Chapter 54
Energy Efficiency Building Codes and Green Pyramid Rating System

George Bassili Hanna

Abstract Three building energy codes were introduced in Egypt between 2005 and 2010. They impose mandatory energy performance requirements for residential, commercial, and governmental buildings. Another code was presented (2013) to improve the indoor air quality and ventilation requirements and system. This chapter addresses the current states and the potential of energy efficiency, renewable energy, and green buildings to reduce the dependence on the fossil fuel. These codes were the base line for green building code. The first edition of the Green Pyramid Rating System was published in December 2010. The Green Pyramid Rating System is a national environmental rating system for buildings. It provides definitive criteria by which the environmental credentials of buildings can be evaluated, and the buildings themselves can be rated. The Egyptian government has an interest in promoting green buildings as part of Egyptian policies of overall sustainable development. The Housing and Building Research Centre (HBRC) established the Egyptian Green Building Council (EGBC) at the beginning of 2009. Another code is under preparation for Green Hotel Rating System in Egypt to improve the Egyptian Touristic sector. The essence of this chapter is to introduce the efforts being undertaken by Egypt to improve the quality of life and highlight the barriers and overcome the challenges that Egypt faces, and these are summarized in three main parameters, namely, energy, water, and housing.

Keywords Energy in Egypt · Passive technique · Energy Codes · Renewable Energy · Green Energy · Green Buildings Code · Green Pyramid Rating System

54.1 Egypt: Background and Energy Consumption

About two thirds of Egypt's total population of 90 million (2014) are living in urban areas. Egypt's population is concentrated in only 6% of the territory. About 30% of the Egyptians are living in Cairo and Alexandria, and about 65% of the total

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population are living in Greater Cairo and the Nile Delta. The Egyptian building stock comprises about 12 million buildings, and 60 % of building units are in the residential sector. The number of residential units are about 18 million [1], and it is expected to reach 23 million in 2030, while the number of nonresidential units is about 12 million and is expected to reach 17 million in 2030 [2]. In Egypt, more than 60 % of the total electricity consumption is attributed to residential, commercial, and institutional buildings. Artificial lighting is estimated to account for 36 % of the electricity used in the nonresidential sector and 35 % of the electricity used for heating, ventilating, and air conditioning (HVAC) system. A significant increase in electricity demand is expected over the next 5 years with a growth rate of 8 %. To improve the energy efficiency of buildings, energy efficiency codes have been developed for new residential [3], nonresidential [4] and governmental buildings [5] in Egypt. Energy subsidies are about 147 million which is only 6 % of the total subsidies that go to the residential sector. Energy consumption in Egypt is increasing very fast, at rates more than 5 %. Estimates indicate that energy consumption could be more than double in 2030 and triple in the building sector. Energy consumption in the building sector increases due to growing populations, comfort demand, and electricity use of low-income inhabitations. The household sector is the biggest consumer of electric energy and accounts for 41.1 % [1]. The Egyptian energy tariffs are still very low with respect to other developing countries, but there is a plan to increase the electricity tariff for housing for consumers using more than 650 kWh/m. The current national energy supply mix in Egypt is 96 % from fossil fuel (petroleum products and natural gas) and 4 % from renewable recourses (mainly hydro and limited wind).

54.1.1 Key Issues and Challenges

The energy sector plays an important role in achieving the economical and social development in Egypt, through supplying the energy resources mix required for different sectors. In 2009/2010, oil accounted for 40 % of the total primary energy consumption, while natural gas "NG" accounted for 56 % (about 70 % goes for electricity), and only 4 % was from renewable energy "RE" including hydro recourses. The industrial and transport sectors are the largest end users of primary energy sources, accounting for 34 %, respectively, in 2009/2010. The electricity consumption for the domestic sector was the highest (39 %), followed by the industrial sector (32 %), as shown in Fig. 54.1. The passive design is the most cost-effective to reduce the energy consumption through the building envelope. Figure 54.2 shows [6] the design level from urban planning to architectural design [7], and it is cost-effective energy-efficient buildings. A good design can reduce the investment cost of a building, when considering compacts, efficient layouts, and orientation (Figs. 54.3 and 54.4).

