Poll Res. 40 (4) : 1105-1117 (2021)

ISSN 0257–8050

ENVIRONMENTAL AND COMMUNITY COSTS OF COAL FIRING IN CEMENT INDUSTRY

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(Received 31 November, 2020; accepted 3 April, 2021)

ABSTRACT

Air pollutants associated with burning Coal, which is the worst fossil fuels in terms of the quantity and quality of emissions harmful to the environment and human health. Besides Carbon Emissions, the combustion products include particulate matter (PM10, PM2.5) - Sulfur Oxides – Nitrogen Oxides - Carbon Monoxide - Hydrocarbons, in addition to a large number of toxic air pollutants such as Lead, Mercury, Dioxins and Furans, some of these pollutants spread at varying distances around the source and the distances increased to which the emissions travel in the wind direction until they reach more than 1,000 km for some pollutants such as particulate matter (PM 2.5) and mercury , increasing the number of people exposed to health risks affecting organs body, especially the Brain, Nervous system, Heart, Circulation and Respiratory system. Community incurred the costs associated with the use of Coal or any other fuel outside the plants, the cost is not such health treatment cost incurred by the community , but the unforeseen social and income loss consequences due to health deterioration and loss of jobs or life, regardless of the cost of fuel purchase. Developed countries rely on the development of strategies and policy-making on total costs (Including societal costs), i.e. external community costs (Externalities) in addition to the direct cost of buying or managing fuel.the government of Egypt (Environmental authorities) had imposed relatively high charges in return to import and use of coal as a fuel, in addition to a set of regulatory decrees and environmental limits on handling and burning Coal. But the environmental issues associated with the use of Coal as a fuel are still mortgaged to the ability of the Environmental authorities to implement these regulations and minimize the negative and health impacts of burning Coal as a fuel. In Egypt "Integrated and Sustainable Energy Strategy" EIES report issued in November , 2015, in the third section 3.5 Challenges, The strategy reported that the government of Egypt will do the following among other commitment actions: Support policies aimed at reducing greenhouse gas emissions, including the dissemination of ultra-critical Coal technologies as well as the reduction of air pollutant emissions in the energy sector. In this regard , there are two issues , first issue is :In reality, the government via the Environmental Authorities issued the rules and regulation of handling and use Coal as a fuel before issuing the so called " Support policies aimed at reducing greenhouse gas…..". prior to the date of declaring the strategy and the actions commitment to reduce air pollutants by one year nearly. The second issue is that the Government of Egypt in its policy commitment is focusing on the <u>Energy sector</u> and didn't mention any commitment to what should be done to alleviate the negative effect of air pollutants from industrial sector that are using Coal as a fuel(eg. Cement Industry) in the "Support policiy" although the industrial sector came in the first rank in energy consumption with 37.4% , and Cement industry came in the second rank in energy consumption after Iron & stell industry. In the context of widespread action to fight climate change,and as Coal remains the most polluting source of energy(It emits CO_2 twice as much as N.G), surprisingly enough that there are some 20 countries are turning to coal, including nine in Africa (Egypt one of them) In terms of coal, Egypt has no Coal mines except the Coal of Al Maghara (the cave) in Sinai Peninsula and its quantities are limited and not currently usable in practical and in economic terms. Hence, Egypt is a net importer for Coal, and are even expected to increase in the short-medium term,as a consequences

to the approval of Egyptian government to use coal as a fuel in April 2014. Since that date, 19 cement companies out of 22 companies are using coal in the energy mix with rates ranging between 85% to 95%. According to Egypt Second and Third National Communication Reports (SNC report May, 2010 and 3rd NC report Mars, 2016 - Green House Gas Inventory in Industrial Sector, respectively), indicate that the main sources of GHG emissions in the industrial processes are headed by Cement Industry according to data published in both reports. What supporting the superiority of cement industry to heading GHG emissions among other industrial sectors is that the average energy consumption in Egypt per ton of cement is much higher than the European average and the highest consumption rate in Germany. Meaning that there is a waste of energy in the Egyptian cement factories about 22% to 34%. This waste has two negative aspects. The first aspect is that this energy waste is subsided by the government for the industrial sector and the second aspect is that the waste of energy means directly an increase in GHG emissions that is not counted in the National Inventory for GHG emissions, and not counted in the Environmental Impact Assessment EIA studies submitted to EEAA to get the Environmental approval on using Coal as fuel in Cement industry. The Government of Egypt takes the view that a more diverse energy mix is a more secure energy mix as it is less vulnerable to fluctuations in the availability of any one fuel and to face challenges in energy sector. The EIES strategy comprises 5 scenarios. All scenarios except the third scenario excluding the use of Coal in energy production, but the rest four scenarios are emphasizing on the use of coal in energy production after 2019/2020 which is expect to reach up to 6%. The reason for that is the consumption of Coal is limited in Industrial sector to Iron production in Blast Furnace and Cement industry, and the consumption in Iron production almost constant , but Cement production is increasing rapidly (Yet Egypt has around 27.9 % over the market capacity) . In calculating community cost with reference to average consumption of production of 60 million tons / year of cement in Egypt using Coal as a fuel compared to European average consumption of Coal as a fuel to produce the same quantity revealed that the use of Coal instead of Natural Gas leads to the increased emissions of Nitrogen oxides by (22,899 tons), Sulfur Oxides (221.796 tons), Particulate matter PM10 (41.491 tons), PM2.5 (38.103 tons), Carbon emissions.9,323,321 tons, and that would increase the societal cost added to the National Economy by about (2.8-3.9) billion dollars annually. So, the new strategy for INTEGRATED SUSTAINABLE ENERGY STRATEGY TO 2035 in its best scenarios is dedicated for negative impacts of using Coal as a fuel in industrial sector for the next two decades.

KEY WORDS : Egypt, Coal, Environmental, Societal and economic impacts, Energy crisis, Natural gas, Egypt energy strategy, Energy mix.

