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Towards Sustainable Supply of Electricity to Egyptian Cities by Introducing of Rooftop Solar PV Feed in Tariff System in Universities, and Research Centers

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***Abstract*— Renewable energy technologies are among the alternatives for developing countries like Egypt to fulfill its national energy needs. The Egyptian government was introduced different incentives to attract private investment sector to on grid renewable energy system. Also, it has introduced a new initiation to introduce PV feed in tariff system in 1000 governmental buildings in 2014, but till now only 320 governmental buildings had introduced the system.**

Although PV technology has been developed and the initiation is very ambitious, but still there are several barriers which can affect the implementation of the Egyptian government to install PV Feed in Tariff in governmental and commercial buildings.

The paper is discussing the strategy of the Egyptian government for using renewable energy (wind and solar) Feed in Tariff system. It also described some of the barriers for implementation this system in governmental buildings.

After studying the Egyptian context, the paper proposed to use the rooftops of the buildings in the universities and research centers because they have big numbers of buildings, are distributed around most of the cities in Egypt, have good technical capacity and finally can provide economic and sustainable solutions for the energy needs of these buildings and can help the country for its strategy of using renewable energy as one of the main sources.

Index Terms—**Solar, PV, Feed in Tariff (TIF), Universities, Research Egypt.**

I. INTRODUCTION

Experiences from all around the world show that the use of solar energy for the supply of electricity to cities is the future option with the positive side effect of pollution reduction.

In Egypt, residential, commercial and public buildings account for almost 50 per cent of total electricity consumption, with governmental buildings consuming almost 5 per cent. Net oil imports and rising government subsidies for energy are a growing burden on the public budget. At the same time, electricity consumption is forecast to increase, resulting in power shortages and a need for investments in new power generation capacities. In order to meet these challenges, the Egyptian Government has taken some initial steps towards to overcome these challenges by introducing renewable energy system as an option for the strategic energy mix plan, [1].

Solar and wind power are expected to play a key role in the energy process of Egypt country profile. The government launched different programs of renewable energy and other keystone elements of a strategic plan to develop what's considered a very rich base of renewable energy resources, [2].

On September 2014, Egypt has announced its ambitious Feed in Tariff (FiT) program for deploying 4300 MW of wind and solar energy in a 2 years' time. It is believed that the program as designed in this way would overcome most of the barriers that have hindered the renewable energy market in Egypt. Also, it has introduced a new initiation to introduce PV feed in tariff system in 1000 governmental buildings, but till now only 320 governmental buildings had introduced the system.

This paper will discuss the renewable energy strategy, and the barriers faced the PV Feed in Tariff Program in governmental buildings and will set a proposal to overrun these barriers.

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II. RENEWABLE ENERGY AND SUSTAINABLE DEVELOPMENT STRATEGY

The use of renewable energy technologies contributes to a sustainable development of energy and ecology at national, public and private levels giving a considerable measure of energy security, reducing dependency on fossil fuel resources and paving the way for mitigating emissions of greenhouse gases.

In March 2015, the Egyptian government announced its 2030 Sustainable Development Strategy (Egypt 2030) with aims at creating a modern, open, democratic, productive, and happy society, [3]. In the energy sector, the Egyptian government aims at maximizing the use of domestic energy resources (traditional and renewable); and developing the capacity of its energy sector to effectively contribute to competitiveness, and to adjust effectively to domestic and international developments in the field of energy and innovation; and to be a pioneer in the field of renewable energy, [3]. In the strategy, the main key performance indicators (KPIs) in energy sector include the followings:

- Secure energy resources
- Increase reliance on local resources
- Reduce the intensity of energy consumption
- Raise the actual economic contribution of the energy sector to national income.

