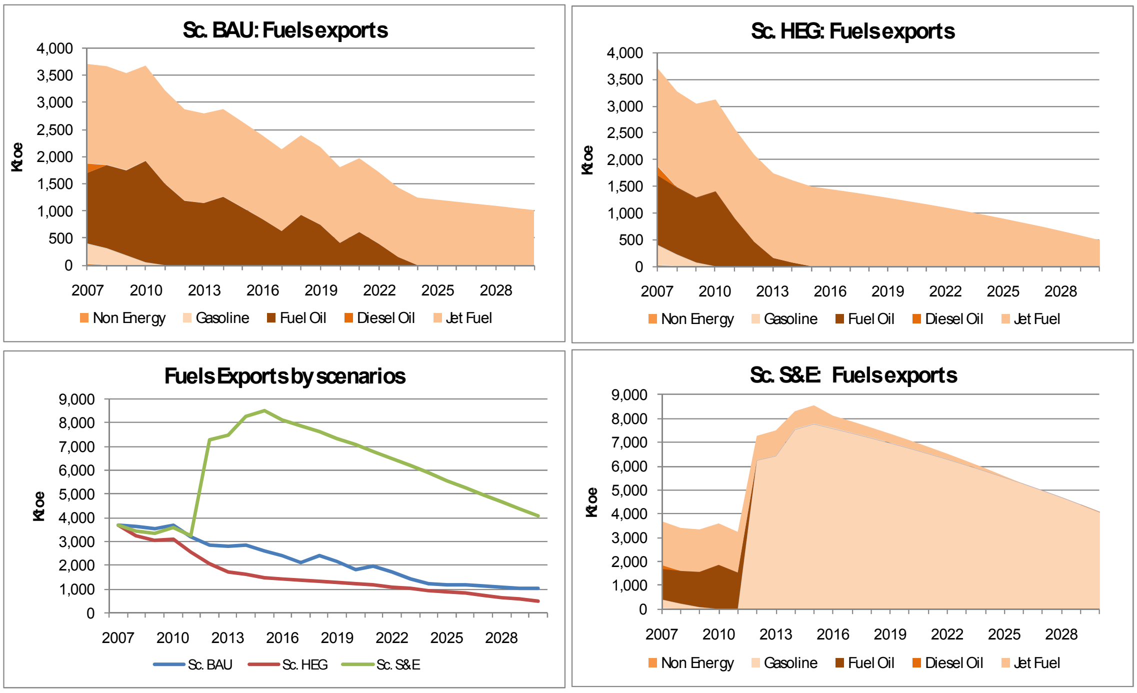
The combined steps of sectoral efficiency and substitution, replacement of petroleum products in power generation, and changes in refineries have a very clear effect on the trade balance of petroleum products. (See Figures 34 and 35.) Such steps would relieve Egypt of high imports of light products for non-energy use (LPG and gasoline), which have higher prices. Instead, the much lower total imports would consist of lesser-value fuel oil, and exports would consist of higher-value products.

Figure 34. Fuel Imports to Egypt, by Scenario and Fuel Type, 2007–30



Source: Author's analysis

Figure 35. Fuel Exports to Egypt, by Scenario and Fuel Type, 2007–30



Source: Author's analysis

The S&E scenario is clearly preferable from an energy perspective. The economics of the scenarios have not been determined; however, the savings in imports are on the order of 20 mtoe by 2030, or more than US$10 billion at today's prices, a conservative estimate. The structural change would represent another US$2 billion. In addition, the S&E scenario would allow, at least for a certain period, not only more products but also the export of higher-value fuels, in particular gasoline.

2.5 Primary Energy

2.5.1 Total Primary Energy

In all three scenarios, primary energy demand in the period 2008–30 grows less than in the historical period 1965–2008 due to the substitution of conventional electricity capacity with renewable energy, mainly wind and solar.[liii] (See Table 12.) Domestic demand for energy shows different behavior in 1965–2008 compared with projections for 2008–2030 under each scenario because of varying projections of the demand drivers (e.g., GDP per capita) for the BAU and HEG scenarios.

Table 12. Egypt's Primary Energy Demand, 1965–2008, and Three Scenarios for 2008–30

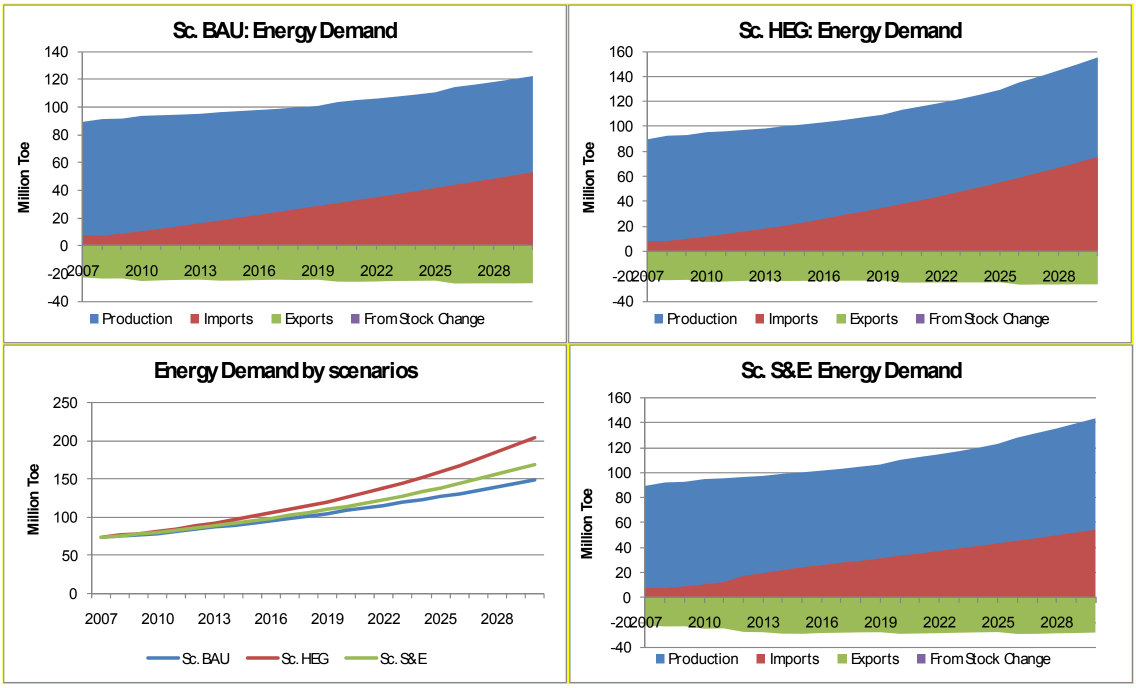
Period	Energy demand trends		
	BAU scenario	HEG scenario	S&E scenario
1965–2008		5.3%	
2008–2030	3.2%	4.6%	3.7%

Source: BP and author's analysis

The trajectories of energy demand in the three scenarios are significantly distinct (see Figure 36)[liv]:

- High growth without a responsive energy policy (HEG scenario) would drive up primary energy consumption to over 200 mtoe by 2030. The S&E scenario is able to mitigate that growth by 20 percent and more.
- Energy imports would increase dramatically in the high-growth case and exceed exports by more than 40 mtoe. Again, S&E would be an efficient strategy and would reduce the energy export deficit to approximately 20 mtoe.

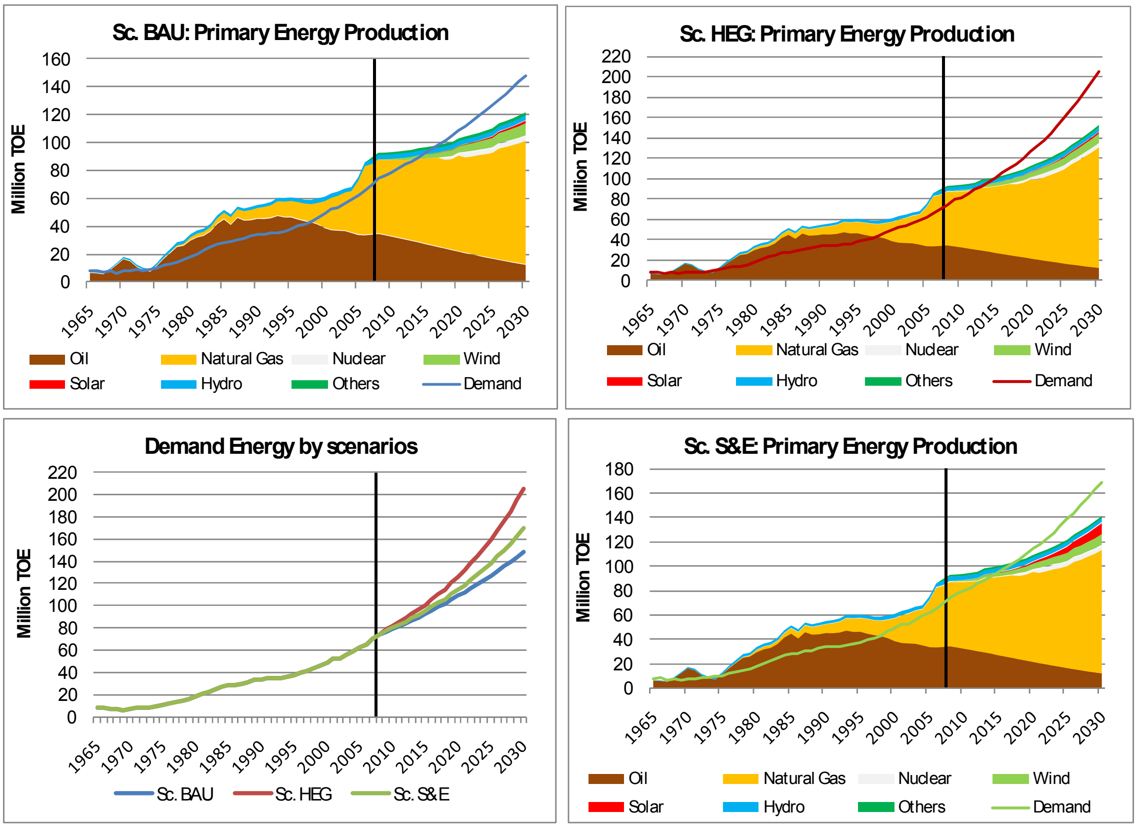
Figure 36. Egypt's Energy Balance and Demand, Three Scenarios, 2007–30



Source: Author's analysis

In the future, Egypt's primary energy demand can no longer be met without net imports.[lv] (See Figure 37.) Even in case of low growth, the deficit opens up by 2015 and grows quickly to around 15 percent. Only with a vigorous S&E policy can the time period during which this happens be postponed to after 2020 and the absolute deficit kept below 10 percent in the long run.

Figure 37. Egypt's Primary Energy Production and Demand, by Scenario and Energy Source, 2007–30



Source: Author's analysis based on data from BP

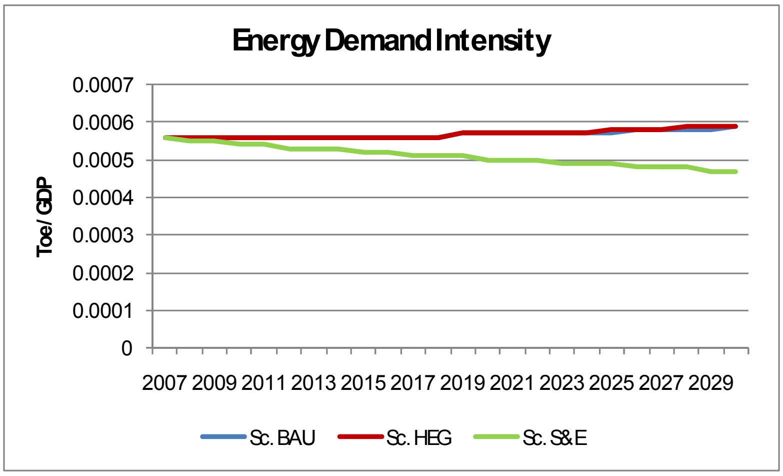
With decreasing oil production, domestic natural gas becomes the mainstay of Egypt's energy supply, as discussed in the following chapter. Exports of some of this domestic gas will partly offset the ever-increasing imports of oil and oil products.

Renewable energy technologies, primarily domestic wind and solar energy resources, become the key alternatives, which can complement natural gas in balancing the energy supply. Unlike natural gas, these resources are not exhaustible, and solar power and heat in particular could be expanded even more than is envisioned in the S&E scenario.