Analysis of the Egyptian population quintiles [8] (20 % population segments based on income, low–high) found that the richest urban quintile received 46 % of the total benefits of petroleum subsidies, while the poorest urban quintile received

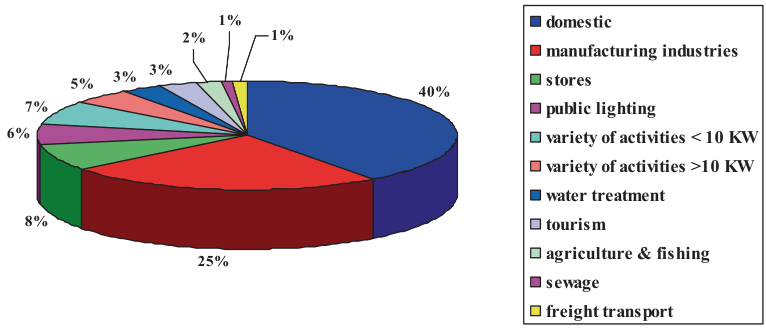


Fig. 54.1 Distribution of electricity consumption by sector

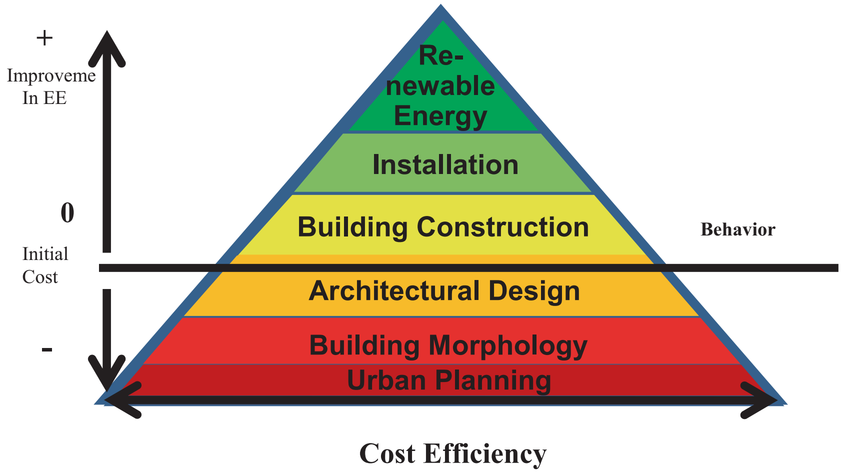
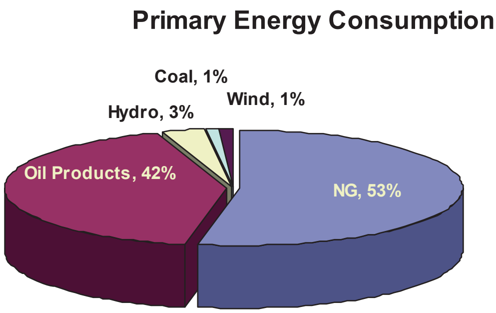


Fig. 54.2 Strategy for cost-effective energy-efficient buildings

Fig. 54.3 Primary energy consumption 2011/2012 = 81.7 Mtoe. *NG* natural gas, *Mtoe* million tons of oil equivalent



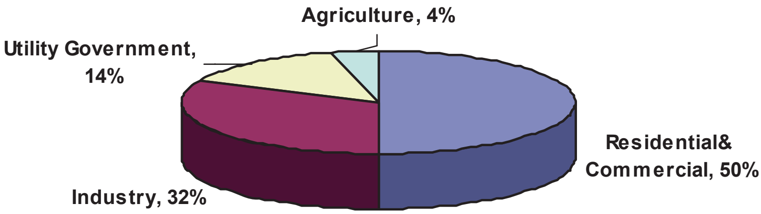


Fig. 54.4 Total electricity consumption, 2011/2012 = 134×10^9 kWh

only 9 %. The stark divide illustrates the division in benefits of subsidies between the rich and the poor. A similar divide also exists within both urban and rural areas as well as between them, with benefits primarily going to the urban rich, rather than to the rural poor. These figures give strong evidence of the common reality of inequitable distribution of universal energy subsidies (Fig. 54.5).

