Title

Present Capacity Building Schemes in Egypt

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Abstract: Building of capacities that stimulates the sharing of scientific knowledge and best practices, promotes the development of energy policies, supports pilot initiatives and provides technical assistance to the government. The number one barrier to renewable energy scale-up in Egypt - and the developing world in general - is identified to be cost. In Egypt, the Science and Technology Development Fund (STDF) has been found in 2007 as a governmental entity that helps building capacities in terms of infrastructure and human resources with an annual budget of $100 million. It is under the umbrella of the Egyptian Ministry of Scientific Research and is therefore considered as the focal point to solve national challenges from an R&D perspective. Targeting research proposals that deal with energy-food-water has been a focus in the last two years. In collaboration with the Ministry of Electricity and Energy large solar power plants, with production capacities ranging from 20 MW to 50 MW, will start operation in 2016 and will add 1,500 MW to the grid's total capacity.

Keywords: renewable energy, STDF, national priority, Egypt.

Full Paper

Introduction:

Energy security is of strategic importance for sustainable development and poverty reduction. In recognition to this, the General Assembly of the United Nations announced 2012 as the International Year of Sustainable Energy for All. The global nature of energy challenges requires that local conventional and renewable energy resources be appropriately managed and used. Egypt's total primary energy demand has grown at an average annual rate of 4.5% during the last two decades. This rather high growth is linked to strong economic growth and is particularly reflected in the rapid increase in demand for electricity and transport services. Table 1 shows the energy balance in 2013, given the size of a population at that time exceeding 82 million and consequently a growing domestic market [1].

Table 1 : Energy balance in 2013 in thousand tonnes of oil equivalent (ktoe) on a net calorific value basis [1]

	Crude Oil	Natural gas	Hydro	Geothermal/ solar	Biofuels and Waste	Total
Production	34820	45112	1113	131	1644	82821
Imports	3028	0	0	0	1	3029
Exports	-9886	-5171	0	0	-24	-15081
TPES	**27962**	**39941**	**1113**	**131**	**1621**	**70769**

Fossil fuels dominate electricity production in Egypt (Figure 1), accounting for around 95 % of total electricity production in 2013. Electricity consumption is 148.72 TWh with 184.32 Mt of CO_2 emissions [1].

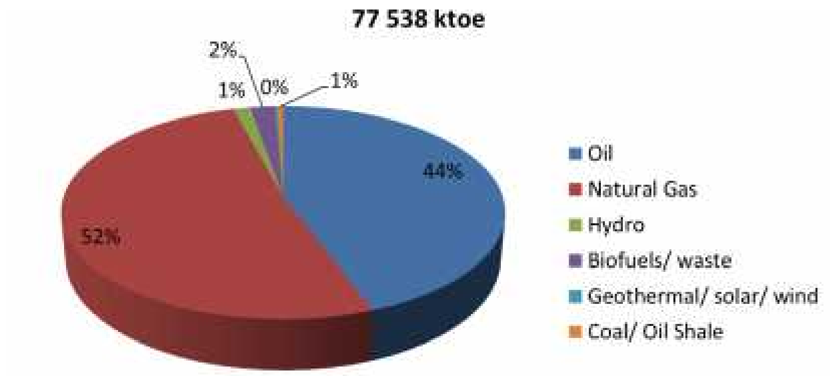

Figure 1: Share of total primary energy supply in 2013[1]

A greater use of renewable energy resources and greater use of advanced energy technologies, including green technologies for use of fossil fuels is urged. To achieve these objectives, Egypt is continuously seeking to mobilize sufficient financial resources, in an economically viable, reliable, affordable and acceptable way on a social and environmental level creating the necessary conditions for the governmental and private sectors to invest in clean and more sustainable energy technologies [2]. Against this background, enhancing national capacities that focus on institutional and human capacity building is a must.

Egypt's present energy strategy (the resolution adopted by Supreme Council of Energy in February 2008 and February 2010 [3]) aims at increasing the share of renewable energy to 20% of the energy mix by 2020. This target is expected to be met largely by scaling-up of wind power as solar is still very expensive and the hydro potential is largely developed. The share of wind power in total electricity generation is expected to reach 12 percent, while the remaining 8 percent would come from hydro and solar. This translates into a wind power capacity of about 7200 MW by 2020. The solar component is limited to 100 MW of CSP and 1 MW of PV power. Currently, the electricity production is 1286 GWh, 242 GWh and 12940 GWh, from wind, solar (PV) and hydro, respectively [1]. Thus, the development of renewable energy resources in Egypt is on the right track.

Egypt's progress in implementing solar projects has been limited although it has high potential and very promising sites for solar energy that could be used to produce heat through solar collectors, or generate electricity directly through photovoltaic (PV) technology or in a Concentrated Solar Power (CSP) system [4]. The solar atlas published in 1991 indicates a solar irradiation level of 2000 to 3200 kWh/m^2 /year from north to south with average sunshine of 9 to 11 hours a day [5] . Egypt has the highest economic capacity for solar energy in North Africa as of 2005, it has the 4th largest capacity for CSP in the Mediterranean [6].