The starting point for RE policy making is usually the definition of targets in terms of installed capacity or minimum shares in the country's electricity production. In February 2008, the Supreme Council of Energy has set a target to have a 20% of the total generated electricity to be from renewable energy resources by the 2020. Wind energy has been given the priority such that it would represent 12% of the total target (equivalent to 7200 MW). Hydro power will provide 6% and the remaining 2% will come from other RE resources including solar and biomass energies. In July 2012, the Cabinet approved the Egyptian Solar Energy target with a total installed capacity of 3500 MW by the year 2027. It includes 2800 MW from Concentrated Solar Power (CSP); in addition to 700 MW from Photovoltaic (PV). The private sector should participate with 67% of the mentioned capacities, while the governmental projects share, represented by New and Renewable Energy Authority (NREA), will be 33%, [4]. In 2014, the government had issued a new plan for energy mix and it presented in its Egypt Vision 2030 as shown in figure (1).

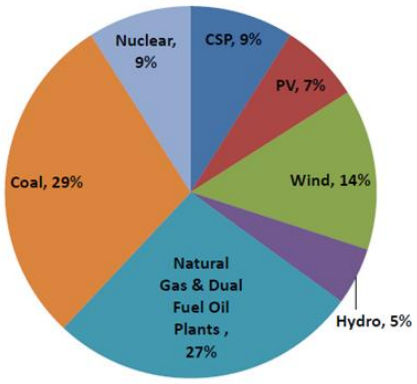

Fig (1): Egypt Vision 2030, Energy Mix 2030, [3].

There are different legal framework dealing with renewable energy systems in Egypt, [5] and these include the followings:

a) Constitution / Article 32 which states: to get optimum benefits from renewable energy, promote its investments, and encourage R&D, in addition to local manufacturing.
b) Law No. 203 of Year 2014: to Motivate Production of Electricity from Renewable Energy Sources.
c) Cabinet Decree No. 1947 of Year 2014 on Feed-in Tariff.
d) Cabinet Decree No. (37/4/15/14) of Year 2015 Regulations: to Avail Land for renewable Energy Projects.
e) Law No. 8 of Year 1997: On Investment Guarantees and Investments.
f) The Rules and Regulations related to reposition of the renewable energy projects already in operation before the issuance of Law No. 203 of year 2014.

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III. FEED IN TARIFF (FIT) PROGRAM IN EGYPT

Feed in Tariff (FiT) is one of the mechanisms that has been adequately studied but was never recognized as a possible solution to the deployment of renewable energy due to existing electricity tariff subsidies. Now, there are great concerns all over the world about FiT programs and meanwhile the FITs have been implemented in 68 countries worldwide and it is now used in 23 out of 27 of the European Union states and a number of developing countries, [6].

Figure (2) shows a new headquarters building for the International Renewable Energy Agency (IRENA) which has achieved a reduction in energy demand by 42% compared to global standards and includes 1,000 m^2 of rooftop photovoltaic solar panels supplying electricity to the building.

Fig (2): PV System on the Rooftop of Headquarters Building for the International Renewable Energy Agency (IRENA), Abu Dhabi, UAE, [7].

In September 2014, the Egyptian government announced the new Feed in Tariff law for renewable (PV-Wind) projects to encourage private developers and governmental entities and public to install 4,300 MW of renewable electricity generation capacity. This target includes:

- 300 MW for small solar systems (less than 500 KW);
- 2,000 MW of medium- and large-size of solar plants;
- 2,000 MW of medium- and large-size of wind plants;

In addition to the new Feed in Tariff, producers will enjoy long-term leases of land charged at 2 percent of the value of energy produced, and a customs tariff of 2 percent will apply to imported equipment and materials. The government had developed an integrated energy strategy that includes new energy prices to reduce the energy subsidy bill. The plan also aims at developing demand-side initiatives to ease energy consumption and implement initiatives based on a phased approach. Utility companies are obliged by law to buy electricity from renewable energy sources at a specified price over a guaranteed period making in this way the installation of PV systems a secure investment with a fast Return of Investment (ROI) for the investor respectively for the producer of clean energy, [8].Till now 67 consortiums have qualified for PV projects with total capacity 2,880 MW and 27 consortiums have qualified for wind projects with total capacity of 1,670 MW, [2]. Feed in Tariff (FiT) guarantee the generation of a large-scale deployment of energy produced from renewable resources like photovoltaics. Also, it has different benefits such as climate protection, security of energy supply as well as creating and securing jobs. Feed in Tariff can be the best motor that drives sustainable economic growth and social development, [8]. Table (1) shows Feed in Tariff rates for PV Rooftop.