The electricity generation activity utilizes around 30 % of the fossil fuel and natural gas resources in addition to all the hydro and wind energy resources. The industrial activities in Egypt consume around 40 % of the overall energy available. The average annual gross for energy use was less than 6 % over the past decade, and it is expected to continue if the GOE not solve the energy problem. The actual data of electricity consumption are very limited. Surveys indicate that lighting and cooling are the most important end use of electricity in the residential sector. All account about two thirds of the consumption. The increased use of electricity for cooling adds sustainability to the peak load during summer, requiring new power stations. More than three million air-conditioners (ACs) were installed in the residential sector. About 13 % of electricity of the electricity-generated lost in the transmission lines and cables are lost when the ambient temperature reaches 40 °C or above in summer. The overheating period reaches about 5–6 months. The Ministry of Electricity and Energy must add about 10,000 MWh in the next few years to overcome the cut in the supporting the houses with electricity. The second problem is housing for low-income inhabitants. More than half of the new housing stock is

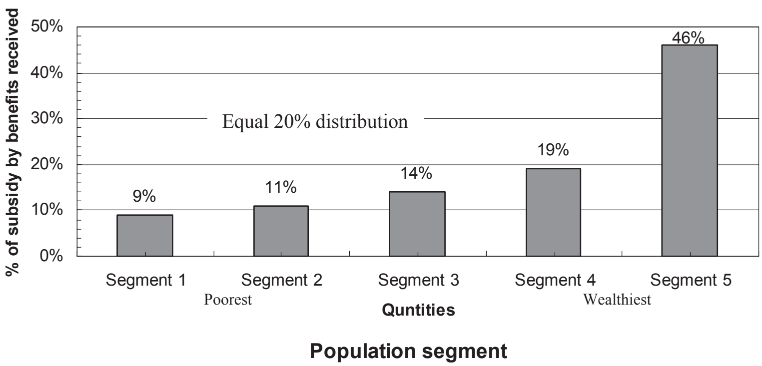


Fig. 54.5 Distribution of subsidy in Egypt

Table 54.1 Indicator of primary energy (Mtoe) and electricity consumption (GWh)

Description (sectors)	Energy (Mtoe)	Electricity (GWh)
Industries	44%	32.5%
Agriculture	1%	4%
Transport	27%	0
Governmental utilities	3%	10.5%
Residential, governmental, and commercial	25%	52.6%
Total (Mtoe)	100%	99.7%

built informally; the rest is shared by the government and the private sector. Energy subsidies more than 140 B. Egyptian pounds which affects the other matter of life. The third problem is water, Fig. 54.2. The Egyptian chair from the river Nile is limited by 55.5 B m^3/year. Table 54.1 shows the primary energy indictor (million tons of oil equivalent) and electricity consumption (giga watt hour; Fig. 54.6).

The new government of Egypt (GOE), after June 30, 2013, signed an agreement with the United Arab Emirates represented by the Arabtec company and the engineering division in the Ministry of Defence to build one million residential units in the next 5 years, that is, 200,000 units per year for low-income group. Another million residential units will be established from the Egyptian private investor's sector and GOE. These buildings must consider and apply the Egyptian building codes for energy efficiency and the green building concept (envelope requirements; ventilation; window to wall ratio, WWR; solar heat gain coefficient, SHGC; and solar water heating, SWH, in addition to energy-labelled appliances) could save more than 50% from electricity consumed in the residential sector (Fig. 54.7).

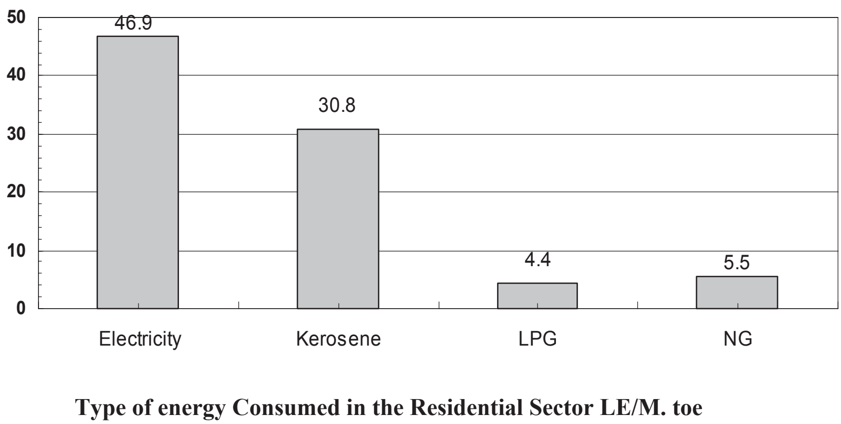


Fig. 54.6 Energy subsidy in Egypt. *LPG* liquefied petroleum gas, *NG* natural gas