INTRODUCTION

Before the discovery of oil, Coal was the main source of energy, especially in the industrialized countries where there are large reserves, especially in India, America, China and some European countries also large quantities in Australia and South Africa. By mid of nineteen century, and the emerging of petroleum era, industrial sector shifted towards petroleum as a fuel. With the evolution of petroleum prices with the first petroleum shock in 1973 and second petroleum shock in 1979 (Egypt in Figure), the prices of petroleum went up with high rates. With energy crisis emerged in Egypt beginning of 2011 and the interruption of electric supply due to the gap between production and demand (AFREC, 2017), which driven by populations growth and industrial development. Coal came back to the front as a an alternative fuel in thermal energy in power plants , a source of energy in Energy-intensive industries such as the cement industry, and as input to industrial processes for the production of metals such as iron, steel and aluminum, as the case in Egypt.

Egypt has been known to mainly depend in all its energy-related activities, on three major sources: Oil, Natural Gas and the Hydroelectric power generated from the large dam projects over the Nile: the High Dam, Aswan I and Aswan.

Despite being a major producer and net exporter of oil, especially in the 1990s, when its oil production peaked, reaching approximately over 900000 Barrel /day, Egypt has become a net oil importer around 2009/2010(EMP/EEA, 2013). This can be traced back to:

- Economic growth.
- Intense extraction projects of Oil and Natural Gas.

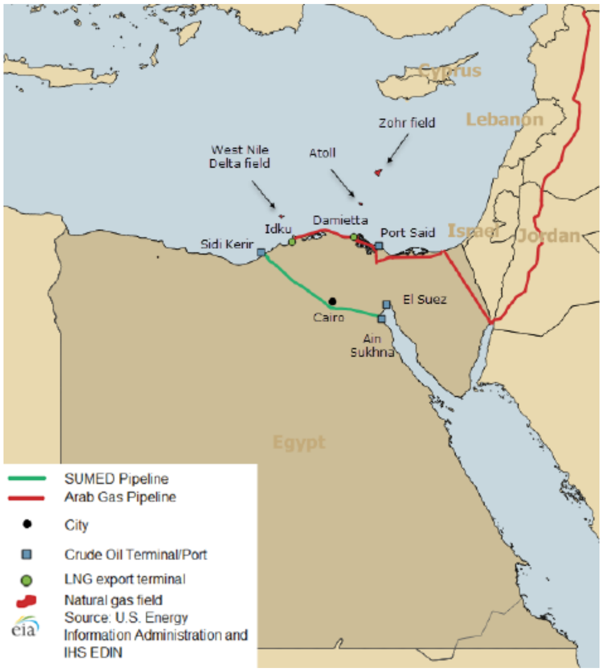

Fig. 1. Egypt Map-sources of energy.

- The un-controllable and continuously increasing population growth.
- The ascending rate of private and commercial vehicle sales.
- The social subsidy policy for energy products.
- The increased industrial output.

which accompanied the beginning of 2001 (the new millennium), leading to an increase in consumption by about 3% per year, resulting in growing of demand, and falling in production, that could roughly meet consumption requirements, resulting in a significant drop in the country's oil refinery output since 2009 (EEAA, 2010).

Starting of 2011, Egypt had a significant gap between production and consumption and by 2017 became a net importer of oil and gas and refined petroleum products (Fig. 2).

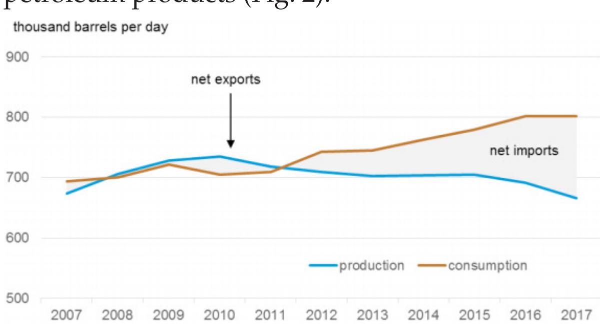

Fig. 2. Egyptian annual petroleum and other oil-products production, consumption, net exports and net imports (EIA, 2018)

The combination of increasing consumption and declining production has led to a decline in natural gas exports since 2009, as the government started to divert Natural Gas supplies from exports, in order to satisfy domestic demand, eventually turning the country into a natural gas importer since 2015, and a net importer for fuel oil and oil products by 2017.

The increased industrial output which include the boom in Cement production which exceeded the capacity of the market by about 27% (56 million tons per year of ~85 million ton/year), supported by the government facilitations to use Coal as a fuel in cement industry by 2014(EEAA, 2014).

In terms of coal, Egypt has no Coal mines except the Coal of Al Maghara (the cave) in Sinai Peninsula and its quantities are limited and not currently usable in practical and in economic terms. Hence, Egypt is a net importer for Coal, and are even expected to increase in the short-medium term, since the Egyptian government has approved the use of coal as a fuel in April 2014. Since that date, 19 cement companies out of 22 companies use coal in the energy mix with rates ranging between 85% to 95% while use 10% of other derivatives of energy such as Mazot, Natural Gas and Waste (NIB, 2017).

In the same year the government of Egypt signed a construction deal for the first Coal-fired power plant in the country (Al Hamraween Power plant-Red Sea coast).

The Government takes the view that a more diverse energy mix is a more secure energy mix as it is less vulnerable to fluctuations in the availability of any one fuel and to face challenges in energy sector. For this reason, Egypt make to ensure that planned and future investments in energy sector provides more security of energy supply via a range of fossil fuels (e.g. Coal), renewable energy (e.g. Solar, Wind and Biomass) and nuclear technologies.

By 2015 Egypt developed an Energy Strategy to year 2035. The strategy comprises 5 scenarios. All scenarios except the third scenario excluding the use of Coal in energy production, but the rest four scenarios are emphasizing on the use of coal in energy production after 2019/2020 which is expect to reach up to 6% of energy mix where this paper discusses the Environmental, Social and Economic consequences of increasing consumption of coal in industrial sector especially Cement industry in light of the best scenario for using Coal In industry.