2.5.2 Primary Energy intensity

Egypt's overall energy intensity—that is, the input of primary energy per unit of GDP—in all sectors is similar in both the BAU and HEG scenarios.[lvi] (See Figure 38.) Improved energy efficiency of approximately 20 percent under the S&E scenario reflects the specific policies assumed under the scenario. However, the scenario fails to tap all of the potentials, particularly in transportation but also through the use of combined heat and power (CHP) in industry and of agricultural and municipal residues. Thus, potentioal efficiency savings and renewables' contributions could be even greater than those put forward in this analysis.

Figure 38. Egypt's Primary Energy intensity, Three Scenarios, 2007–30



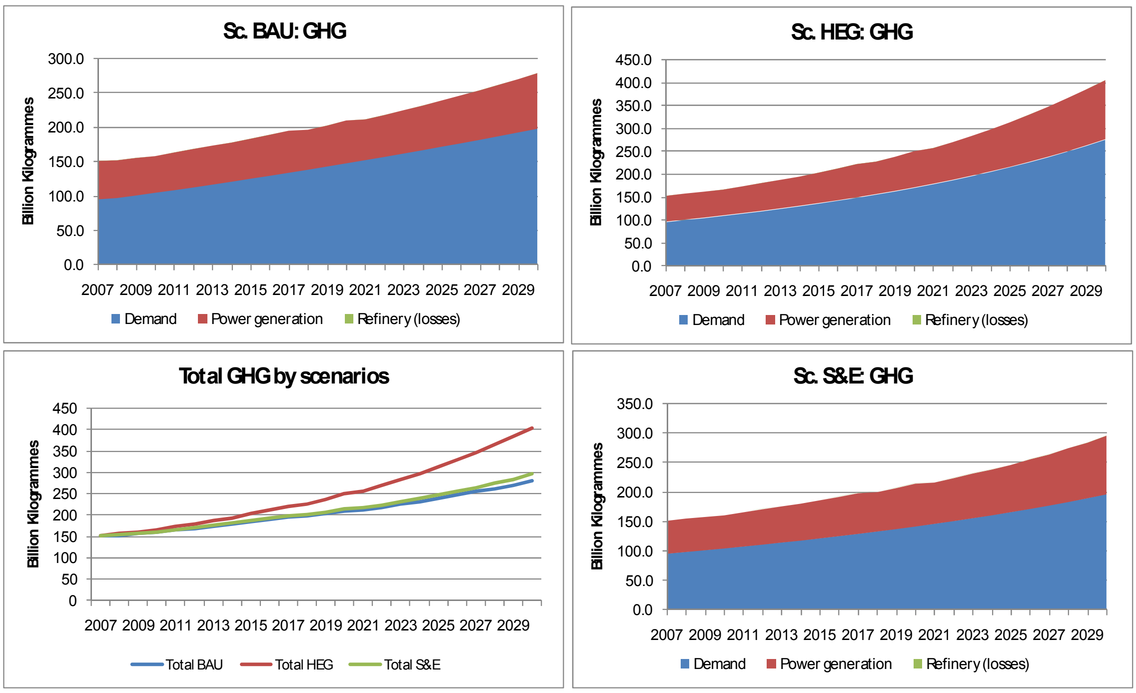
Source: Author's analysis

Although the relationship between primary energy and GDP is a complex indicator of efficiency and is influenced by varying methodological assumptions (e.g., GDP value in exchange rates vs. purchasing power parity; primary electricity calculated in energy content vs. substitution potential), it shows in general terms the progress over time. Figure 38, which reflects the assumptions in the scenarios, demonstrates the potential decoupling of energy from economic growth.

2.5.3 Total GHG Emissions from the Energy Sector

GHG emission projections under the three scenarios illustrate that climate change mitigation is possible only with a vigorous S&E policy that contains strong renewable energy elements.[lvii] (See Figure 39.) The alternative for achieving low emissions growth is to have sluggish economic growth, as in the BAU scenario, which is clearly not desirable.

Figure 39. Egypt's GHG Emissions, by Scenario and Source, 2007–30

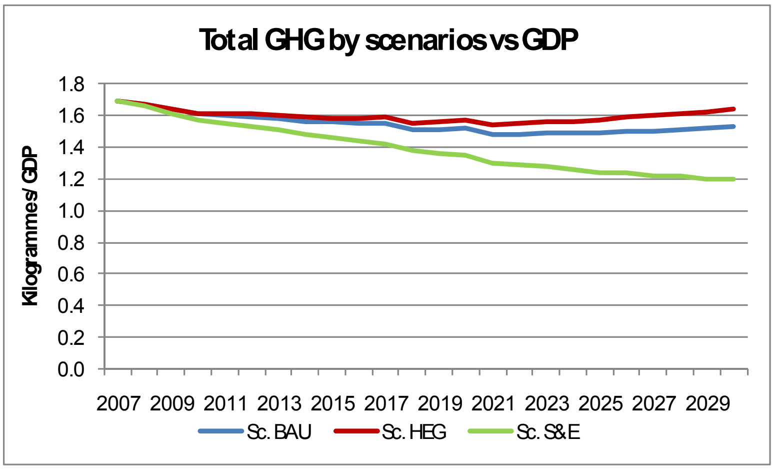


Source: Author's analysis

High growth without S&E would increase Egypt's energy-related GHG emissions to more than 400 $MtCO_{2eq}$, which would expose and weaken Egypt's international position. S&E can keep the increase to below 300 $MtCO_{2eq}$, 25 percent below HEG. This could benefit Egypt as a highly valued contribution in international negotiations.

In the case of GHG emissions per unit of GDP, the substitution with renewable energy sources in particular demonstrates their effectiveness and reduces the indicator value to 1.2.[lviii] (See Figure 40.) Per capita emissions from the energy sector would remain below 3 tCO_{2eq}, compared with nearly 4 tCO_{2eq} in the HEG scenario.

Figure 40. GHG versus GDP in Egypt, Three Scenarios, 2007–30



Source: Author's analysis

3. Sustainability of Egypt's Oil and Natural Gas Supply to 2030

This chapter discusses varying perspectives on Egypt's domestic oil demand (assuming that refining capacity remains constant) and natural gas demand (final and own consumption plus power generation demand), considering historical trends.

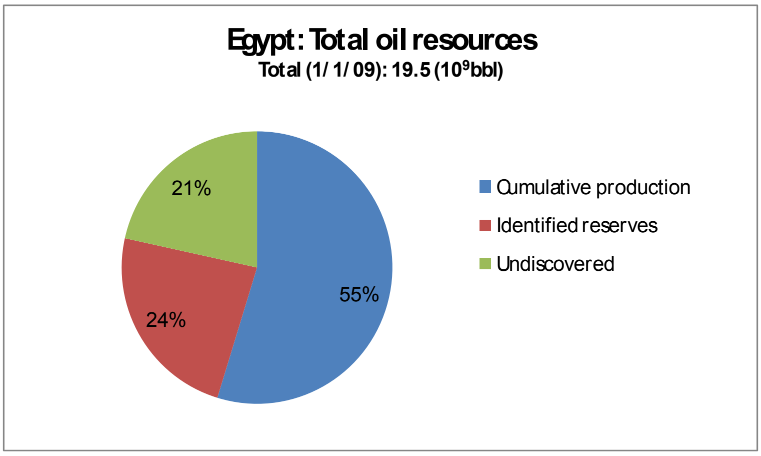
3.1 Oil Reserves and Production: Perspectives to 2030

Egypt's oil resources have been fairly well explored and developed using relatively advanced oilfield technologies.

Since the start of exploitation, 55 percent of the country's estimated 19.5 billion barrels of total oil resources have been produced.[lix] (See Figure 41.) As of 2008, the proved or identified reserves left to extract[2], recoverable to 100 percent, amounted to 4.3 billion barrels, or 24 percent of total resources. Resources still to be discovered are estimated at 21 percent of volumes in situ, with a recovery probability of 6–10 percent or more depending on the type of exploration technology used.[lx] This means that Egypt may still be able to recover 45 percent of its total resources.

[2] Generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions.

Figure 41. Egypt's Total Oil Resources, 2009

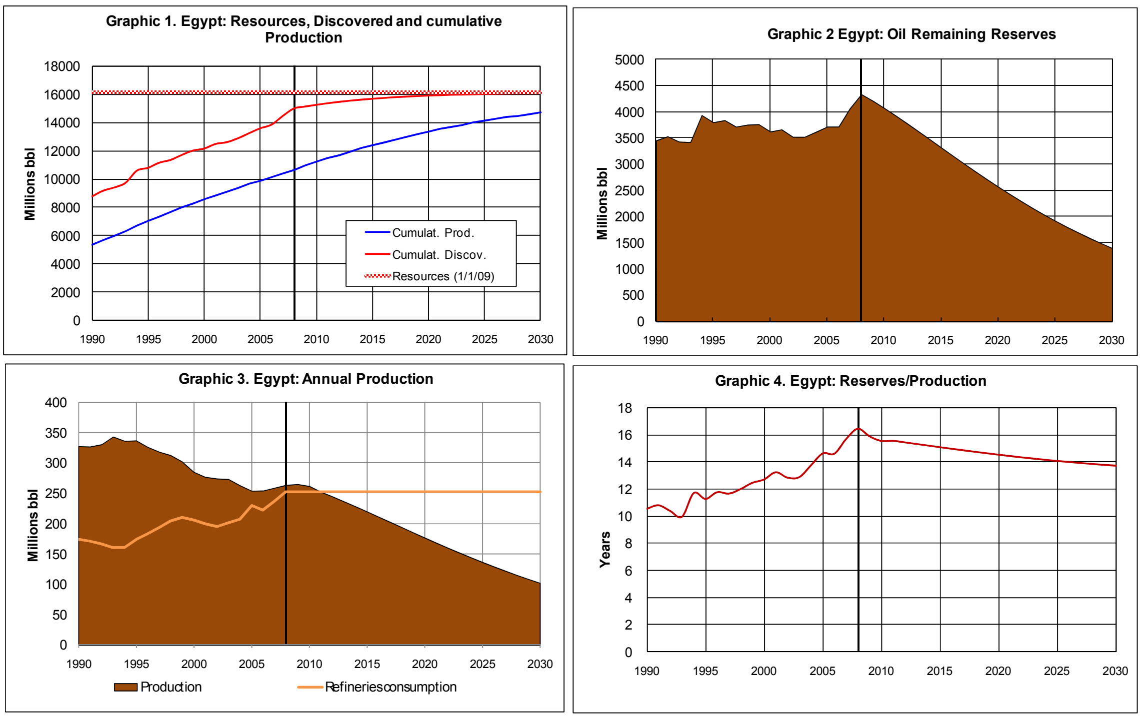


Source: Masters et al 1994, BP 2009, USGS 2001

Cumulative oil discoveries in Egypt have grown rapidly in the last few years, approaching the limit of estimated total resources.[lxi] (See Figure 42, Graphic 1.) More than 90 percent of total recoverable resources appear to already be discovered.

Cumulative production grew at about the same pace as discoveries, and lately at an even slower pace, keeping remaining reserves stable. (See Figure 42, Graphic 2.) Due to falling production (see Graphic 3), the reserve-to-production ratio (R/P ratio) could even be increased (see Graphic 4). If discoveries continue to grow, this may require a re-assessment of total recoverable resources and an expansion of the limit, based on a re-evaluation of recovery factors and potential volumes. This would also increase remaining reserves.

Figure 42. Egypt's Oil Production and Reserves, 1990–2030



Source: Author's analysis based on data from USGS and BP

In the case of oil, the present analysis has developed a single scenario to 2030. It assumes, based on current information and a maintaining of the cumulative production growth rate, that the peak of remaining reserves was reached in 2008. Remaining reserves would decline steadily in the future even with continuously reduced domestic production, required to keep the R/P ratio above 10 years.

At the current pace of production, the R/P horizon is 16 years; however, it should be noted that the rationale for economic operation of oil fields is different than the one applied by more conservative traditional oil companies. This rationale is: (1) because average annual production is 722,424 barrels per day, this may indicate a medium yield, and (2) because drillings are determined based on superficial exploration, avoiding the addition of proved reserves that may led to costs of immobilized capital until they are in production.

Technology development has pushed aside the old view that 15 years of reserves-to-production is the optimum index. Most independent companies work with an eight-year margin, making the R/P ratio of 16 appear conservative. (See Figure 42, Graphic 4.)

In 2008, Egypt's actual oil production averaged 722,465 barrels per day, less than 1 percent of world production. Despite discoveries and enhanced recovery techniques at mature fields, the country's crude oil production has continued to decline from its 1996 peak of 922,000 barrels per day.

If the pace of oil production observed over the last few years continues, current refinery requirements of 726,000 barrels per day may be satisfied by domestic production to 2011. (See Figure 42, Graphic 3.) In this case, Egypt will need to import crude starting in 2011 to supply domestic refineries. With diminishing domestic production, crude imports will rise and could reach over 400,000 barrels per day, or over 20 mtoe per year, by 2030.[lxii] (See Table 13.)