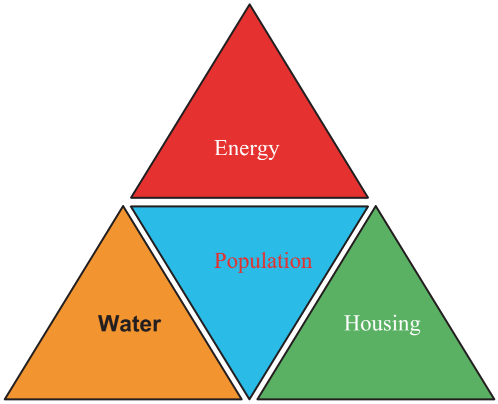


Fig. 54.7 Egyptian parries

54.1.2 Green Energy and Green Buildings

Egypt was among the first nations to use renewable energy resources, especially in solar architecture, crop dehydration, pumping, and in using animals and agricultural wastes. The Egyptian renewable energy strategy [10] aims to generate 3 % of the total electricity demand using renewable energy by 2014. The estimated energy saving in some households and industrial applications is 90,000 toe and 60000 toe from electricity generation using wind farms, in addition to 3.6 Mtoe biomass. A new and renewable energy resource includes solar, wind, and biomass. The energy utilization from such resources was estimated to be 150,000 toe in 2003 plus 3.6 Mtoe biomass.

54.1.2.1 Hydropower

Hydropower potential resources were established at Nagah Hamady and Assuit, as well as some other small available capacities at main canals of the river Nile, in delta, and at the Zefta barrages on the Damietta branch of the Nile. A feasibility station (pump and store) at Attaka and El-Gallala on the Red Sea is now being made. The share of hydro generation to the total generations represents about 8.2 % in 2010–2012.

54.1.2.2 Solar Energy

Egypt lies between latitudes 22 and 32 with a daily sunshine of 9–11 h. Solar energy is available in all regions with an average total solar radiation of 1900–2600 kWh/m^2/year, while the direct solar radiation is 1970–3200 kWh/m^2/year. The first thermal power plant was constructed at El-Kuraymat, 50 km southwest of Cairo. The installed capacity was 140 MW out of which 20 MW was the capacity of solar component and it used hybrid solar, combined cycle *(CC)* before the steam turbine *(ST)* was introduced to generate electricity. The power plant is financed by the Global Environmental Facility *(GEF)* and Japan Bank (Japan International Cooperation Agency, *JICA*) for International Development. The project started on 30/6/2011 with an estimated total energy generation of 852 GWh/year. This station will save about 10,000 t toe and reduce the CO_2 emission by 20,000 t/year. A Solar Energy Programme is implemented during the five years started 2012–2017 for the concentrated solar power plants, with total capacity of 100 MW at Kom Ombo south of Egypt. The New and Renewable Energy Authority (NREA) built and operated 547 MW of wind farm capacities and 140 MW solar thermal power plant using parabolic concentrators through technology integrated with combined cycle power plant. A total of 25 governmental office buildings will install (PV) systems on their rooftops as the one installed in the main office of the electricity office building in Cairo.

54.1.2.3 Wind Energy

Egypt is endowed with an abundance of wind energy resources, especially in Suez Gulf area which is considered as one of the best sites in the world due to high and stable wind speeds. The west of Suez Gulf is the most promising sites in the Middle East and Africa. The wind speed ranges from 8 to 10.5 m/s on average, and also due the arability of large inhabitant desert area. Egypt enjoys considerable wind energy resources, with an average wind speed of 10 m/s in the Gulf of Suez area and 7 m/s in the East Owainat area and the Zafrarana region with about 9.5; a wind atlas has been issued for the Gulf and is being developed for Egypt. A pilot wind farm was built at Hourghada; it consists of 42 wind units (100–300 KW each) with 5.4 MW capacities. Its output has been connected to local electricity grid since 1993.

Two successive stages of wind farm at Zafrana (140 MW) have been executed as of 2001. The estimated electrical energy consumption is more than 570 TWh/year. The energy saving will be more than 125,000 toe/year. The target for total installed capacity of wind energy is about 650 MW in 2010. A new project was started at Gabal El-Zeit in the Suez Governorate to establish a new wind farm to produce 220 MW.

54.1.2.4 Biomass

Production of biomass energy using agriculture, animal, human, and solid wastes has high potential in Egypt. Power generation from gasification of sewage slued in waste water treatment plants (El-Gabal El-Asfer 23 MW plant) has already been used. High potential projects for power generation based on gasification or direct combustion of organic solid wastes or agricultural wastes are under consideration. A potential of 1000 M could be generated from agriculture waste.