Air Pollutants

Exhaust gases from Coal combustion contain many harmful air pollutants, as well as "Greenhouse Gases". These emissions spread at varying distances around the source and the distances increased to which the emissions travel in the wind direction until they reach more than 1,000 km for some pollutants such as particulate matter (PM 2.5) and mercury). Weather conditions in the vicinity of fuel combustion sources play a significant role in determining the concentration of pollutants in these areas

Health risks

The inhalation of air polluted by Coal combustion products cause many health hazards due to the negative effects on the organs of the body (Figure 3), including primarily the Respiratory system, Circulatory system, Heart, Nervous system and Brain. Mercury is considered to be one of the most toxic air pollutants from the use of Coal, which spreads through the air and pollutes sea and river waters and hence to aquatic creatures, which peoples feed on them. Where the Mercury settle in the brain and cause serious damage to the Nervous system.

The nature of the disease and the degree of risk depend on the concentration of pollutants in the air and the duration of exposure to polluted air, in addition to the general health and age groups of peoples in areas exposed to air pollution. It should be noted that the concentration of pollutants is significant in areas near the sources of pollution, "power stations - cement plants" and the concentration gradually decreases whenever the distance went away.

Community costs

Community costs are the costs associated with the use of Coal or any other fuel outside the plant or power plant, external costs incurred by the community (externalities), regardless of the cost of fuel purchase. Developed countries rely on the development of strategies and policy-making on total costs, i.e. external community costs (Externalities) in addition to the direct cost of buying or managing fuel.

In terms of costs or losses incurred by the society, it depends primarily on a number of economic factors, the most important of which are the cost of treatment and losses resulting from the days of absence from work, in addition to the cost of total and partial disability and loss of life due to air pollutants and consequent loss of National Product.

The community cost is divided into two parts:

- The cost of health and environmental risks. The most important is the health risks, and any cases of illness and loss of life due to air pollution.
- Cost of Greenhouse Gas emissions (Climate Change).

The cost of health and environmental risks

The cost of health varies according to the types of

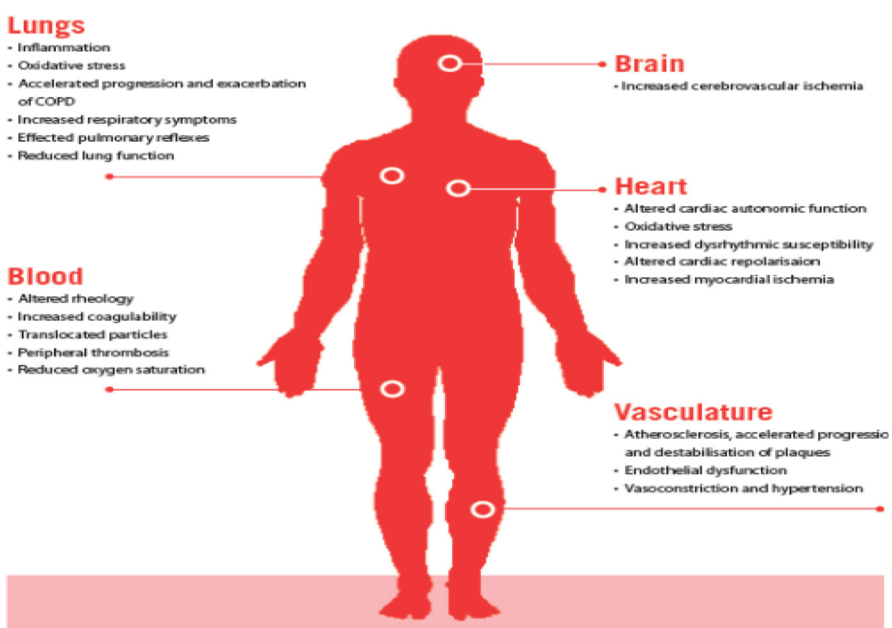

Fig. 3.

contaminants that can be identified and evaluated for health effects. The cost of the risks of increasing concentrations of sulfur oxides, nitrogen oxides and particulate matter (PM10, PM 2.5) is considered the common denominator in all the studies.

Cost of climate change

According to IEA estimates (IEA, 2019), the total world coal production reached 7.813 billion Mt, and the production increased in 2018 by 250 Mt, an increase of 3.3%, which was approximately the same as the growth rate in 2017. In 2018, total global coal consumption in energy terms increased by 1.2% or 66.0 Mtce,

China accounted for no. 1 in Coal consumption, followed by India and United States in the third rank, and Egypt are ranked as no. 92 in Coal consumption with 180,000 Mt.

Turning Back to Coal

In the context of widespread action to fight climate change,and as Coal remains the most polluting source of energy: it generally emits twice as much as N.G, its main competitor, Surprisingly enough that there are some 20 countries are turning to coal, including nine in Africa (DRC, Egypt, Ivory Coast, Kenya, Morocco, Mozambican, Niger, Senegal and Tanzania), three in Central America (Panama, Salvador and Dominican Republic), two in the Middle East (UAE and Jordan) and three in Asia (Bangladesh, Cambodia and Myanmar).

By 2025, more than 65 coal-fired power plants could be commissioned in these countries, representing a capacity of 50 GW (equivalent to more than 2% compared to global capacity in 2017). Most of these countries do not even have coal resources, with the exceptions of Bangladesh and Tanzania. Most often, they develop their projects with Indian or Chinese funding since the major international funding agencies no longer support this type of project. One example is the megaproject Lamu coal-fired power plant, built by China Power Global, with the support of the African Development Bank in Kenya.

The impact of climate change losses is subject to many assumptions because of the variability of uncertainty levels for pessimistic scenarios that predict a significant rise in global temperature soon due to uncontrolled Greenhouse Gases and some relatively optimistic about the rate of rise of temperature and occurrence timing, and despite the wide variation in the cost estimates related to climate change, the common estimates range from US$ 10-100 per ton of carbon dioxide based on data from the Central Agency for Public Mobilization and statistics (CAPMAS) of the social cost due to carbon emissions is about US$ 80 per ton, according to the Ministry of Petroleum in Egypt.

Cement Industry share in GHG

According to Egypt Second and Third National Communication Reports (SNC report May, 2010 and 3rd NC report Mars, 2016 respectively) Green House Gas Inventory in Industrial Sector which is based on Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines) and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (GHG 2000) both are the main source of methodology for Egypt National Green House Gas Inventory.