Table 13. Egypt's Oil Balance, 1990–2030

Year	Supply		Total	Demand	
	Production	Imports		Consumption (Refineries)	Exports
	bbl/day				
1990	897134	0	897134	477372	419762
1991	895721	0	895721	469654	426067
1992	905971	0	905971	456689	449282
1993	940686	0	940686	438278	502408
1994	921427	0	921427	437318	484108
1995	923511	0	923511	474256	449254
1996	893826	0	893826	500802	393024
1997	872504	0	872504	530940	341564
1998	856731	0	856731	559434	297297
1999	827452	0	827452	573381	254071
2000	781180	0	781180	564263	216916
2001	758396	0	758396	548221	210175
2002	751307	0	751307	534467	216839
2003	749140	0	749140	550193	198947
2004	720694	0	720694	566948	153746
2005	696082	0	696082	628642	67440
2006	696959	0	696959	609654	87305
2007	709962	0	709962	650197	59764
2008	722425	0	722425	692593	29831
2009	726000	0	726000	692593	33407
2010	717574	0	717574	692593	24981
2011	691968	625	692593	692593	0
2012	670712	21881	692593	692593	0
2013	648641	43952	692593	692593	0
2014	625926	66667	692593	692593	0
2015	602734	89859	692593	692593	0
2020	484834	207759	692593	692593	0
2025	374361	318232	692593	692593	0
2030	280050	412543	692593	692593	0

Source: Author's analysis; 1990–2008 historical information from BP

In addition, growing domestic demand for petroleum products will require imports, and the trade balance of these products will become increasingly negative (as demonstrated in section 2.4.2.2). The deficit may rise to between over 20 and over 40 mtoe of products, depending on the scenario. (See Figures 34 and 35.) In total, Egypt's economy faces the prospect of a massive petroleum deficit of 40–65 mtoe in 2030.

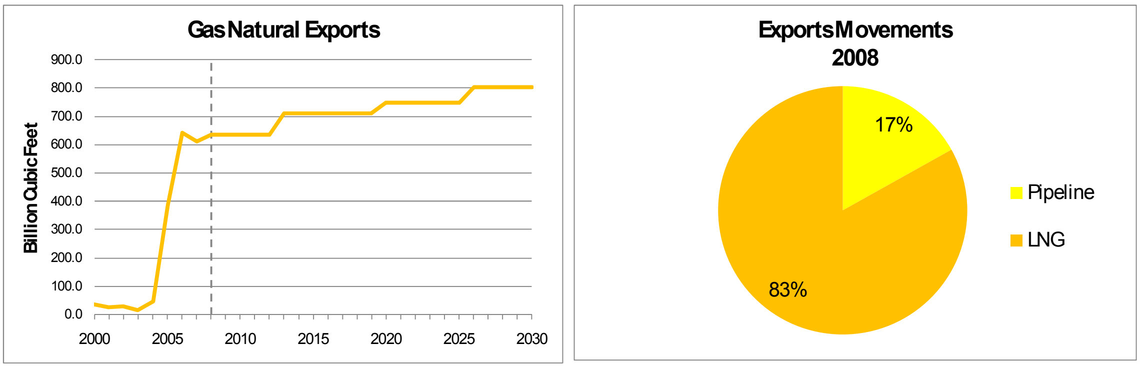
3.2 Natural Gas Reserves and Production: Perspectives to 2030

3.2.1 Exports

In addition to reviewing the domestic demand for natural gas, Egypt's natural gas export strategy must be taken into account in any analysis of future resources.

In 2008, Egypt exported natural gas overseas both by international pipeline (17 percent) and as Liquefied Natural Gas (LNG) (83 percent).[lxiii] (See Figure 43.) Exports for the year totaled 633.9 billion cubic feet (bcf). Based on an unique expansion of capacity that facilitates export increments, total exports under the three scenarios are calculated at 711.2 bcf in 2013, 750 bcf in 2020, and 803.1 bcf in 2026, representing a 27-percent increase in capacity between 2009 and 2030.

Figure 43. Egypt's Natural Gas Exports , 2000–2030, and Mode of Movement



Source: 2000–08 historical information from BP

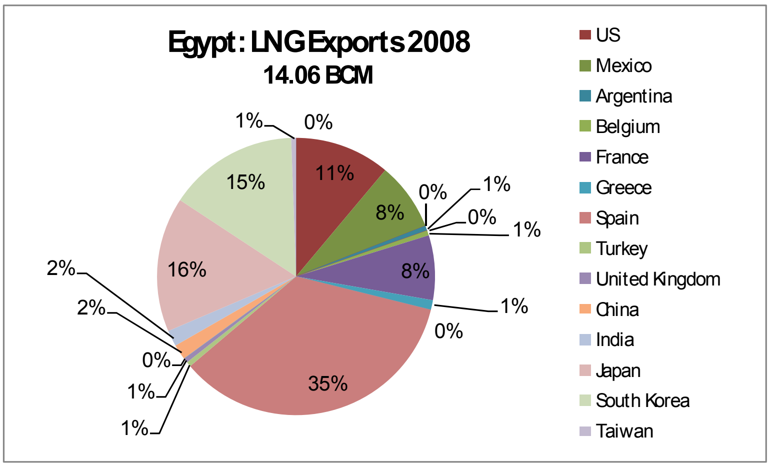
Pipeline

Egypt's most expansive export project is the Arab Gas Pipeline that currently connects Egypt to Jordan and Syria. In June 2003, a 270-kilometer gas pipeline between Egypt (El Arish) and Jordan (Aqaba) was inaugurated. In 2008, the Jordan-Syria section of the Arab Gas Pipeline was completed, and Egypt is expected to export 77.3 bcf in 2013. In 2008, Turkey and Syria also signed an agreement to connect the pipeline to the Turkish grid for use in 2011 and to extend the pipeline into Europe for export to Austria via Bulgaria, Romania, and Hungary. There is also discussion of connecting the pipeline to Lebanon and Cyprus. The Arish-Ashkelon gas pipeline to Israel became operational in 2008 and began transferring what is expected to be 60 bcf per year. Recently, Libya also agreed to build a natural gas pipeline between Alexandria and the eastern Libyan city of Tobruk to import gas from the Nile Delta region and the Mediterranean deepwater permits.[lxiv]

LNG

In 2008, Egypt exported 525.1 bcf of LNG to progressively diversifying market destinations. LNG represented 25.3 percent of natural gas production and 83 percent of total gas exports.[lxv] (See Figure 44.) The country has three LNG trains, and in 2006 LNG exports reached an estimated 528 bcf, including 129 bcf to the United States. The Spanish firm Union Fenosa has built a single-train liquefaction facility at Damietta, which started annual production of 240 bcf in late 2004. In June 2006, partners ENI, BP, and Union Fenosa signed a framework agreement for expansion of the plant and production with a second train planned to begin in 2010–11. However, this agreement may be put at risk by Egypt's June 2008 announcement that all export contracts are on hold until 2010. The Egyptian Petroleum Minister warned that the second train faces opposition within parliament. A second LNG export project called Egyptian LNG, at Idku, was built by BG in partnership with Petronas and currently has two 173 bcf per year of trains. The project is tied to natural gas production from BG's Simian/Sienna offshore fields and began production in 2005. BG hopes to build a third liquefaction plant, fed partly by gas from the Palestinian-controlled Gaza Marine Field in the Mediterranean Sea, with targeted start up in 2011.[lxvi]

Figure 44. LNG Exports from Egypt, by Destination Country, 2008



Source: BP, 2009

Another potential use for Egypt's natural gas reserves is gas-to-liquids (GTL) projects. Shell has proposed a 75,000 barrel per day GTL plant to be co-located with its planned LNG export terminal using natural gas production from its offshore NEMED field. The LNG and GTL plants could be built within three years, but a final decision is awaiting the outcome of Shell's exploration program on NEMED, expected to be completed after 2009.[lxvii]

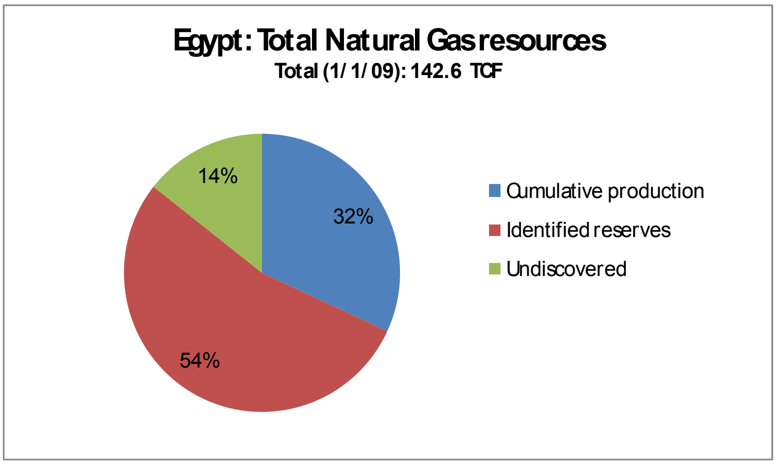
3.2.2 Reserves and Production

Natural gas reserves and production are linked to oil exploitation, as described earlier, through different Gas-to-Oil Ratios (GOR). Taking into account that gas production is increasing in relative terms while oil production is declining, it is assumed for the purposes of this study that in general the focus is non-associated gas. About 10 percent of gross production is either flared or re-injected, and 15 percent is auto-consumed or lost.

Between the start of exploitation and early 2009, 32 percent of Egypt's 142.6 trillion cubic feet (tcf) of total natural gas resource had been produced.[lxviii] (See Figure 45.) An estimated 54 percent of proven or identified reserves has been put in commercial production, recoverable to 100 percent, and resources to be discovered totaled 14 percent, with a recovery probability of about 10 percent. Overall, the country has yet to recover 68 percent of its total gas resources, weighted by their respective recovery factors, if no new resources are added.

Egypt has proven gas reserves of 76.6 tcf, or just over 1 percent of the world total. The success rate of natural gas exploration has increased since 1991, when foreign companies were first allowed to participate in the Egyptian gas sector. Egypt has both medium-sized and small fields, especially offshore. The largest existing fields include Abu Madi-El Qar´a, Port Fouad Marine area, Raven, Sapphire, Temsah, and Wakar. Production from West Deep Marine, the Khalda area, and Port Fouad is expected to account for nearly half of the production in 2010. Development of new fields, from already discovered reserves, will account for two-thirds of production in 2030. Egypt settled for new drillings in order to increase its gas reserves, which has helped the country become one of the 10 largest gas producers in the world.

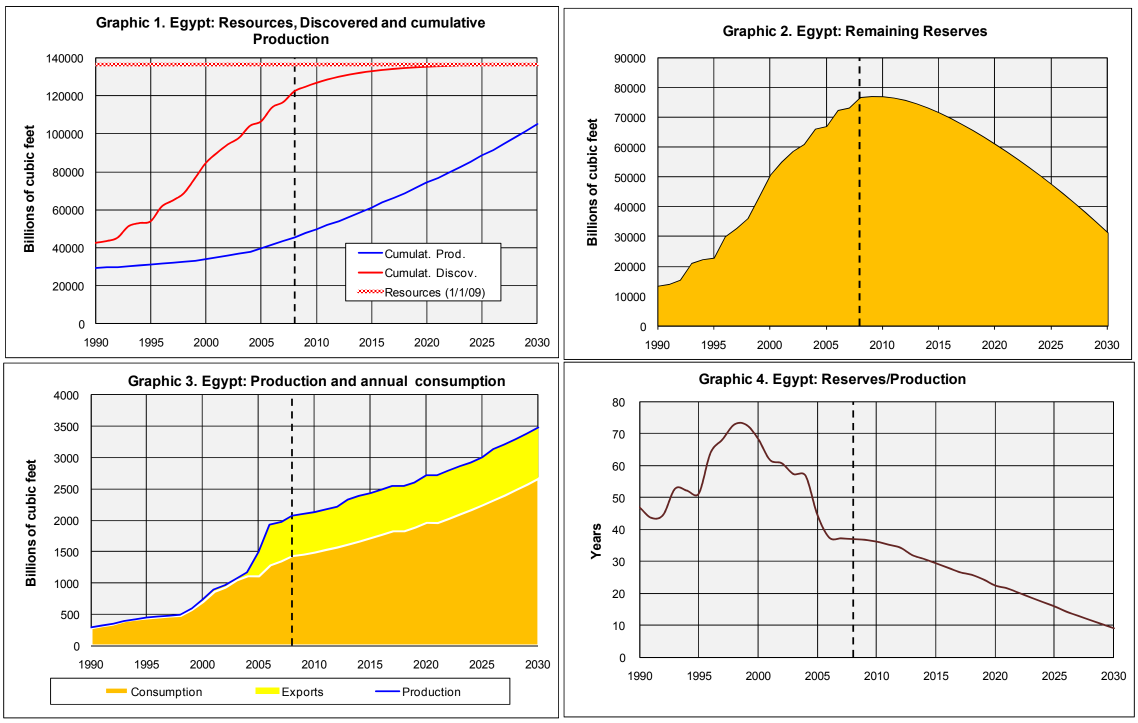
Figure 45. Egypt's Total Natural Gas Resources, 2009



Source: Masters et al 1994, BP 2009, USGS 2001

Maintaining the current pace of production results in a reserves-to-production horizon of about 37 years. Cumulative discoveries and production since the beginning of exploitation indicate that discoveries were at the limit (within 90 percent) of total resources by 2008, due to the fast increase of discoveries; however, there remain important amounts to produce. (See Figure 46, Graphic 1.) This remarkable evolution has permitted remaining reserves to increase steadily. (See Figure 46, Graphic 2.)