Table (1): Feed in Tariff Rates for PV Rooftop, [8]

Sector	Tariff	
	US$/kWh	EGP/kWh
Residential	0.113	0.844
Installed Capacity < 200 kW	0.120	0.901
200 kW < Installed Capacity < 500 kW	0.130	0.973

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According to a research published in 2017, [9]. It is highlighted the benefits of PV Feed in tariff installed in administration building in Egypt, they stated that the approximately payback period to recover the investment costs for PV systems is about 5 years, [9].

IV. PV FEED IN TARIFF INITIATION IN GOVERNMENTAL BUILDINGS

In 2014, the Egyptian Cabinet issued a prime minster decree to introduce PV Feed in Tariff system in 1000 governmental buildings. The Egyptian Electricity Holding Company (EEHC) and its affiliated companies took the lead to install PV systems at the rooftop of their administrative buildings and interconnected these systems to the electricity network. About 90 PV systems have been mounted with a capacity of 9 MW, [9]. Figure (3) shows PV on the rooftop of New and Renewable Energy Building, Nasr City.

Fig (3): PV System on Rooftop of New and Renewable Energy Building, Nasr City.

A. PV Feed in Tariff in Gaza New Shopping Market for Street Vendors

Gaza new market is located in Port Said road at Al Zawia Al-Hamra district in Cairo. It is owned and operated by Cairo governorate. It was a joint cooperation project between Informal Settlements Development Facility (ISDF) and Cairo governorate. It is designed to accommodate about 390 of the informal street vendors from city center of Cairo. The area of the market is about 4200 sq.m and it has a complete on-grid photovoltaic (PV) solar system to generate power of 90 kWP, the PV system was introduced from the beginning of architecture design. The PV cells is Mono-crystalline module panels dual voltage property grouped in series strings connected in parallel to formulate series parallel array and arranged and installed taken into consideration the sun array and the shades of each row to the other. Figures (4), (5) show Gaza New markets in Al Zawia Al-Hamra and the PV on the rooftop.

Fig (4): View of Gaza New Shopping Market for Street Vendors, Powered by 90 KW PV Feed in Tariff System (Designed by the Author)

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Fig (5): PV Feed in Tariff System on Rooftop of Gaza Shopping Mall For Street Vendor (Designed by the Author)

On the other hand, and according to official source from Ministry of Energy and Renewable Energy in February 2017, it is stated that the ministry succeeded to install PV systems only on 320 governmental buildings, [10]. So, this figure open the question why this initiation did not reached the planned number and it proves that some barriers are still existing in Egypt to implement this renewable energy initiation.

V. BARRIERS TOWARDS IMPLEMENTATION OF PV FEED IN TARIFF IN GOVERNMENTAL BUILDINGS

There are numerous barriers that explain why PV Feed in Tariff system, which appear as cost effective, are not chosen or not implemented in large scale in governmental and private owned buildings in Egypt. Barriers can occur all along the process of selecting the products, installation of the system, connection with the grid, but most attention is directed towards consumers and their decisions. Among the most important general barriers are the following:

- Limited information;
- Limited awareness and interest in renewable energy investment and reducing energy expense both in public, governmental and private owned buildings;
- Administrative costs of making and implementing decisions;
- Risk and lack of consumer confidence;
- Limited capital and rapid payback requirements.