Good practice guidance is provided for major emissions source categories – including: Cement production, lime production, iron and steel industry etc.

Data Sources

Data used in the GHG Inventory was depended on the Egyptian "Industrial Development Authority (IDA) for supplying the factory license data including the production capacity, raw material and date of license issuance, and another data source was the Holding Companies and the Companies working in Cement industry.

According to the "1996 IPCC Good Practice Guidance and UncertaintyManagement in National Greenhouse Gas Inventories", Chapter 3, "Industrial Processes", the Main sources of GHG emissions in the industrial processes are headed by Cement Industry according to data published in both reports as clear in Table 1.

Table 2 and Fig. 4 depict the emissions by gas from different industrial sectors, and it is easy to note that Cement Industry is heading the main industrial sectors in emissions of Co_2 equivalent tons/year by 62.13 % of total equivalent CO_2 emissions per year (accordingto SNC report May, 2010), and by 82% of total equivalent Co_2 emissions per year (according to 3rd NC report Mars, 2016), review also Table 3 and Fig. 5.

Table 5 gives some significant indicators for the Egyptian industrial production and related CO_2e emissions which shows nearly a triple emissions of CO_2e between 1990 and 2000.

Table 1. GHG emissions by gas type and industrial sources.

2nd NC report May, 2010.	3rd NC report March, 2016.
Cement industry	Cement industry
Limestone and Dolomite production and use.	Iron and steel industry.
Iron and steel industry.	Limestone and Dolomite production and use.
Ammonia Production.	Nitrous Oxide (N2O) production for nitric acid and fertilizers production.
Nitric Acid Production.	Carbon Fluorides from Aluminum smelting.
Aluminum Production.	Sulfur Fluorides due to Magnesium production.

Table 2. Emission of Carbon Dioxide (Co_2) from industry, 2005.

Item	Industrial Sector	Carbon Dioxide Tons/year	Co_2 Equivalent Tons/year
1	Cement production	16,716,754	16,716,754
2	Lime production	202,844	202,844
3	Iron and Steel Industry	1,576,175	1,576,175
4	Ammonia not used in Urea	1,924,848	1,924,848
	Total CO_2 from Industry	20,420,621	20,420,621

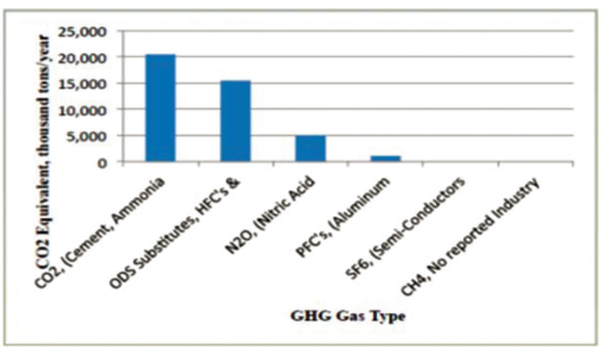

Fig. 4. Emission of Carbon Dioxide (Co_2) from industry, 2005.

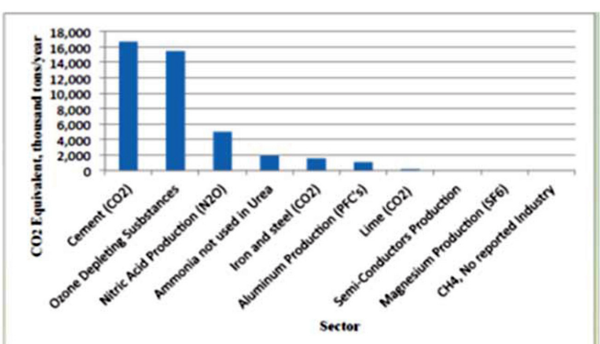

Fig. 5. GHG emissions by sector in descending order of industrial sector, 2005.

Egypt's open market economy attracted energy-intensive industries such as cementand fertilizers industries which are highly dependent on the consumption of natural resources, including NG. In year 2000, the GHG emissions due to cement, iron and steel and fertilizers industries represented 95.8% of the total emissions of Egypt's industrial sector, as evident in Table 3. This resulted in a 275% increase of the GHG emissions of the industrial sector for 2000 relative to those of 1990, while the increase in the overall GHG emissions of Egypt amounted to 165% for the same period. This large increase in emissions from the industrial sector, coupled with significant increments inprofit, resulted to a 10% decrease in GHG emissions per monetary value, for industrial production, from 1.79 ton to 1.61 ton CO_2 e/1000 US$ over the period 1990 to 2000.

Current Energy consumption rate in Mega Joule/ton cement (MJ / ton cement)in Egypt

The average energy consumption in Egypt in Mega Joule MJ (3,890MJ / t cement) is much higher than the European average (3,000-3,200 MJ / t cement) and the highest consumption rate in Germany (2,866 MJ / t cement), meaning that there is a waste of energy in the Egyptian cement factories about 22% to 34%. This waste has two negative aspects. The first aspect is that the energy up to the date of research is subsided by the government for the industrial sector and the second aspect is that the waste of energy in these ratios means directly an increase in emissions that is not estimated in the same proportions in the EIA studies submitted to EEAA to get the Environmental approval on using Coal as fuel, and with an increase in the production capacity of the cement industrial area in Ain Sokhna as planned by the local government in Suez governorate based on a study by Suez Canal

Table 3. GHG emissions by sector in descending order of industrial sectors emissions, 2005.