Figure 46. Egypt's Natural Gas Reserves and Production, BAU Scenario, 1990–2030



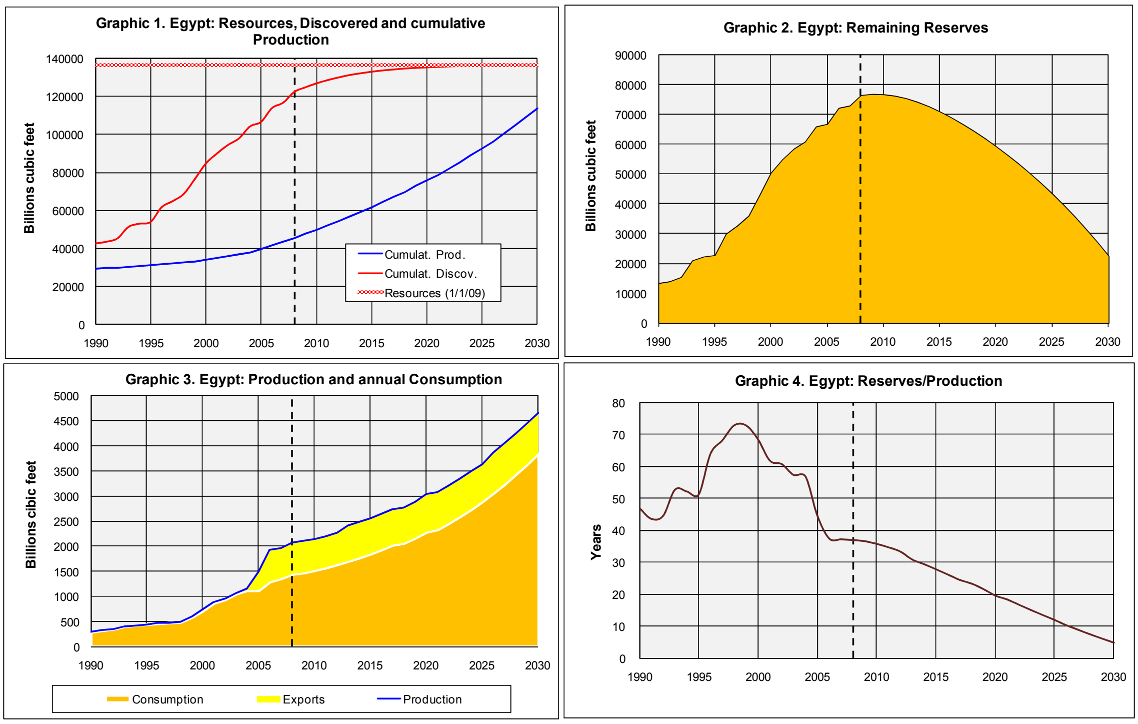
Source: Author's analysis based on data from USGS and BP

The natural gas system, particularly with a long R/P horizon, has more flexibility in the medium and long run compared to the oil system, which is burdened by a refinery system where the crude has to be transformed into products. Natural gas can therefore be developed in closer alignment with demand. The current study analyzes the different effects of the three demand scenarios on Egypt's future gas production and reserve situation.

The BAU scenario illustrates the effects of continuing the discovery rates of the past several years, with production accelerating somewhat to satisfy internal demand and sustain the pace of exports. (See Figure 46, Graphics 2 and 3.) This entails reduced remaining reserves and slightly reducing the R/P ratio from 37 years to 17 years to 2030. (See Figure 46, Graphic 4.) Under this scenario, Egypt can meet internal demand and increase exports.

The HEG scenario, in contrast, shows a different natural gas demand and requires speeding up production slightly in order to meet a major portion of internal demand and exports.[lxix] (See Figure 47, Graphic 3.) In this case, making higher rates of production possible requires duplicating the annual growth of accumulated production, with the view that the accumulated discoveries are approaching the resource limit for exhaustion of the remaining reserves. (See Figure 47, Graphic 1.) This leads to a decline in the R/P ratio from the current 37 years to an alarming 5 years by 2030, indicating that preventive actions are required. (See Figure 47, Graphic 4.) In the HEG scenario, gas production will be reaching the limit of exhaustion by 2030.

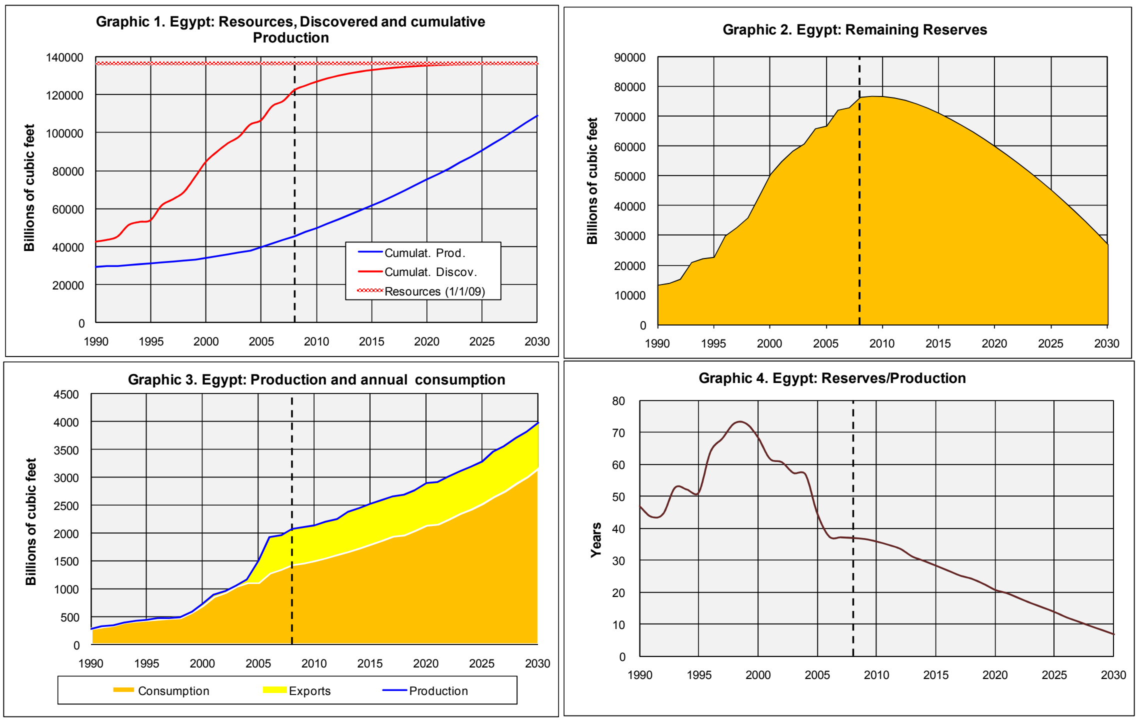
Figure 47. Egypt's Natural Gas Reserves and Production, HEG Scenario, 1990–2030



Source: Author's analysis based on data from USGS and BP

In the S&E scenario, natural gas production stands between that in the previous two scenarios due to the strong penetration of renewable sources that could attenuate its demand. (See Figure 48, Graphic 3.) This reflects a somewhat slower but still alarming exhaustion of reserves, and the R/P ratio will be in 7 years by 2030.[lxx] (See Figure 48, Graphics 2 and 4.)

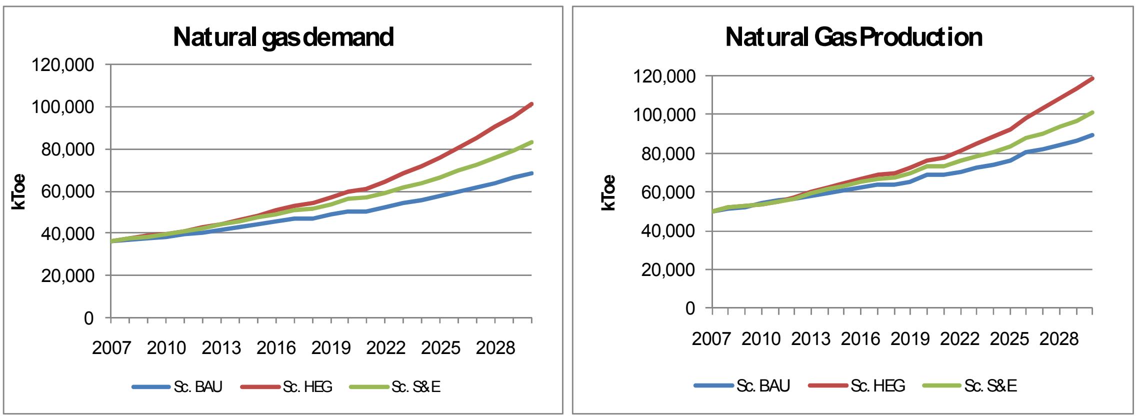
Figure 48. Egypt's Natural Gas Reserves and Production, S&E Scenario, 1990–2030



Source: Author's analysis based on data from USGS and BP

A comparison of natural gas demand comparison between the scenarios shows clearly the effects of driving variables that determine both final and own consumption, as well as the energy transformation processes, particularly power generation, which is a very important gas consumer. It indicates that the production required in the S&E scenario would not grow as aggressively as in the HEG scenario, although given the abundance of the gas resource it is still possible to increase its penetration regarding that of the BAU scenario to substitute derived of the petroleum.[lxxi] (See Figure 49.)

Figure 49. Egypt's Natural Gas Demand and Production, Three Scenarios, 2007–30



Source: Author's analysis based on data from BP

Nevertheless, it is still possible to further slow the exhaustion of reserves via an aggressive penetration of renewable energy, in the event that it is not possible to expand the limit of resources by means of exhaustive exploration.

Table 14 illustrates the evolution of Egypt's natural gas balance to 2030 under the three scenarios, indicating production, demand, and exports.[lxxii]