54.1.2.5 Solar Distillation

The maximum water allowed from the river Nile is only 55.5×10^9 m^3 since 30 years ago, and the population was doubled in this period (less than 45 million), and the needs for fresh water became vital. The Arab Organization for Industrialization in Egypt manufacture and apply 168 projects in the Red Sea Region to provide this area by fresh water for domestic and touristic resorts away from the water pipe lines.

54.1.3 Egyptian Building Energy Codes

For the past two decades, the GOE has published three energy-efficiency building codes for residential [3], commercial [4], and governmental buildings [5] and another code was approved for ventilation [6]. Five energy label was approved and used in life practice with testing facilities to reduce the electricity consumption in the residential sector. At the time, detailed studies had shown the close line between population growth and energy. The thermal elements for eight climatic regions are summarized and shown in Table 54.2. The thermal envelope is very important which includes wall, roof, insulation, windows (ventilation and daylighting), doors, finishes, weather strip, and air/vapour retarders.

54.1.4 Egyptian Green Building Code

The second draft of the Egyptian building code was introduced to the Egyptian Green Building Council (EGBC) for discussion [9]. The main items that were considered in the green building draft code for new buildings were energy efficiency (EE), water efficiency (WE), and indoor air quality (IA).

Table 54.2 Design of an overall thermal transfer values for residential buildings

Description	Roof		Walls			
Thermal Indices	U r (W/ m^2 °C)	OTTV r (W/m^2)	U w (W/ m^2 °C)	OTTV w(W/m^2)	WWR (%)	SHGC[a]
North coast	≤0.40	≤20	≤1.4	≤95	>10–<30%	>0.4–<0.7
Cairo and Delta	≤0.50	≤25	≤1.0	≤90	>10–<20%	>0.45–<0.7
North upper region of Egypt	≤0.35	≤20	≤0.6	≤95	>10–<20%	>0.42–<0.68
South upper region of Egypt	≤0.333	≤25	0.566–1.111	≤55	>10–<20%	>0.4–<0.65
Eastern coast	≤0.357	≤20	0.909–2.222	≤45	>10–<20%	>0.4–<0.68
Highland Hhlls	≤0.500	–	0.83–1.0	–	>10–<30%	–
Western desert	≤0.333	≤25	≤55	0.71–1.25	>10–<20%	>0.55–<0.71
Southern Egypt	≤0.333	≤25	0.667–1.000	≤60	>10–<20%	>0.4–<0.7

OTTV overall thermal transfer value, *SHGC* solar heat gain coefficient, *WWR* window to wall ratio
[a]Depends on orientation of the main façade

54.1.5 The Green Pyramid Rating System

The energy-efficiency code was the first step to go further to develop the green building code. The Egyptian Green Building Council (*EGBC*) was established in 2009 and consists of both national and international personalities, including governmental ministers from cabinet-level agencies, officers from respected NGOs, and others. One of the objectives for establishing this council is to provide a mechanism to encourage building investors to adopt the BEECs as well as other sections of existing codes that satisfy both energy efficiency and environmental conservation.

Climate change is the greatest challenge facing humanity, and research shows that the phenomena are a result of increased levels of greenhouse gas emissions resulting from human activity. It is estimated that half of the total carbon-related emission comes from buildings and their use, sustainable building development, and green building. The GOE, represented by the Ministry of Housing has an interest in promoting green buildings as part of the ministry's overall sustainable development policies. As a result, Green Pyramid Rating System (GPRS) has been developed. GPRS is a rating system that can redefine the way we think about projects we design in Egypt [11]. Contemporary design, architecture design firms make sure their buildings are green, and seek to award the GPRS certification. Green building should reduce pollution and enhance the efficiency of energy and water use.

54.1.5.1 Category Weightings

The GPRS system [12] consists of the main topics, such as EE, WE, and indoor air quality and stmosphere, and other topics called "credit categories". The building performance regarding each of these credit categories is evaluated. Each category in turn contains several elements that need to be assessed in the building. These elements are credit Green Pyramid Category Weightings are as follows:

No	Green pyramid category	Category weighting (%)
1	Sustainable site, accessibility, ecology	10
2	Energy efficiency	25
3	Water efficiency	30
4	Materials and resources	10
5	Indoor environmental quality	10
6	Management	10
7	Innovate on added value	5