Sector	CO_2 Equivalent thousands Tons/year
Cement (CO_2)	16,717
Ozone Depleting Substances (ODS Substitutes, HFC's and PFC's)	15,473
Ammonia not used in Urea (CO_2)	5,042
Iron and Steel (CO_2)	1,925
Aluminum production (PFC's)	1,077
Lime (CO_2)	203
Semi-Conductors production (SF6)	0
Magnesium production (SF6)	0
CH4, No reported Industry	0
Total CO_2 Equivalent, thousands Tons/year	

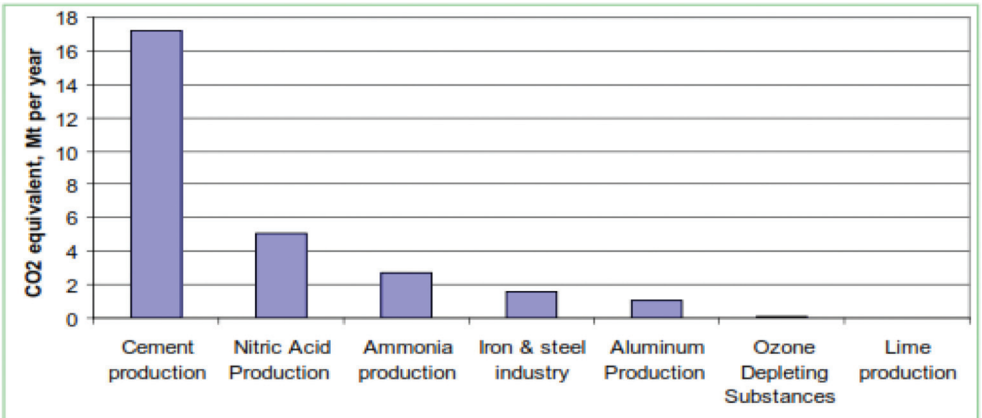

Fig. 6. GHG emissions by different industrial sectors, according to gas type, 2000.

University-Egypt, that means unforeseen load of pollution would certainly break up the ceiling load of the area.

Egypt Coal consumption in Industrial sector

Based on the African Energy Commission AFREC, the Industrial Consumption of Different Energy Sources during 2005-2017 in thousand tone equivalent Ktoe shows the development of Coal consumption in Egypt starting with 203 ktoeup to 224 ktoein 2017 in Parallel with the boom of cement industry (Table 6).

By 2015, Egypt turned into a natural gas importer and a net importer for fuel oil and oil products by 2017 including Coal.

Table 4. GHG emissions by different industrial sectors, according to gas type-2ndCN report.

Source Sectors	GHG gas	Specific gas emissions (Tons)	CO2e (Metric ton Mt)	Contribution to total emissions (%)
Cement production	CO2	17,251,370	17.25	62.13
Lime production	CO2	31,400	0.03	0.11
Iron and Steel production	CO2	1,576,175	1.58	5.68
Ammonia production	CO2	2,736,000	2.74	9.85
Nitric Acid production	N2O	16,266	5.04	18.16
Aluminum production	PFCs	160	1.08	3.88
Ozone Depleting Substances ODS substitutes HFCs	28	0.05	0.18	
Total emissions from the Egyptian Industry (CO2e)			27.77	100

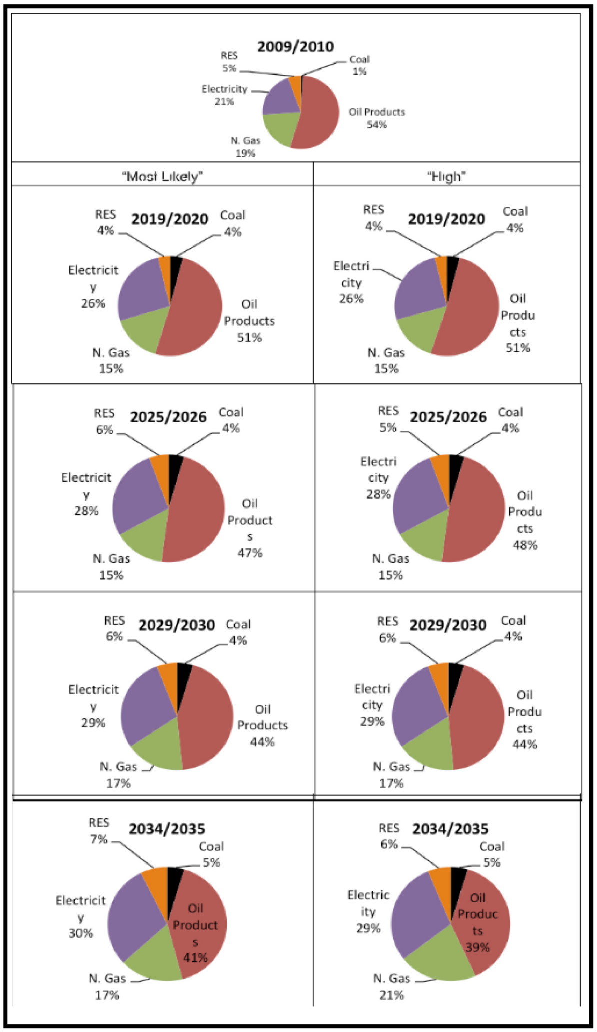

Fig. 7. Evolution of the share of energy commodities in the final energy consumption – scenario base -b

But according to Egyptian strategy "INTEGRATED SUSTAINABLE ENERGY STRATEGY TO 2035- VOLUME 1"[2] released in 2015, on the base scenario –b the Coal will remain as a fuel with 4-5 % of the total energy used in 2035, i.e. after 19 years from now Figure 7).

The share of Coalin the average of different scenarios is increased in the final energy consumption and reaches up to 5% of the Final Energy Consumption FEC and stabilizes to around 5% (Figure 8).

The reason for that is the consumption of Coal is limited in Industrial sector to Iron production in Blast Furnace and Cement industry, and the consumption in Iron production almost constant.

Coal consumption share in Industrial sector up to 2035

Table 7 shows energy consumption per sector and energy commodity and corresponding shares. It is clear from the table that the share of Coal most likely to jump starting from year 2019/2020 to reach its maximum consumption rate in year 2023/2035.

Sustainable and Integrated Energy Strategy up to 2035

Energy Mix-Current situation up to strategy target year 2035

In all scenarios other than Scenario 3 (Renewable Energy source scenario based on the fullest exclusion of the use of Coal and Nuclear Power) Coal-fired power plants will be available to generate electricity after 2019 and 2020, which corresponds to the four-year period since the adoption of the decision to use Coal in the energy mix.