Table 14. Egypt's Natural Gas Balance, 1990–2030

Year	BAU scenario					HEG scenario					S&E scenario				
	Supply		Total	Demand		Supply		Total	Demand		Supply		Total	Demand	
	Production	Imports		Domestic	Exports	Production	Imports		Domestic	Exports	Production	Imports		Domestic	Exports
	Billions Cubic Feet														
1990	285.0	0.0	285.0	285.0	0.0	285.0	0.0	285.0	285.0	0.0	285.0	0.0	285.0	285.0	0.0
1991	320.7	0.0	320.7	320.7	0.0	320.7	0.0	320.7	320.7	0.0	320.7	0.0	320.7	320.7	0.0
1992	345.8	0.0	345.8	345.8	0.0	345.8	0.0	345.8	345.8	0.0	345.8	0.0	345.8	345.8	0.0
1993	398.7	0.0	398.7	398.7	0.0	398.7	0.0	398.7	398.7	0.0	398.7	0.0	398.7	398.7	0.0
1994	427.3	0.0	427.3	423.8	3.5	427.3	0.0	427.3	423.8	3.5	427.3	0.0	427.3	423.8	3.5
1995	444.9	0.0	444.9	441.4	3.5	444.9	0.0	444.9	441.4	3.5	444.9	0.0	444.9	441.4	3.5
1996	468.4	0.0	468.4	457.8	10.6	468.4	0.0	468.4	457.8	10.6	468.4	0.0	468.4	457.8	10.6
1997	480.3	0.0	480.3	473.2	7.1	480.3	0.0	480.3	473.2	7.1	480.3	0.0	480.3	473.2	7.1
1998	494.4	0.0	494.4	483.8	10.6	494.4	0.0	494.4	483.8	10.6	494.4	0.0	494.4	483.8	10.6
1999	593.3	0.0	593.3	579.2	14.1	593.3	0.0	593.3	579.2	14.1	593.3	0.0	593.3	579.2	14.1
2000	739.6	0.0	739.6	704.4	35.2	739.6	0.0	739.6	704.4	35.2	739.6	0.0	739.6	704.4	35.2
2001	889.9	0.0	889.9	865.2	24.7	889.9	0.0	889.9	865.2	24.7	889.9	0.0	889.9	865.2	24.7
2002	964.1	0.0	964.1	935.8	28.3	964.1	0.0	964.1	935.8	28.3	964.1	0.0	964.1	935.8	28.3
2003	1063.0	0.0	1063.0	1048.8	14.1	1063.0	0.0	1063.0	1048.8	14.1	1063.0	0.0	1063.0	1048.8	14.1
2004	1162.2	0.0	1162.2	1116.4	45.8	1162.2	0.0	1162.2	1116.4	45.8	1162.2	0.0	1162.2	1116.4	45.8
2005	1500.9	0.0	1500.9	1115.9	384.9	1500.9	0.0	1500.9	1115.9	384.9	1500.9	0.0	1500.9	1115.9	384.9
2006	1931.7	0.0	1931.7	1289.0	642.7	1931.7	0.0	1931.7	1289.0	642.7	1931.7	0.0	1931.7	1289.0	642.7
2007	1966.7	0.0	1966.7	1354.7	612.0	1966.7	0.0	1966.7	1354.7	612.0	1966.7	0.0	1966.7	1354.7	612.0
2008	2073.3	0.0	2073.3	1439.4	633.9	2073.3	0.0	2073.3	1439.4	633.9	2073.3	0.0	2073.3	1439.4	633.9
2009	2096.4	0.0	2096.4	1462.5	633.9	2103.7	0.0	2103.7	1469.8	633.9	2101.4	0.0	2101.4	1467.5	633.9
2010	2128.5	0.0	2128.5	1494.6	633.9	2149.7	0.0	2149.7	1515.8	633.9	2144.6	0.0	2144.6	1510.7	633.9
2011	2171.4	0.0	2171.4	1537.5	633.9	2203.4	0.0	2203.4	1569.5	633.9	2194.7	0.0	2194.7	1560.8	633.9
2012	2210.0	0.0	2210.0	1576.1	633.9	2267.1	0.0	2267.1	1633.2	633.9	2253.2	0.0	2253.2	1619.3	633.9
2013	2334.4	0.0	2334.4	1623.2	711.2	2409.0	0.0	2409.0	1697.8	711.2	2386.6	0.0	2386.6	1675.4	711.2
2014	2381.9	0.0	2381.9	1670.7	711.2	2479.1	0.0	2479.1	1767.9	711.2	2449.7	0.0	2449.7	1738.5	711.2
2015	2436.0	0.0	2436.0	1724.8	711.2	2557.8	0.0	2557.8	1846.6	711.2	2517.6	0.0	2517.6	1806.4	711.2
2020	2721.5	0.0	2721.5	1971.5	750.0	3031.7	0.0	3031.7	2281.7	750.0	2897.1	0.0	2897.1	2147.1	750.0
2025	3000.5	0.0	3000.5	2250.5	750.0	3639.4	0.0	3639.4	2889.4	750.0	3286.6	0.0	3286.6	2536.6	750.0
2030	3479.7	0.0	3479.7	2676.7	803.1	4650.3	0.0	4650.3	3847.2	803.1	3977.2	0.0	3977.2	3174.2	803.1

Source: Author's analysis; 1990–2008 from BP, 2009

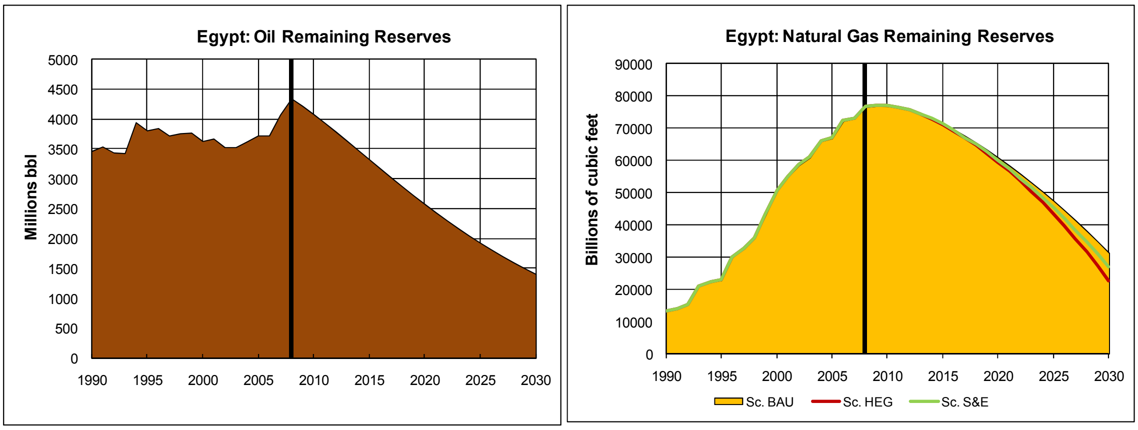
3.3 Egypt's Oil and Gas Reserves: Perspectives and Strategic Interrelationship

The future of Egypt's oil and gas resource is characterized by dwindling remaining reserves. However, there is a very important difference in the scale and time for these two resources. Whereas the decline in oil has been experienced for more than a decade and kept at bay only by reduced production and intensive exploration activity, natural gas production still can be expanded and kept at a higher level for more than a decade. As projections show, however, it is inevitable that after 2020 the reserves-to-production ratio will fall to an unsustainable level in the natural gas sector as well. Policy choices made today can influence both the point in time and the scope of the issue in the future. The three domestic energy demand scenarios demonstrate the potential outcomes via their differing trend lines for remaining reserves.

Despite Egypt's enormous natural gas reserves, exhaustion of these resources must be taken into account in current policy decisions, particularly when these decisions fix or preempt long-term situations and options. This is particularly the case with electricity generation, where the choice of technology today contributes to the structure of generation capacity for the next 30 years. But it also applies to strategies in the residential sector, where gas supply pipelines have a lifetime of more than 30 years. In the case of the transport sector, the supply and usage systems have a shorter lifetime. In any case, natural gas is an exhaustible resource, and today's consumption contributes to the remaining reserves forever.

Even beyond its current remarkable planned advances in renewable energy, Egypt can further preserve the horizon of its oil and natural gas reserves in order to maintain exports and produce financial resources for economic and social development.[lxxiii] (See Figure 50.)

Figure 50. Egypt's Remaining Oil and Natural Gas Reserves, 1990–2030



Source: Author's analysis

Within the energy sector, this means, among other things, that oil and gas activities have to be efficient in order to avoid a premature exhaustion of reserves, absorb the labor force and pay salaries according to productivity, preserve natural resources, and avoid damages from oil spills and natural gas flaring that may degrade the local and global environment, with associated impacts on human health.

Beyond the energy sector, expansion of oil and gas activities must secure long-term supply to other productive activities and population demands (Input-Output).

4. Final Considerations

This short study relies on straightforward use of the scenario technique to assess Egypt's energy sector. It does not assume dynamic adjustments that would be undertaken within real-life policy to respond to certain obvious deficits in developments. In reality, it may well be that policy will necessarily switch from the HEG scenario to the S&E scenario during the contemplated time horizon. Or, policy may take even more radical steps.

The study has not described with precision the kinds of policies and their costs, which would lead to the quantitative effects of energy flows. Nor has it attempted to assess the benefits. In future studies, such reactions and further scenarios can be studied and submitted for analysis.

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Annexes

I. Energy Balances

1. Base Balance

Country: Egypt
Base Balance
Year: 2007
Unit: Thousand TeraJoule

	Electricity	Oil Products	Solid Fuels	Crude Oil	Natural Gas	Hydropower	Renewables	Non Energy	Total
Production	0	0	1	1,428	2,099	147	69	0	3,743
Imports	1	169	50	102	0	0	0	0	323
Exports	-3	-270	-15	-92	-568	0	0	-1	-949
From Stock Change	0	7	0	-28	0	0	0	0	-21
Total Primary Supply	**-2**	**-94**	**36**	**1,410**	**1,531**	**147**	**69**	**-1**	**3,096**
Natural Gas pipelines	0	0	0	0	-285	0	0	0	-285
Refineries	0	1,298	18	-1,384	0	0	0	67	-2
Treat. Natural Gas	0	62	0	0	-62	0	0	0	0
Power Generation	451	-194	0	0	-751	-147	-7	0	-648
Electricity Distribution	-65	0	0	0	0	0	0	0	-65
Total Transformation	**386**	**1,166**	**18**	**-1,384**	**-1,099**	**-147**	**-7**	**67**	**-1,000**
Own Consumption	0	54	19	26	0	0	0	0	100
Tranportation	0	494	0	0	13	0	0	0	506
Industry	133	254	17	0	280	0	32	0	717
Residential	145	189	0	0	31	0	30	0	395
Comercial Ss. and Public	61	0	0	0	0	0	0	0	61
Agro, Fishing, and Mining	15	81	0	0	0	0	0	0	96
Construction and Other	30	0	0	0	0	0	0	0	30
Non Energy	0	0	18	0	108	0	0	66	192
Total Demand	**384**	**1,072**	**54**	**26**	**432**	**0**	**62**	**66**	**2,096**

2. BAU Scenario

Country: Egypt

Scenario: BAU

Year: 2010

Unit: Thousand TeraJoule

	Electricity	Oil Products	Solid Fuels	Crude Oil	Natural Gas	Hydropower	Renewables	Solar Heat	Non Energy	Total
Production	0	0	1	1,368	2,195	150	114	0	0	3,827
Imports	0	223	54	158	0	0	0	2	6	443
Exports	0	-270	-15	-92	-588	0	0	0	0	-965
From Stock Change	0	5	0	-20	0	0	0	0	0	-15
Total Primary Supply	**0**	**-42**	**40**	**1,413**	**1,607**	**150**	**114**	**2**	**6**	**3,289**
Natural Gas pipelines	0	0	0	0	-295	0	0	0	0	-295
Refineries	0	1,298	18	-1,384	0	0	0	0	67	-2
Treat. Natural Gas	0	62	0	0	-62	0	0	0	0	0
Power Generation	490	-144	0	0	-767	-150	-47	0	0	-619
Electricity Distribution	-58	0	0	0	0	0	0	0	0	-58
Total Transformation	**432**	**1,215**	**18**	**-1,384**	**-1,125**	**-150**	**-47**	**0**	**67**	**-974**
Own Consumption	0	60	21	29	0	0	0	0	0	110
Tranportation	0	539	0	0	17	0	0	0	0	557
Industry	147	280	19	0	309	0	35	0	0	790
Residential	169	205	0	0	36	0	32	2	0	444
Comercial Ss. and Public	66	0	0	0	0	0	0	0	0	66
Agro, Fishing, and Mining	17	89	0	0	0	0	0	0	0	106
Construction and Other	33	0	0	0	0	0	0	0	0	33
Non Energy	0	0	18	0	119	0	0	0	72	209
Total Demand	**432**	**1,174**	**58**	**29**	**482**	**0**	**67**	**2**	**72**	**2,315**

Country: Egypt

Scenario: BAU

Year: 2015

Unit: Thousand TeraJoule

	Electricity	Oil Products	Solid Fuels	Crude Oil	Natural Gas	Hydropower	Renewables	Solar Heat	Non Energy	Total
Production	0	0	1	1,145	2,514	152	211	0	0	4,022
Imports	0	385	62	378	0	0	0	7	20	852
Exports	0	-227	-15	-92	-660	0	0	0	0	-993
From Stock Change	0	3	0	-12	0	0	0	0	0	-9
Total Primary Supply	**0**	**161**	**48**	**1,419**	**1,854**	**152**	**211**	**7**	**20**	**3,872**
Natural Gas pipelines	0	0	0	0	-329	0	0	0	0	-329
Refineries	0	1,298	18	-1,384	0	0	0	0	67	-2
Treat. Natural Gas	0	62	0	0	-62	0	0	0	0	0
Power Generation	589	-132	0	0	-870	-152	-136	0	0	-701
Electricity Distribution	-59	0	0	0	0	0	0	0	0	-59
Total Transformation	**530**	**1,227**	**18**	**-1,384**	**-1,261**	**-152**	**-136**	**0**	**67**	**-1,091**
Own Consumption	0	71	25	35	0	0	0	0	0	132
Tranportation	0	639	0	0	32	0	0	0	0	671
Industry	176	336	23	0	371	0	42	0	0	947
Residential	217	236	0	0	47	0	33	7	0	541
Comercial Ss. and Public	79	0	0	0	0	0	0	0	0	79
Agro, Fishing, and Mining	20	106	0	0	0	0	0	0	0	126
Construction and Other	38	0	0	0	0	0	0	0	0	38
Non Energy	0	0	18	0	143	0	0	0	87	248
Total Demand	**530**	**1,389**	**66**	**35**	**593**	**0**	**75**	**7**	**87**	**2,781**