In Egypt, although PV technology has been introduced in the last years in different stand-alone systems, but there are several barriers which can affect the implementation of the government initiation to install PV Feed in Tariff in governmental buildings, and some of these barriers can be summarized as follows:

a) Electricity Cost

One of the barrier is the electricity cost which is subsidized by the government for a long time which allow the users to have a choice to use electricity from the grid directly instead of PV especially in governmental buildings and also in private and public buildings such as commercial, educational, research buildings.

b) Maintenance and Operation

The responsibility to operate and maintain the PV technology is another barrier. This can be related to the lack of technology awareness especially in governmental entities. Some users are also concerned about the complexity of the system, technological maturity, durability, efficiency, safety, and stability. The quality of PV systems in the Egyptian market is also of vital importance for customers and professional as well. It can be influenced by not only the type, specification and country of origin but also the cost because all items are still imported, [11].

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c) Dimensions of Roofs

The architectural dimension of the roof areas is also an important factor for the existing buildings and can become a barrier to install of PV system. A key barrier is the in adequate installation space. PV panels need to be angled toward the right direction which is South n in Egypt to maximize solar exposure. In fact, different existing governmental buildings have limited surface area in the roof and also the location of the building can be shaded by other buildings.

d) Lack of Technical Capacity

The existing technical capacity and experiences in PV systems in governmental entities can be one of the technical barriers and affect the diffusion of PV Feed in Tariff system in governmental buildings. Most of the engineering department in governorates had no experience in PV or renewable energy systems in general. So, all stakeholders of this initiation should understand the local conditions of the particular context in order to overcome these barriers.

VI. INTRODUCING PV FIT IN UNIVERSITIES AND RESEARCH CENTERS

The research had evaluated the barriers facing application of the governmental initiation for installing PV Fit for 1000 governmental buildings. It studied the Egyptian context and it is reached that there is big opportunity to install PV systems in the roofs of universities and research centers because Egypt has 27 governmental universities and 20 private universities. Also, the ministry for high education has 14 research centers and the other ministries have about 219 research centers.

These big number of universities and research centers which had normally big land to accommodate their different faculties and research facilities and distributed in most of the Egyptian cities and also had a well knowledgeable technical departments can offer a good opportunity which can overcome the barriers which faced the old initiation. This proposal can enlarge the amount of energy which can be produced by PV systems in cities and can reduce the cost of the energy bill in these education and research centers.

As example of Al Azhar University which has about 79 faculties can apply the PV feed in tariff system in their buildings. Figure (6) shows an aerial view of Al Azhar University site in Nasr City.

Fig (6): An Aerial Google View of Al Azhar University Site at Nasr City.

To start such program, the government should introduce a new initiation which can encourage the universities and research centers to install PV Feed in tariff in their buildings. Also, it should give some incentives to these governmental entities and also the PV suppliers to convenience them to join this initiation.

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VII. CONCLUSIONS

The implementation of a Feed-in Tariff Law makes people interested in investing in photovoltaic projects. The law is a very important step in a sequence of steps and activities towards a sustainable urban development and infrastructure program with the long-term target to convert the electricity grid into a smart grid.

Despite the increasing attention given to the development of renewable energy, there are still significant barriers for implementation the governmental initiation for installing PV Feed in Tariff in governmental buildings and these include subsidy, electricity cost, maintenance and operation, dimension of roofs and lack of technical capacity.

The government can introduce a new initiation for universities and research centers to benefit from their big numbers and distribution in all Egyptian cities. Also it should offers some intensives to both the consumers and suppliers such as exemption of value added tax to several components of solar PV system such as solar cells, modules, batteries which will be used in these initiation.

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Dr. Algohary had a practical, managerial experiences, in Egypt as well as internationally, in the fields of sustainable desert development, informal settlements development, environmental architecture, energy efficiency in buildings, solar passive architecture, and application of renewable energy systems. He was a visiting professor at Sandia National Laboratories, USA; International Research Centre, Julich in Germany also he was a consultant for sustainable desert project and development of slums in New Mexico, operated by Department of Energy (DOE), USA.