Taking into account the need to develop the infrastructure for the import of Coal (Ports, Transportation, and Storage) which would increase the potential for Coal emission due to Transportation, Handling and Storage activities. The decision to introduce Coal-fired power stations is based on a Cost-Cutting model to a minimum.

Primary Energy Supply Scenario

Figure 8 shows the development of the primary energy supply until 2034/2035. It seems that the use

Table 5. Egypt indicators for the Industrial sector.

Industry production Market prices * (Billion L.E)		Egypt 's Industrial production Market prices** (Billion US$)	Industrial process GHG emissions (Mt CO_2e)	Specific emissions (Ton CO_2e)/ 1000US$	Specific emissions relative to those of 1990(%)
1990	18.02	5.63	10.10	1.79	—
2000	61.21	17.25	27.77	1.61	90

*(Ministry of Economic Development, 2007)
**Average exchange rates are based on Central Bank data. This is 3.2 LE/US$ for 1990 and 3.41 for year 2000

Table 6. Egypt's Industrial Consumption of Different Energy Sources during 2005-2017 in Ktoe.

	2005	2012	2013	2014	2015	2016	2017
Thousand Ton Oil Equivalent							
Oil	5548	3716	3279	3133	6369	6713	7080
Natural Gas	5567	6649	6789	8002	9083	9303	9536
Electricity	2812	3430	3500	3288	369	3488	3612
Coal	203	204	188	188	200	211	224

Table 7. Final energy commodity and consumption by sector and corresponding shares.

Sector	Energy Commodity Thousand Ton Oil Equivalent (Ktoe)	2009/10	2019/20	2019/30	2034/35
Industry	Coal	412	3217	3676	4468
	Oil products	5815	12634	11515	8785
	N. Gas	8238	9730	9667	11956
	Electricity	3362	5892	6395	6725
	Bioenergy	586	751	2649	3806
	Total	18413	32224	33902	35740

Table 8. Coal emission factor in cement industry

Fuel	Factors	Emissions (gm/GJ)				
		Nitrogen Oxides	Sulphur Oxides	PM10	PM2.5	Carbon Dioxide
Coal	Average	173	900	117	108	96,000
	High value	200	1000	240	220	
Mazot	Average	513	47	20	20	77,400
	High value	718	66	28	28	
Natural Gas	Average	74	0.67	0.78	0.78	56,100
	High value	103	0.94	1.09	1.09	
Bio fuel	Average	91	11	143	140	34,000
(Wastes) 20%	High value	120	40	285	279	

Table 9. Pollution loads from burning coal in cement industry

Emissions (gm/GJ)	Factors	Fuel Nitrogen Oxides	Sulphur Oxides	PM10	PM2.5	Carbon Dioxide
Coal	Low value	40,424	210,300	27,339	25,236	22,432,052
	High value	46,733	233,667	56,080	51,407	
Mazot	Low value	119,871	10,982	4,637	4,673	18,015,741
	High value	167,733	15,422	6,453	6,453	
Natural Gas	Low value	17,291	157	182	182	13,108,730
	High value	24,086	220	255	255	
Bio fuel	Low value	5316	643	8,345	8,345	1,588,937
(Wastes) 20%	High value	7,010	2,337	16,649	16,649	

Community Cost:

Community cost was calculated and adjusted according to the per capita GDP in Egypt and Europe as shown in Table 9[17].

of Coal will increase steadily after 2015/2016 due to its use in the industrial sector, specifically in the Cement industry.

By 2019/2020, Coal will also be used in the electricity production sector. Nuclear fuel will be imported after 2022/2023 when the first nuclear power plant will be operated, and will increase steadily until last unit is built in 2029/2030. Renewable energy sources will also increase steadily. The primary energy will reach up to 9.8% by 2034/2035.

The proportion of Natural Gas in primary energy supply will decline after 2025/2026 due to a change in the initial energy mix, especially with the emergence of higher Coal rates and will settle at 32% in the case of "most likely" and 36% in the case "high" by 2029/2030. The proportion of oil and petroleum products in the primary energy supply will increase until 2014/2015 in order to compensate for the shortage of available gas, and then decrease the proportion even more to reach the level of 28% by 2034/2035 in the case of "most likely"

And "26 % in the "high" case where Coal is part of the primary energy supply. The availability of domestic Natural Gas in the "high" scenario will lead to a slight decrease in Coal levels in the first 2030/2030 and 2034/203, but it is not significant.

Coal and Nuclear Fuel, as well as a large percentage of petroleum products, are being imported and a smaller portion of Natural Gas in the form of liquefied Natural Gas after 2014/2015.

Community cost due to use of Coal as a fuel in Cement industry.

The cement industry is one of the energy-intensive industries. As a result of the energy support policies in Egypt, the investments in this industry have increased to the number of companies operating in Egypt to 21 companies having 24 factories with 48 Kiln furnaces and a production capacity of about 68 million tons per year.

The implementation of the energy subsidiary policy in Egypt encouraged cement companies to shift from the use of diesel to natural gas. In 2011/2012, the cement sector consumed 3.6 billion cubic meters, accounting for 7.4% of the total domestic gas consumption. The sector consumed 4 million tons of Mazot which accounts for about 18% of domestic consumption.