Country: Egypt

Scenario: BAU

Year: 2020

Unit: Thousand TeraJoule

	Electricity	Oil Products	Solid Fuels	Crude Oil	Natural Gas	Hydropower	Renewables	Solar Heat	Nuclear	Non Energy	Total
Production	0	0	1	913	2,815	152	304	0	73	0	4,257
Imports	0	558	70	611	0	0	0	15	0	35	1,290
Exports	0	-192	-15	-92	-696	0	0	0	0	0	-994
From Stock Change	0	2	0	-7	0	0	0	0	0	0	-5
Total Primary Supply	**0**	**368**	**56**	**1,425**	**2,119**	**152**	**304**	**15**	**73**	**35**	**4,547**
Natural Gas pipelines	0	0	0	0	-365	0	0	0	0	0	-365
Refineries	0	1,298	18	-1,384	0	0	0	0	0	67	-2
Treat. Natural Gas	0	62	0	0	-62	0	0	0	0	0	0
Power Generation	714	-111	0	0	-971	-152	-220	0	-73	0	-814
Electricity Distribution	-71	0	0	0	0	0	0	0	0	0	-71
Total Transformation	**642**	**1,249**	**18**	**-1,384**	**-1,399**	**-152**	**-220**	**0**	**-73**	**67**	**-1,252**
Own Consumption	0	84	30	41	0	0	0	0	0	0	155
Tranportation	0	743	0	0	55	0	0	0	0	0	799
Industry	207	394	27	0	435	0	49	0	0	0	1,112
Residential	277	270	0	0	62	0	34	15	0	0	658
Comercial Ss. and Public	92	0	0	0	0	0	0	0	0	0	92
Agro, Fishing, and Mining	23	125	0	0	0	0	0	0	0	0	148
Construction and Other	43	0	0	0	0	0	0	0	0	0	43
Non Energy	0	0	18	0	168	0	0	0	0	102	288
Total Demand	**642**	**1,617**	**74**	**41**	**721**	**0**	**83**	**15**	**0**	**102**	**3,295**

Country: Egypt

Scenario: BAU

Year: 2025

Unit: Thousand TeraJoule

	Electricity	Oil Products	Solid Fuels	Crude Oil	Natural Gas	Hydropower	Renewables	Solar Heat	Nuclear	Non Energy	Total
Production	0	0	1	700	3,115	152	440	0	146	0	4,553
Imports	0	754	79	828	0	0	0	24	0	51	1,737
Exports	0	-167	-15	-92	-696	0	0	0	0	0	-969
From Stock Change	0	1	0	-4	0	0	0	0	0	0	-3
Total Primary Supply	**0**	**589**	**65**	**1,431**	**2,419**	**152**	**440**	**24**	**146**	**51**	**5,318**
Natural Gas pipelines	0	0	0	0	-406	0	0	0	0	0	-406
Refineries	0	1,298	18	-1,384	0	0	0	0	0	67	-2
Treat. Natural Gas	0	62	0	0	-62	0	0	0	0	0	0
Power Generation	861	-93	0	0	-1,084	-152	-350	0	-146	0	-964
Electricity Distribution	-86	0	0	0	0	0	0	0	0	0	-86
Total Transformation	**774**	**1,267**	**18**	**-1,384**	**-1,552**	**-152**	**-350**	**0**	**-146**	**67**	**-1,457**
Own Consumption	0	97	35	47	0	0	0	0	0	0	179
Tranportation	0	851	0	0	90	0	0	0	0	0	942
Industry	239	455	31	0	503	0	57	0	0	0	1,284
Residential	354	308	0	0	80	0	34	24	0	0	800
Comercial Ss. and Public	105	0	0	0	0	0	0	0	0	0	105
Agro, Fishing, and Mining	27	144	0	0	0	0	0	0	0	0	171
Construction and Other	49	0	0	0	0	0	0	0	0	0	49
Non Energy	0	0	18	0	195	0	0	0	0	118	330
Total Demand	**774**	**1,855**	**83**	**47**	**868**	**0**	**90**	**24**	**0**	**118**	**3,860**

Country: Egypt

Scenario: BAU

Year: 2030

Unit: Thousand TeraJoule

	Electricity	Oil Products	Solid Fuels	Crude Oil	Natural Gas	Hydropower	Renewables	Solar Heat	Nuclear	Non Energy	Total
Production	0	0	1	519	3,622	152	567	0	146	0	5,007
Imports	0	1,010	88	1,013	0	0	0	34	0	68	2,214
Exports	0	-159	-15	-92	-745	0	0	0	0	0	-1,011
From Stock Change	0	1	0	-2	0	0	0	0	0	0	-2
Total Primary Supply	**0**	**852**	**74**	**1,438**	**2,877**	**152**	**567**	**34**	**146**	**68**	**6,208**
Natural Gas pipelines	0	0	0	0	-468	0	0	0	0	0	-468
Refineries	0	1,298	18	-1,384	0	0	0	0	0	67	-2
Treat. Natural Gas	0	62	0	0	-62	0	0	0	0	0	0
Power Generation	1,035	-106	0	0	-1,309	-152	-470	0	-146	0	-1,148
Electricity Distribution	-104	0	0	0	0	0	0	0	0	0	-104
Total Transformation	**932**	**1,253**	**18**	**-1,384**	**-1,839**	**-152**	**-470**	**0**	**-146**	**67**	**-1,722**
Own Consumption	0	111	39	54	0	0	0	0	0	0	204
Tranportation	0	963	0	0	141	0	0	0	0	0	1,104
Industry	272	519	35	0	573	0	65	0	0	0	1,464
Residential	455	349	0	0	103	0	32	34	0	0	974
Comercial Ss. and Public	119	0	0	0	0	0	0	0	0	0	119
Agro, Fishing, and Mining	30	163	0	0	0	0	0	0	0	0	194
Construction and Other	54	0	0	0	0	0	0	0	0	0	54
Non Energy	0	0	18	0	222	0	0	0	0	135	374
Total Demand	**932**	**2,105**	**92**	**54**	**1,039**	**0**	**96**	**34**	**0**	**135**	**4,487**

3. HEG Scenario

Country: Egypt

Scenario: HEG

Year: 2010

Unit: Thousand TeraJoule

	Electricity	Oil Products	Solid Fuels	Crude Oil	Natural Gas	Hydropower	Renewables	Solar Heat	Non Energy	Total
Production	0	0	1	1,368	2,256	150	115	0	0	3,890
Imports	0	257	56	159	0	0	0	2	8	482
Exports	0	-247	-15	-92	-588	0	0	0	0	-942
From Stock Change	0	5	0	-20	0	0	0	0	0	-15
Total Primary Supply	**0**	**15**	**42**	**1,414**	**1,668**	**150**	**115**	**2**	**8**	**3,415**
Natural Gas pipelines	0	0	0	0	-304	0	0	0	0	-304
Refineries	0	1,298	18	-1,384	0	0	0	0	67	-2
Treat. Natural Gas	0	62	0	0	-62	0	0	0	0	0
Power Generation	507	-160	0	0	-800	-150	-47	0	0	-650
Electricity Distribution	-60	0	0	0	0	0	0	0	0	-60
Total Transformation	**447**	**1,200**	**18**	**-1,384**	**-1,166**	**-150**	**-47**	**0**	**67**	**-1,015**
Own Consumption	0	62	22	30	0	0	0	0	0	114
Tranportation	0	559	0	0	20	0	0	0	0	579
Industry	153	291	20	0	321	0	36	0	0	821
Residential	175	211	0	0	37	0	32	2	0	457
Comercial Ss. and Public	69	0	0	0	0	0	0	0	0	69
Agro, Fishing, and Mining	17	92	0	0	0	0	0	0	0	110
Construction and Other	34	0	0	0	0	0	0	0	0	34
Non Energy	0	0	18	0	124	0	0	0	75	217
Total Demand	**447**	**1,215**	**59**	**30**	**502**	**0**	**68**	**2**	**75**	**2,400**

Country: Egypt

Scenario: HEG

Year: 2015

Unit: Thousand TeraJoule

	Electricity	Oil Products	Solid Fuels	Crude Oil	Natural Gas	Hydropower	Renewables	Solar Heat	Non Energy	Total
Production	0	0	1	1,145	2,692	152	215	0	0	4,204
Imports	0	481	66	381	0	0	0	8	27	962
Exports	0	-179	-15	-92	-660	0	0	0	0	-945
From Stock Change	0	3	0	-12	0	0	0	0	0	-9
Total Primary Supply	**0**	**305**	**52**	**1,422**	**2,032**	**152**	**215**	**8**	**27**	**4,212**
Natural Gas pipelines	0	0	0	0	-353	0	0	0	0	-353
Refineries	0	1,298	18	-1,384	0	0	0	0	67	-2
Treat. Natural Gas	0	62	0	0	-62	0	0	0	0	0
Power Generation	639	-168	0	0	-969	-152	-136	0	0	-786
Electricity Distribution	-64	0	0	0	0	0	0	0	0	-64
Total Transformation	**575**	**1,191**	**18**	**-1,384**	**-1,384**	**-152**	**-136**	**0**	**67**	**-1,205**
Own Consumption	0	77	27	38	0	0	0	0	0	142
Tranportation	0	687	0	0	42	0	0	0	0	729
Industry	190	363	24	0	400	0	45	0	0	1,023
Residential	237	254	0	0	51	0	34	8	0	584
Comercial Ss. and Public	85	0	0	0	0	0	0	0	0	85
Agro, Fishing, and Mining	21	115	0	0	0	0	0	0	0	136
Construction and Other	41	0	0	0	0	0	0	0	0	41
Non Energy	0	0	18	0	155	0	0	0	94	266
Total Demand	**575**	**1,497**	**70**	**38**	**648**	**0**	**79**	**8**	**94**	**3,007**

Country: Egypt

Scenario: HEG

Year: 2020

Unit: Thousand TeraJoule

	Electricity	Oil Products	Solid Fuels	Crude Oil	Natural Gas	Hydropower	Renewables	Solar Heat	Nuclear	Non Energy	Total
Production	0	0	1	913	3,206	152	310	0	73	0	4,655
Imports	0	828	79	617	0	0	0	17	0	50	1,592
Exports	0	-168	-15	-92	-696	0	0	0	0	0	-970
From Stock Change	0	2	0	-7	0	0	0	0	0	0	-5
Total Primary Supply	**0**	**662**	**65**	**1,431**	**2,511**	**152**	**310**	**17**	**73**	**50**	**5,272**
Natural Gas pipelines	0	0	0	0	-418	0	0	0	0	0	-418
Refineries	0	1,298	18	-1,384	0	0	0	0	0	67	-2
Treat. Natural Gas	0	62	0	0	-62	0	0	0	0	0	0
Power Generation	820	-180	0	0	-1,180	-152	-220	0	-73	0	-985
Electricity Distribution	-82	0	0	0	0	0	0	0	0	0	-82
Total Transformation	**738**	**1,180**	**18**	**-1,384**	**-1,660**	**-152**	**-220**	**0**	**-73**	**67**	**-1,487**
Own Consumption	0	96	34	47	0	0	0	0	0	0	178
Tranportation	0	846	0	0	88	0	0	0	0	0	934
Industry	237	452	30	0	499	0	56	0	0	0	1,275
Residential	319	305	0	0	70	0	34	17	0	0	745
Comercial Ss. and Public	105	0	0	0	0	0	0	0	0	0	105
Agro, Fishing, and Mining	27	143	0	0	0	0	0	0	0	0	170
Construction and Other	50	0	0	0	0	0	0	0	0	0	50
Non Energy	0	0	18	0	193	0	0	0	0	117	328
Total Demand	**738**	**1,842**	**82**	**47**	**850**	**0**	**90**	**17**	**0**	**117**	**3,784**