It is clear from the above table that energy (50 credits) and water (70 credits) efficiency are very important categories for Egypt. The objective of the EE are (1) to reduce energy consumption and carbon emissions by cooperating passive design stage, (2) to optimize the choice of electrical and mechanical equipment and evaluate the inventory of energy and carbon for each development mechanical/electrical/plumbing (MEP) system, and to minimize their impact on the environment, (3) to reduce energy demand for loads at peak use times through efficient building and services design and site based through renewable energy generation, (4) to encourage the provision of metering facilities that allow energy performance of the building, and (5) to minimize the energy consumed. The maximum credits in this category at 12 points for RE sources and 6 points to reduce the peak load, followed by 5 points for passive external heat gain reduction, that is, more than 50 %. The objective of water efficiency are summarized as follows: (1) Passive distillation systems is 12 points for storm water harvesting, 8 points for water efficiency improvements, 8 points for outdoor water efficiency improvements, 8 points for waste water management, 6 points for water leakage detection, and 6 points for water feature efficiency with a total 70 pints credit.

54.1.5.2 Certification and Levels of Rating

To earn the pyramid certification a project must satisfy all the stated mandatory minimum requirements and may obtain credit points by meeting certain criteria. Projects will be treated based on credit points accumulated, according the following rating system:

- GPRS certified: 40–49 credits
- Silver pyramid: 50–59 credits
- Gold pyramid:60–79 credits
- Green pyramid:80 credits and above

Projects with less than 40 credits will be classified as "uncertified".

54.1.5.3 Process of assessment

The assessment used a spreadsheet for evaluation process as follows:

1. For each category the number of credits awarded will be determined by a green pyramid.
2. The credit achieved for each green pyramid category is calculated.
3. The percentage of credits achieved is then multiplied by the corresponding category weighting.
4. This section score.
5. The scores for each category are then added to give the overall green pyramid rating, see Table 54.3

54.1.5.4 Green Star Hotels

Tourism is one of the major contributions to Egypt's gross domestic product (GDP). It is considered as one of the many sources of foreign currency, about 15 % from the

Table 54.3 Green Pyramid Rating Calculation

Green pyramid category	A	B	C=A/B×100%	D	E=C×D
	Credits available	Credits available	% Credits achieved	Category weight	Category score
1. Sustainable site, accessibility, ecology	10	5	50%	10%	5
2. Energy efficiency	50	40	80%	25%	20
3. Water efficiency	70	35	50%	30%	15
4. Materials and resources	20	15	75%	10%	7.5
5. Indoor environmental quality	30	15	50%	10%	5
6. Management	20	10	50%	10%	5
7. Innovation and added value	10	0	0%	5%	0
Total	57.5				
Green pyramid rating	SILVR				

national income after Suez Canal. Green Hotel Rating System [13] became necessary for the Egyptian touristic sector. A case study [14] focussed on hotels in the Red Sea costal area to estimate the energy efficiency base line and compared that data with the energy performance of some typical hotels in the Red Sea area according to a protocol signed between Gesellschaft für Internationale Zusammenarbeit (GIZ) and HBRC in 2010. The study is in progress and has not been completed yet.

54.2 Conclusion

This chapter presents the potential of EE and RE sources with the potential of GPRS in Egypt. The main conclusions derived from this chapter may be summarized as follows:

1. Hydro power from the high dam and other stations contribute about 9% of the total power.
2. Wind energy is very promising and needs more chair from the private sector.
3. Solar energy has not received much attention, since the electricity is subsidised and must be given to SWH for domestic use but, with incentives and rebates, many projects have been started in different locations.
4. As long as all petroleum products and natural gas are priced far below value, there will be no level playing field for RE (RE appears too costly) in power generation and decentralized application.
5. The only way out is to change the instruments, restrict misappropriation, smuggling, and wasteful low energy prices to basic energy (and public consumption transportation, and increase the incentives.
6. Egypt decided to reduce the value added tax (VAT) for efficiency and disincentives for renewable energy equipment.

The energy crisis threatens the whole world and specially Egypt. It can be summarized in that most of the energy needs in Egypt is dependent upon fossil fuel, whose supply is constantly decreasing, while the demand is greatly increasing. Another problem is the pollution growth which greatly threatens the health of all living creatures. Third, global warming due to the emission of green house gases as by-products of energy production, a problem that causes the temperature to rise constantly which threatens the life of many species, leads to more energy consumption in cooling, and causes floods in areas and droughts in others. As a response to these problems, and as buildings are important contributors to the problems, green buildings have emerged, and green building rating systems like GPRShave been developed.

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