From figure 9 and Table 8, it is clear to identify

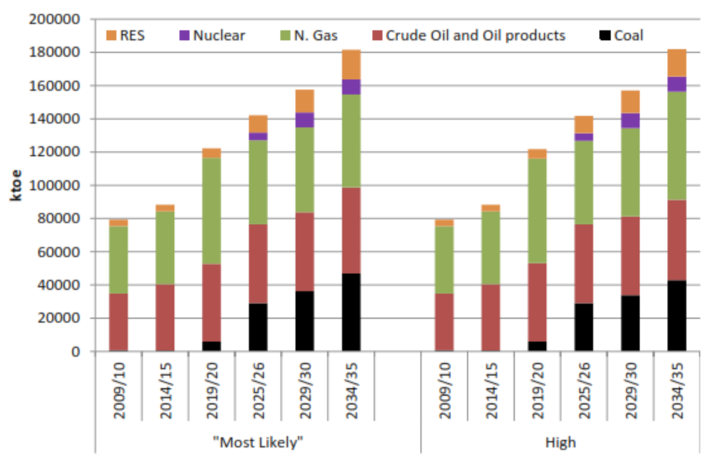

Fig. 8. Scenario of primary power supply

Table 10. Community cost per capita GDP in Egypt and Europe

Fuel	Range	Cost of air pollution		Cost of Carbon Emission (US$)	Total
		Europe Cost (EURO)	Egypt Cost(US$)		
Coal	Max.	7,074,053,066	2,133,406,396	1,794,564,125	3,927,970,521
	Min.	10,886,160,521	3,283,069,022	5,077,633,147	
Mazot	Max.	2,192,271,775	661,149,497	1,441,259,313	2,102,408,810
	Min.	3,069,367,419	925,665,672	2,366,924,985	
Natural Gas	Max.	232,547,240	70,132,039	1,048,698,411	1,118,830,450
	Min.	323,833,399	97,662,293	1,146,360,704	

higher Coal emission factors than other fuels, and higher CO_2 emission factors,and lower emission factors for Natural Gas than other fuels, except for Nitrogen Oxides.

Energy required

Based on the energy mix strategy (Evolution of Coal Consumption), calculations for different air pollutants expected to release from Coal in cement industry and community cost are set based on the energy rate needed to produce one ton of Clinker in Egypt taking an average of production of 60 million tons of cement to compare it with different fuel alternatives for community cost and air pollutants.

The energy required to produce 60 million tons / year was calculated as the average energy consumption in the cement factories in Egypt (3.894 GJ / t Clinker), through the available data on a number of factories, which represent more than 70% of cement production in Egypt. Total power =60.000.000 (GJ) X 3.894 GJ / t Clinker = 233.667.2043.894 GJ.

Emissions load

The potential range of emissions loads was calculated according to the emission parameters shown in Table 9.

Community cost of the energy unit

The total societal cost is then calculated and includes the cost of environmental degradation, i.e. the cost of health and environmental risks and the cost of carbon emissions when using each of the different fuels, as shown in the following Table 11 and Fig. 10.

Cement Industry

The use of Coal instead of Natural Gas to produce 60 million tons / year leads to the following:

Increased emissions of Nitrogen oxides by (22,899 tons), Sulfur Oxides by (221.796 tons),Particulate Matter PM10 by (41.491 tons), Particulate Matter PM2.5 by (38.103 tons), Carbon emissions by9,323,321tons), and that increase the societal cost added to the National Economy to about (2.8-3.9 billion dollars) annually.

Conclusion on Coal and Air quality in context of Egypt Energy Profile.

Cost Implications

The estimated costs mentioned are fuel costs only and do not include the following costs:

- Capital costs for the construction of coal infrastructure.
- Tourism losses due to damage to tourist areas

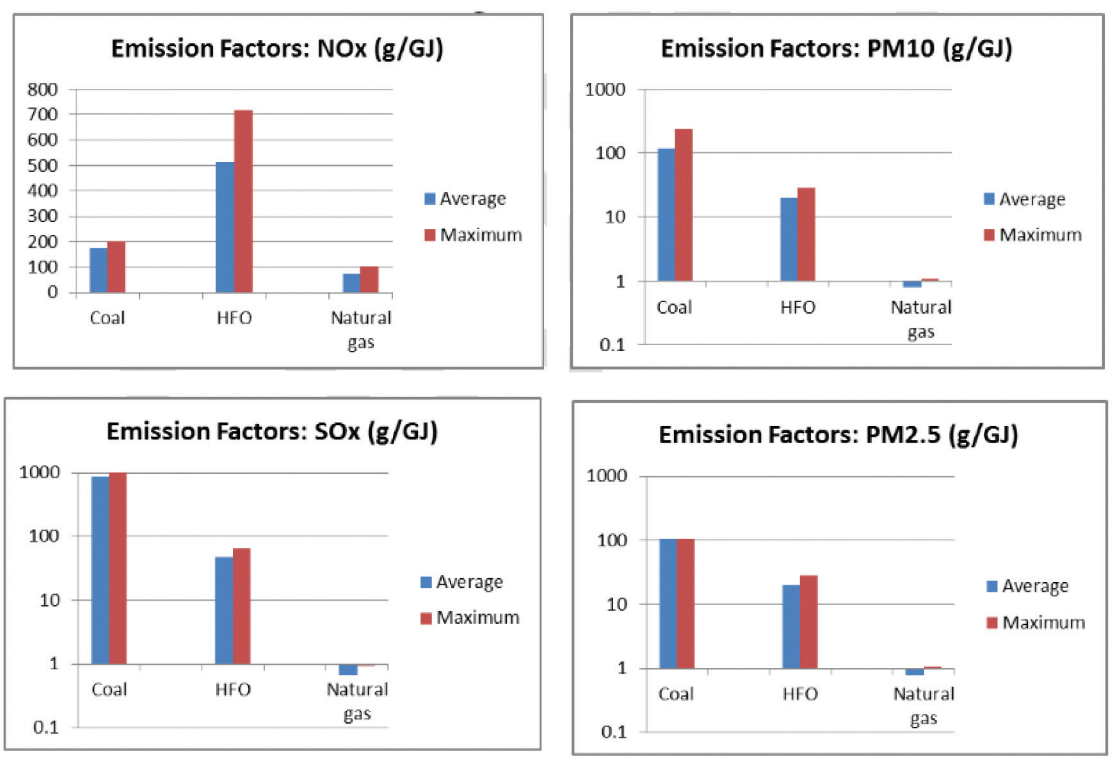

Fig. 9. The graph shows lower emission factors for natural gas than other fuels, higher Coal emission factors than other fuels, and higher CO2 emission factors, except Nitrogen Oxides.