Country: Egypt

Scenario: HEG

Year: 2025

Unit: Thousand TeraJoule

	Electricity	Oil Products	Solid Fuels	Crude Oil	Natural Gas	Hydropower	Renewables	Solar Heat	Nuclear	Non Energy	Total
Production	0	0	1	700	3,875	152	452	0	146	0	5,325
Imports	0	1,270	95	839	0	0	0	29	0	80	2,312
Exports	0	-154	-15	-92	-696	0	0	0	0	0	-956
From Stock Change	0	1	0	-4	0	0	0	0	0	0	-3
Total Primary Supply	**0**	**1,117**	**81**	**1,443**	**3,180**	**152**	**452**	**29**	**146**	**80**	**6,678**
Natural Gas pipelines	0	0	0	0	-509	0	0	0	0	0	-509
Refineries	0	1,298	18	-1,384	0	0	0	0	0	67	-2
Treat. Natural Gas	0	62	0	0	-62	0	0	0	0	0	0
Power Generation	1,056	-210	0	0	-1,464	-152	-350	0	-146	0	-1,265
Electricity Distribution	-106	0	0	0	0	0	0	0	0	0	-106
Total Transformation	**951**	**1,150**	**18**	**-1,384**	**-2,035**	**-152**	**-350**	**0**	**-146**	**67**	**-1,881**
Own Consumption	0	120	43	59	0	0	0	0	0	0	222
Tranportation	0	1,041	0	0	186	0	0	0	0	0	1,227
Industry	296	564	38	0	622	0	70	0	0	0	1,589
Residential	431	364	0	0	95	0	32	29	0	0	951
Comercial Ss. and Public	130	0	0	0	0	0	0	0	0	0	130
Agro, Fishing, and Mining	33	178	0	0	0	0	0	0	0	0	211
Construction and Other	60	0	0	0	0	0	0	0	0	0	60
Non Energy	0	0	18	0	241	0	0	0	0	146	405
Total Demand	**951**	**2,267**	**98**	**59**	**1,145**	**0**	**102**	**29**	**0**	**146**	**4,796**

Country: Egypt

Scenario: HEG

Year: 2030

Unit: Thousand TeraJoule

	Electricity	Oil Products	Solid Fuels	Crude Oil	Natural Gas	Hydropower	Renewables	Solar Heat	Nuclear	Non Energy	Total
Production	0	0	1	519	4,978	152	584	0	146	0	6,380
Imports	14	1,860	115	1,033	0	0	0	43	0	116	3,180
Exports	0	-137	-15	-92	-745	0	0	0	0	0	-989
From Stock Change	0	1	0	-2	0	0	0	0	0	0	-2
Total Primary Supply	**14**	**1,724**	**101**	**1,457**	**4,233**	**152**	**584**	**43**	**146**	**116**	**8,570**
Natural Gas pipelines	0	0	0	0	-652	0	0	0	0	0	-652
Refineries	0	1,298	18	-1,384	0	0	0	0	0	67	-2
Treat. Natural Gas	0	62	0	0	-62	0	0	0	0	0	0
Power Generation	1,351	-295	0	0	-1,920	-152	-470	0	-146	0	-1,632
Electricity Distribution	-136	0	0	0	0	0	0	0	0	0	-136
Total Transformation	**1,214**	**1,065**	**18**	**-1,384**	**-2,635**	**-152**	**-470**	**0**	**-146**	**67**	**-2,423**
Own Consumption	0	150	53	73	0	0	0	0	0	0	277
Tranportation	0	1,282	0	0	394	0	0	0	0	0	1,676
Industry	369	702	47	0	775	0	87	0	0	0	1,981
Residential	583	433	0	0	129	0	26	43	0	0	1,213
Comercial Ss. and Public	161	0	0	0	0	0	0	0	0	0	161
Agro, Fishing, and Mining	41	221	0	0	0	0	0	0	0	0	262
Construction and Other	74	0	0	0	0	0	0	0	0	0	74
Non Energy	0	0	18	0	301	0	0	0	0	183	502
Total Demand	**1,228**	**2,788**	**118**	**73**	**1,599**	**0**	**113**	**43**	**0**	**183**	**6,146**

4. S&E Scenario

Country: Egypt

Scenario: S&E

Year: 2010

Unit: Thousand TeraJoule

	Electricity	Oil Products	Solid Fuels	Crude Oil	Natural Gas	Hydropower	Renewables	Solar Heat	Non Energy	Total
Production	0	0	1	1,368	2,248	150	112	0	0	3,879
Imports	0	219	55	159	0	0	0	4	8	446
Exports	0	-268	-15	-92	-588	0	0	0	0	-963
From Stock Change	0	5	0	-20	0	0	0	0	0	-15
Total Primary Supply	**0**	**-43**	**41**	**1,414**	**1,660**	**150**	**112**	**4**	**8**	**3,347**
Natural Gas pipelines	0	0	0	0	-303	0	0	0	0	-303
Refineries	0	1,298	18	-1,384	0	0	0	0	67	-2
Treat. Natural Gas	0	62	0	0	-62	0	0	0	0	0
Power Public Generation	506	-158	0	0	-798	-150	-47	0	0	-648
Electricity Distribution	-60	0	0	0	0	0	0	0	0	-60
Total Transformation	**446**	**1,202**	**18**	**-1,384**	**-1,163**	**-150**	**-47**	**0**	**67**	**-1,012**
Own Consumption	0	62	22	30	0	0	0	0	0	114
Tranportation	3	550	0	0	18	0	0	0	0	571
Industry	150	263	19	0	316	0	35	0	0	783
Residential	173	191	0	0	40	0	29	4	0	438
Comercial Ss. and Public	69	0	0	0	0	0	0	0	0	69
Agro, Fishing, and Mining	17	92	0	0	0	0	0	0	0	110
Construction and Other	34	0	0	0	0	0	0	0	0	34
Non Energy	0	0	18	0	124	0	0	0	75	217
Total Demand	**446**	**1,158**	**59**	**30**	**498**	**0**	**65**	**4**	**75**	**2,335**

Country: Egypt

Scenario: S&E

Year: 2015

Unit: Thousand TeraJoule

	Electricity	Oil Products	Solid Fuels	Crude Oil	Natural Gas	Hydropower	Renewables	Solar Heat	Non Energy	Total
Production	0	0	1	1,145	2,645	152	210	0	0	4,153
Imports	0	501	64	381	0	0	0	17	52	1,015
Exports	0	-413	-15	-92	-660	0	0	0	0	-1,179
From Stock Change	0	3	0	-12	0	0	0	0	0	-9
Total Primary Supply	**0**	**91**	**50**	**1,422**	**1,986**	**152**	**210**	**17**	**52**	**3,979**
Natural Gas pipelines	0	0	0	0	-347	0	0	0	0	-347
Refineries	0	1,322	18	-1,384	0	0	0	0	42	-2
Treat. Natural Gas	0	62	0	0	-62	0	0	0	0	0
Power Public Generation	631	-161	0	0	-948	-152	-142	0	0	-771
Electricity Distribution	-63	0	0	0	0	0	0	0	0	-63
Total Transformation	**567**	**1,223**	**18**	**-1,384**	**-1,357**	**-152**	**-142**	**0**	**42**	**-1,184**
Own Consumption	0	77	27	38	0	0	0	0	0	142
Tranportation	11	659	0	0	34	0	0	0	0	703
Industry	182	272	22	0	382	0	42	0	0	901
Residential	227	191	0	0	58	0	26	17	0	520
Comercial Ss. and Public	85	0	0	0	0	0	0	0	0	85
Agro, Fishing, and Mining	21	115	0	0	0	0	0	0	0	136
Construction and Other	41	0	0	0	0	0	0	0	0	41
Non Energy	0	0	18	0	155	0	0	0	94	266
Total Demand	**567**	**1,315**	**67**	**38**	**629**	**0**	**68**	**17**	**94**	**2,795**

Country: Egypt

Scenario: S&E

Year: 2020

Unit: Thousand TeraJoule

	Electricity	Oil Products	Solid Fuels	Crude Oil	Natural Gas	Hydropower	Renewables	Solar Heat	Nuclear	Non Energy	Total
Production	0	0	1	913	3,056	152	336	0	73	0	4,530
Imports	0	599	74	617	0	0	0	35	0	81	1,407
Exports	0	-345	-15	-92	-696	0	0	0	0	0	-1,147
From Stock Change	0	2	0	-7	0	0	0	0	0	0	-5
Total Primary Supply	**0**	**256**	**60**	**1,431**	**2,360**	**152**	**336**	**35**	**73**	**81**	**4,785**
Natural Gas pipelines	0	0	0	0	-398	0	0	0	0	0	-398
Refineries	0	1,328	18	-1,384	0	0	0	0	0	36	-2
Treat. Natural Gas	0	62	0	0	-62	0	0	0	0	0	0
Power Public Generation	796	-155	0	0	-1,101	-152	-265	0	-73	0	-950
Electricity Distribution	-80	0	0	0	0	0	0	0	0	0	-80
Total Transformation	**717**	**1,235**	**18**	**-1,384**	**-1,561**	**-152**	**-265**	**0**	**-73**	**36**	**-1,430**
Own Consumption	0	96	34	47	0	0	0	0	0	0	178
Tranportation	20	789	0	0	63	0	0	0	0	0	872
Industry	220	277	26	0	461	0	50	0	0	0	1,035
Residential	294	185	0	0	83	0	21	35	0	0	618
Comercial Ss. and Public	105	0	0	0	0	0	0	0	0	0	105
Agro, Fishing, and Mining	27	143	0	0	0	0	0	0	0	0	170
Construction and Other	50	0	0	0	0	0	0	0	0	0	50
Non Energy	0	0	18	0	193	0	0	0	0	117	328
Total Demand	**717**	**1,491**	**78**	**47**	**799**	**0**	**71**	**35**	**0**	**117**	**3,355**

Country: Egypt

Scenario: S&E

Year: 2025

Unit: Thousand TeraJoule

	Electricity	Oil Products	Solid Fuels	Crude Oil	Natural Gas	Hydropower	Renewables	Solar Heat	Nuclear	Non Energy	Total
Production	0	0	1	700	3,484	152	586	0	146	0	5,068
Imports	0	726	87	839	0	0	0	49	0	110	1,812
Exports	0	-282	-15	-92	-696	0	0	0	0	0	-1,085
From Stock Change	0	1	0	-4	0	0	0	0	0	0	-3
Total Primary Supply	**0**	**445**	**73**	**1,443**	**2,788**	**152**	**586**	**49**	**146**	**110**	**5,793**
Natural Gas Pipelines	0	0	0	0	-456	0	0	0	0	0	-456
Refineries	0	1,328	18	-1,384	0	0	0	0	0	36	-2
Treat. Natural Gas	0	62	0	0	-62	0	0	0	0	0	0
Power Generation	1,005	-147	0	0	-1,245	-152	-514	0	-146	0	-1,199
Electricity Distribution	-100	0	0	0	0	0	0	0	0	0	-100
Total Transformation	**904**	**1,243**	**18**	**-1,384**	**-1,763**	**-152**	**-514**	**0**	**-146**	**36**	**-1,757**
Own Consumption	0	120	43	59	0	0	0	0	0	0	222
Tranportation	25	945	0	0	116	0	0	0	0	0	1,086
Industry	266	276	30	0	554	0	60	0	0	0	1,186
Residential	389	170	0	0	114	0	12	49	0	0	734
Comercial Ss. and Public	130	0	0	0	0	0	0	0	0	0	130
Agro, Fishing, and Mining	33	178	0	0	0	0	0	0	0	0	211
Construction and Other	60	0	0	0	0	0	0	0	0	0	60
Non Energy	0	0	18	0	241	0	0	0	0	146	405
Total Demand	**904**	**1,688**	**91**	**59**	**1,025**	**0**	**72**	**49**	**0**	**146**	**4,035**