Table 11. Community cost of the energy unit

Fuel	Elements of Societal Cost	Total of Societal Cost Dollar/Million British Thermal Unit ($/MBTU)	
		Max.	Min.
Coal	Environmental & Health Cost	9.6	14.8
	Carbon Emission Cost	8.1	8.1
	Total	17.7	22.9
Mazot	Environmental & Health Cost	3.0	4.2
	Carbon Emission Cost	6.5	6.5
	Total	9.5	10.7
Natural Gas	Environmental & Health Cost	0.3	0.4
	Carbon Emission Cost	4.7	4.7
	Total	5.1	5.2

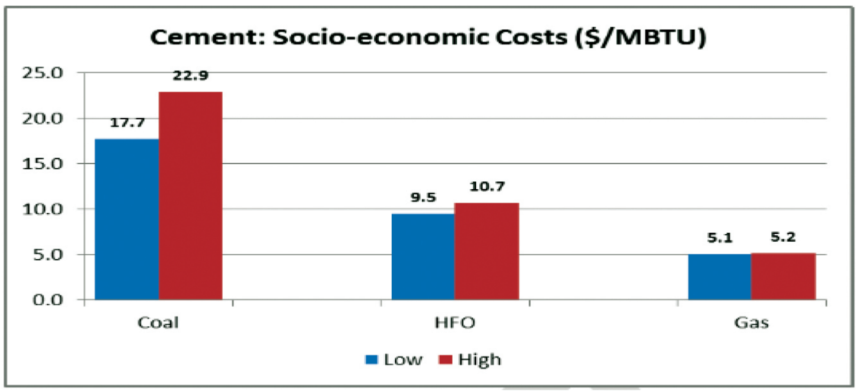

Fig. 10. Societal cost for using Coal as a fuel in cement industry.

on the Red Sea coast as well as migratory bird routes.

- Losses due to the export potential of Egyptian products due to the increase of carbon footprint due to the use of Coal in the production of energy and electricity as most industries depend on electricity, including cement.
- Negative effects on Egypt's negotiating position in the climate change treaties on compensation claimed by Egypt because it is one of the most vulnerable countries affected by climate change.
- Potential constraints on carbon emissions from developing countries or imposition of emission reduction commitments on developing countries. In this case, Coal will be targeted, its use in the cement industry, electricity generation, and industrial growth and the construction sector will be affected by emission reductions.

Share of law and regulations state of implementation

Egypt has been suffering for a long time of weak enforcement of environmental law and regulations, specifically in the three elements that ensure compliance with the standards and norms, which are as follows:

- Weakness of the commitment of owners of large and small enterprises, either because of lack of awareness of the importance of compliance with standards or lack of resources and information or desire to increase profits as possible while reducing spending on environmental compatibility projects and circumvent the implementation of environmental laws and legislation.
- Weakness of the system of adherence to standards and controls, both in terms of human or material capabilities, or the lack of firmness of regulations that facilitate circumvention and non-implementation.
- Weak influence of civil society forces due to lack of awareness, illiteracy and low standard of living.

Law and regulations state of implementation reflections

The effects of the weak system of mandatory standards and controls are clear for the main sources of emissions and the most importantare: industry, transport and open burning of waste of all kinds.

The weak system of mandatory standards and controls are:

- Increased loads of emissions from cement factories in Egypt that use coal compared to those in developed countries that use coal, although most of them belong to the same international companies for the manufacture of cement.
- Increased emissions from public transport and heavy-duty vehicles powered by diesel, including modern models, due to the use of diesel fuel with a very high sulfur content (about 4000 ppm) compared to clean fuels used in Europe and USA (10-50 ppm).

Energy Strategy and Reforming polices

Based on different scenarios addressed in "INTEGRATED SUSTAINABLE ENERGY STRATEGY TO 2035- VOLUME 1-2015" and the previous analysis: Coal will remain as a main fuel in Cement industry and power generation sectors for at least the next two decades, and analysis for air quality based on Air Dispersion models shall continue in the proposed areas for building Coal-Fired power plants.

The Energy Waste assessed in Cement industry in Egypt should be seen as waste of development opportunity in the industrial area in Ain Sokhna and ranked as a direct and hidden threatening factor for the evolving of Touristic Industry on the Gulf of Suez for the next two decades.

The air pollutants associated with burning Coal, which is the worst fossil fuels in terms of the quantity and quality of emissions harmful to the environment and human health. Besides Carbon Emissions, the combustion products include particulate matter (PM10 PM2.5) - Sulfur Oxides – Nitrogen Oxides - Carbon Monoxide - Hydrocarbons, in addition to a large number of toxic air pollutants such as Lead, Mercury, Dioxins and Furans, some of these pollutants travel over long distances, increasing the number of people exposed to health risks affecting organs body, especially the Brain, Nervous system, Heart, Circulation and Respiratory system.

REFERENCES

African Energy Commission (AFREC). (2017). Africa Energy Database.

Egypt in figures, Central Agency for Public Mobilization and Statistics - Source: Ministry of Petroleum.

Egypt Second and Third National Communication Reports, EEAA, 2010, 2016 respectively.

EMEP/EEA air pollutant emission inventory guidebook 2013", Technical guidance to prepare national emission inventories, EEA Technical report, No 12/ 2013.

Excerpted from "Integrated Sustainable Energy Strategy To 2035- VOLUME 1-2015".

http://en.wikipedia.org/wiki/List of_countries_by_GDP_(PPP)_ per_capitattp.

https://en.wikipedia.org/wiki/1979_oil_crisis.

https://energycharter.org/fileadmin/DocumentsMedia/Occasional/Egypt_and_the_Charter.pdf

https://www.americansecurityproject.org/wp-content/uploads/2015/03/Ref-0190-Energy-in-Egypt-Background-and-Issues.pdf.

https://www.eia.gov/beta/international/analysis_includes/countries_long/Egypt/egypt.pdf.

https://www.eia.gov/beta/international/analysis_includes/countries_long/Egypt/egypt.pdf.

https://www.eia.gov/beta/international/rankings/#?iso=EGY&cy=2018.

Integrated Sustainable Energy Strategy to 2035, Egypt.

Societal cost for traditional energy sources and renewable energy, EEAA, 2014.

Studying PM10 pollution load at the Heavy Industrial Area in Ain Sokhna in (Cement factories area- 2005.

The Unpaid Health Bill: How Coal Power Plants Make Us Sick, Health and Environment Alliance (HEAL), 2013.

www.ida.gov.eg.