Country: Egypt

Scenario: S&E

Year: 2030

Unit: Thousand TeraJoule

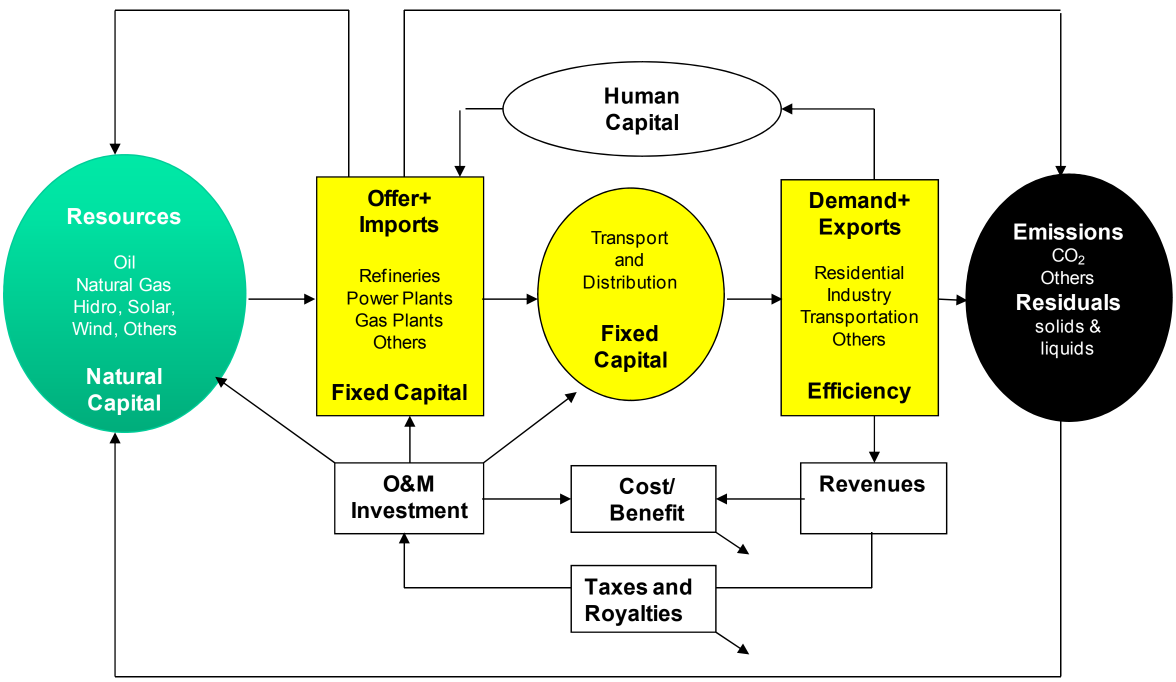
	Electricity	Oil Products	Solid Fuels	Crude Oil	Natural Gas	Hydropower	Renewables	Solar Heat	Nuclear	Non Energy	Total
Production	0	0	1	519	4,234	152	841	0	146	0	5,892
Imports	0	926	103	1,033	0	0	0	61	0	147	2,269
Exports	0	-219	-15	-92	-745	0	0	0	0	0	-1,071
From Stock Change	0	1	0	-2	0	0	0	0	0	0	-2
Total Primary Supply	**0**	**708**	**89**	**1,457**	**3,489**	**152**	**841**	**61**	**146**	**147**	**7,088**
Natural Gas Pipelines	0	0	0	0	-551	0	0	0	0	0	-551
Refineries	0	1,328	18	-1,384	0	0	0	0	0	36	-2
Treat. Natural Gas	0	62	0	0	-62	0	0	0	0	0	0
Power Public Generation	**1,266**	**-187**	**0**	**0**	**-1,541**	**-152**	**-769**	**0**	**-146**	**0**	**-1,529**
Electricity Distribution	-127	0	0	0	0	0	0	0	0	0	-127
Total Transformation	1,140	1,203	18	-1,384	-2,154	-152	-769	0	-146	36	-2,209
Own Consumption	0	150	53	73	0	0	0	0	0	0	277
Tranportation	28	1,132	0	0	215	0	0	0	0	0	1,374
Industry	320	266	35	0	665	0	71	0	0	0	1,357
Residential	515	142	0	0	154	0	0	61	0	0	871
Comercial Ss. and Public	161	0	0	0	0	0	0	0	0	0	161
Agro, Fishing, and Mining	41	221	0	0	0	0	0	0	0	0	262
Construction and Other	74	0	0	0	0	0	0	0	0	0	74
Non Energy	0	0	18	0	301	0	0	0	0	183	502
Total Demand	**1,140**	**1,910**	**106**	**73**	**1,335**	**0**	**71**	**61**	**0**	**183**	**4,879**

II. Methodological Annex

1. Conceptual Framework

This energy prospective for Egypt utilizes an "energy matrix" conceptual framework that evaluates the energy flows associated with natural resources, their emissions and residuals, and energy consumption, within a certain date range. (See Figure 1.) The center of the diagram is the Energy Balance (three central blocks).

Figure 1. Energy Matrix



Source: Based on Wuppertal Institut für Klima, "Zukunftsfähiges Deutschland. Ein Beintrag zu einer global nachhaltigen Entwicklung" (Westfalen: 1995).

2. The Energy Model

Based on the above conceptual framework, the present study developed a simulation model that includes the following stages:

- **Energy demand by sector**. For each sector, the study considers behavioral equations based on energy intensity parameters that vary depending on the respective drivers and balance equations for these sources and sectors. The initial data correspond to the energy balance of the base year.
- **Supply of transformation centers**: For each center, the supply sequence is defined with regard to the above. In each center, the analysis considers the capacities, availability, plant efficiencies, and mix of inputs.
- **Resources and reserves:** These are quantified based on country data, taking into account both production and the potential for exhaustion.
- **Energy balance:** The consistency of the data is verified each year using the respective energy balance.

- **Environmental impacts:** These are calculated based on the energy coefficients for each energy source for final consumption, own consumption, inputs for electricity generation, and refinery losses. They do not consider the impacts of natural gas flaring during extraction.

The model starts from an energy balance for the base year 2007. For each future year, final energy consumption estimates are generated in the various sectors. For the supply of the total final demand, the domestic transformation (mainly electricity and petroleum products) is elaborated, including transmission and other losses, which allows for a calculation of the domestic primary energy (PE) supply. The PE balance, including imports and exports and domestic production, is calculated from this domestic PE supply.

3. The Energy Scenarios

A scenario analysis was carried out to study the impacts of potential energy development and different policies on Egypt's oil and gas reserves. This resulted in three scenarios, which are intended not to predict the future but rather to analyze "what if." (See Figure 2.) The three secnarios are:

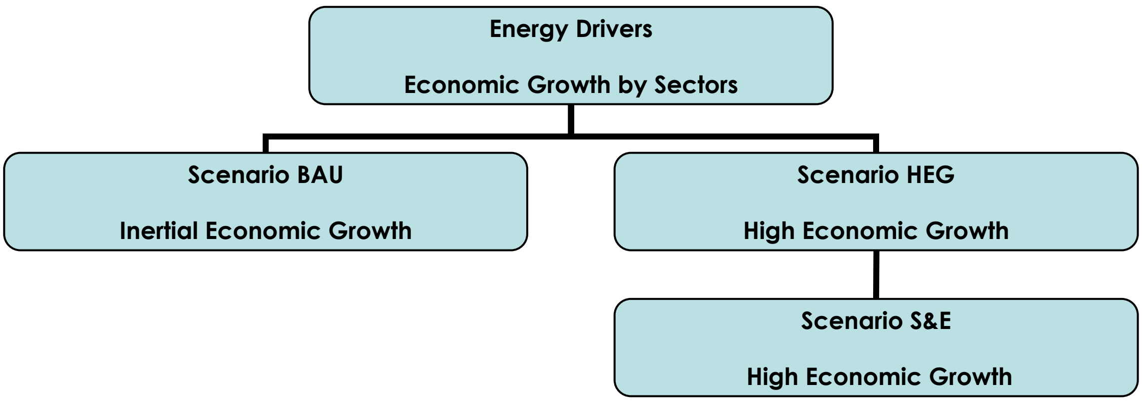
- **BAU (business-as-usual).** An inertial scenario that assumes a linear growth trend and little structural change.

- **HEG (high economic growth).** Assumes dynamic growth but little change in energy structure and policy. The difference in consumption between the BAU and HEG scenarios is due almost exclusively to varying assumptions about the principle drivers.

- **S&E (substitution and efficiency).** This scenario departs from the HEG scenario and assumes a substitution of energy sources in the consumption and transformation sectors due to a different and more vigorous energy policy, including the implementation of energy efficiency and more renewable energy, as is already in the pipeline.

These three scenarios allow for strategic comparison and analysis of the effects of growth, as well as the possible impacts of policies.

Figure 2. Three Scenarios



4. The Software

To analyze future energy development in Egypt, this study used a straightforward quantitative model, the "Long-range Energy Alternatives Planning System" (LEAP). Developed at the Stockholm Environment Institute (SEI), LEAP is a widely used software tool for energy policy analysis and climate change mitigation assessment. In addition, the study used specific simulation and optimization models in a partial context or integrated with this more general model. In particular, a dynamic model of the interplay of resources, additions to reserves, consumption, and remaining reserves was used to analyze the impact of oil and gas reserves.

5. Further Considerations

It is possible to improve future energy patterns through the use of a proper energy-sector prospective based on long-term objectives and policies that can be quantified, are consistent, and are viable.[3] Doing this requires information about the initial status of the energy system, which enables one to see the energy sector as a whole, then showing its interdependence from sector demand to primary energy production, going through the transformation centers (base year energy balance). This study performed this analysis by taking as references the IEA's Egyptian Energy Balance (2009) and information from BP (2009). (See Table 5.)

The formulation of a 10-energy plan requires taking a long-term analysis horizon of at least 20 to 25 years, such as the one performedin this study. Certain details can still be adjusted as new data become available, such as a classification of oil and gas fields by productive area, associated and non-associated natural gas, current and expected yields, cumulative production since the start of exploitation and the evolution of reserves for each field, development prospects and expected yields, probable possible reserves, and potential resources. With this information, it is possible to identify the future contributions of each field and area to total production and to redirect investments in exploration and development.

The inclusion of other energy sources in the analysis, particularly renewables and their corresponding expansion plans, may help to lower the pressure on oil and gas reserves. In this way, the energy prospective allows the definition of short- and medium-term paths, based on long-term objectives and energy policies, using the long-term view as a reference. The difference between the prospective and energy planning is that energy plans include quantified investments for specific projects for an determined medium- to long-term course, with both an operative (physical) plan and an investment (monetary) plan and financial structure to make it feasible.

All of this is possible by using integrated energy planning software like that used in this study.[4] This provides the advantages of analyzing oil and gas activities by fields, opening more scenarios, and altering the data and making new projections with greater detail and in a consistent context of calculations via a year by year energy balance. Having all these tools and information electronically can facilitate the work of energy officals at meetings and international events.

[3] See "Energy and Sustainable Development in Latin America and the Caribbean: Guide for Energy Policymaking," Proyect OLADE/CEPAL/GTZ, June 2000.
[4] A similar instrument, the Long-range Energy Alternatives Planning System, was used for OLADE's Energy Prospective of Latin America and the Caribbean 2007–32.

Endnotes

[i] DOE-EIA, May 2009.

[ii] Ibid.

[iii] Masters et al. 1994; BP 2009; USGS 2001.

[iv] See Masters et al. 1994 and USGS 2001, among others.

[v] Masters et al. 1994; BP 2009; USGS 2001.

[vi] Ibid.

[vii] Ibid.

[viii] Author's analysis based on USGS and BP information

[ix] Ibid.

[x] Author's analysis based on data from EIA, 2009.

[xi] Author's elaboration based on information from BP.

[xii] Masters et al. 1994; BP 2009; USGS 2001.

[xiii] See, for example, Masters et al. 1994; USGS; others.

[xiv] Masters et al. 1994; BP 2009; USGS 2001.

[xv] Ibid.

[xvi] Author's elaboration based on information from USGS and BP.

[xvii] Ibid.

[xviii] Author's elaboration based on information from BP and ENERINTER; Author's preparation based on information from USGS and BP.

[xix] CIF.

[xx] Ibid.

[xxi] AIE.

[xxii] EIA/DOE.

[xxiii] BP 2009.

[xxiv] Author's analysis based on data from IEA 2009.

[xxv] Ibid.; BP 2009.

[xxvi] Author's elaboration based on data from IEA 2009 and BP 2009.

[xxvii] United Nations' medium variant projection, per UN 2009.

[xxviii] UNDP 2009.

[xxix] WB 2009.

[xxx] Author's analysis based on data from UN 2009.

[xxxi] UN 2009.

[xxxii] Author's analysis based on data from UN 2009.

[xxxiii] Ibid.

[xxxiv] Ibid.

[xxxv] Author's analysis.

[xxxvi] Ibid.

[xxxvii] Ibid.

[xxxviii] Ibid.

[xxxix] Ibid.

[xl] Ibid.

[xli] Ibid.

[xlii] Ibid.

[xliii] Ibid.

[xliv] Ibid.

[xlv] EEHC 2009.

[xlvi] Author's analysis based on data in BP 2009.

[xlvii] Author estimates based on EEHC 2009.

[xlviii] Author's analysis.

[xlix] Ibid.

[l] Ibid.

[li] Ibid.

[lii] Ibid.

[liii] BP 2009 and author's analysis; historical demand from BP 2009.

[liv] Author's analysis.

[lv] Author's analysis based on data from BP 2009.

[lvi] Author's analysis.

[lvii] Ibid.

[lviii] Author's analysis

[lix] Masters et al. 1994, updated for 2008 based on BP information; Masters et al. 1994; BP 2009; USGS 2001.

[lx] USGS 2001.

[lxi] Author's analysis based on data from USGS 2001 and BP 2009.

[lxii] Author's analysis; historical information for 1990–2008 from BP 2009.

[lxiii] Historical information for 2000–08 from BP 2009.

[lxiv] DOE/EIA 2009.

[lxv] BP 2009.

[lxvi] DOE/EIA 2009.

[lxvii] Ibid.

[lxviii] Masters et al. 1994; BP 2009; USGS 2001.

[lxix] Author's analysis based on data from USGS 2001 and BP 2009.

[lxx] Ibid.

[lxxi] Author's analysis based on data from BP 2009.

[lxxii] Author's analysis; data for 1990–2008 from BP 2009.

[lxxiii] Author's analysis.