Government policy has consistently emphasized hydropower, but there is a view that most potential hydro resources have already been exploited. In fact, hydroelectricity represents 2,800 MW out of a total of 24,726 MW, thus 11.3% of the total capacity in operation in 2010 [7].

Egypt has been pursuing wind technology since 1970s when it founded its first wind test station in collaboration with DANIDA [8]. However, more progress has been achieved in recent years. The New and Renewable Energy Authority (NREA) has significant in-house expertise through developing about 500 MW of wind power in Egypt in areas ranging from first resource assessment to wind farm operation and maintenance [9]. In Egypt, two atlases on wind energy were published in 2005. Several regions which are conducive to high power wind plants, were identified. Egypt is able to have 20 000 MW of capacity within wind farms [10], this is not far short of the electric capacity already in place (24 726 MW in 2010) [6]. According to the Egyptian electric company [7], some 7200 MW will be able to be mobilised between now and 2020.

Some case studies:
Egypt's major solar power project was commissioned in 2010 in Kuraymat with 140 MW solar thermal combined cycle power plants and financial support from the Global Environment Facility and Japan Bank for International Development [8]. The investment cost of solar power plants is presently very high in comparison with the oil and gas plants [11]. A new proposal relates to the construction of the Kom Ombo plant (located about 40 km North of Aswan and 150 km South of Luxor) of which the meteorological data show an annual sum for direct normal irradiation (DNI) of 2516 kWh/m^2. The land availability and the DNI encourage a proposal for a 100 MW CSP plant [8].

Egypt has little local capacity in the solar sector. It has a number of small companies that are involved in supplying solar water heaters that are commercially viable. Aside from this small sector, Egypt does not have much capacity to locally produce the components of solar power plants.

Egypt's hydropower potential is about 3,664 MW with an estimated energy of 15,300 GWh/ annum. There are currently five main dams in operation which are located on the River Nile, the Aswan High Dam and the Aswan Reservoir Dams generating most of the electricity. The Aswan High Dam power project has a theoretical generating capacity of 2.1GW, although low water levels often prevent it from operating in its full design capacity [12].

Egypt is endowed with an abundance of wind energy resources especially in the Suez Gulf area which is considered one of the best sites in the world due to high and stable wind speeds ranging between 8-10 meter/second on average. There are also other promising sites having wind speed of 7-8 meters/ second in the east and west of Nile River near Beni Sweif and Menia Governorates and El-Kharga Oasis in the New Valley Governorate [13].

Installed wind power capacity comprises two sites, Hurghada and Zafrana. The first site may be regarded as the first pilot experiment in 1993 with 42 turbines encorporating different technologies in collaboration with Germany, Denmark and the USA [14]. The two mentioned sites have a capacity of 522 MW. A number of projects are in the course of realization or at the planning stage, including 120 MW additional capacity at the Zafarana site. Other projects are programmed from 2013 onwards for the Gulf El Zayt and Gulf of Suez sites in partnership with the EU, European Investment Bank (EIB) and Japan with a total capacity of 560 MW. Three other projects, for which financing research is under way, totalling a capacity of 580 MW, are planned in cooperation with MASDAR company in Abu Dhabi, UAE, the EU and EIB [15].
Other projects in the region West of the Nile with a total capacity of 700 MW are planned over a longer term and should be completed in several stages. Alongside these projects initiated by NREA, the Egyptian private sector disposes of a consequent portfolio of a total capacity of 1370 MW, of which the state of progress is variable according to each project like the wind farm for Suez Cement Company [16].

The first hybrid project (natural gas-CSP) in this field is that at Kuraimat, brought into service in July 2011, with a capacity of 140MW, of which 20 MW is solar. The total cost of this project is 340 Mio US$. Financial resources are from NREA (100 Mio US$), the Global Financial Facility (GEF) (50 Mio US$) and a low-interest loan (0.75% repayable over 40 years, with 10 year grace period) and Japanese cooperation. This plant should allow an annual saving of around 10 000 t of fossil resources and a 20 000 t reduction of CO_2 emissions [6].

Currently, the share of renewable energies in final consumption, excluding hydro-electricity and traditional biomass, is negligible even if there have been significant developments over the past five years. The contribution from renewable energies comes essentially from wind farms connected to the network installed in Egypt, Morocco and Tunisia as has been shown by an analysis of the installed electricity capacities, excluding hydro-electricity, in the region [17]. Account should also be taken of decentralized facilities, in particular photo-voltaics for the needs of households, which contribute significantly to the quality of life in rural areas, although they resemble only a small part of total renewable energy capacity.

Objectives :
Egypt aims at increasing the production of renewable energy while reducing the consumption of its fossil fuel resources. Therefore, Egypt developed an energy strategy adopted by the Supreme Court for Energy in February 2008 [18]. Given the importance of wind power potential, Egypt has given priority to developing this energy resource which has seen strong development in installed capacities. However, other technologies are also supported, but with far less investment. As of late 2009, installed wind power capacity reached 430 MW, for a production of 948 GWh. Such production has made possible a saving of 205 000 t of fossil fuels, a reduction of 521 000 t of CO_2 [6]. Solar Energy is the second technology in terms of importance and involves the most promising large-scale applications.

Implementation:
There are a number of research areas critical for growth and economic development in this regard. For example, large solar power plants, with production capacities ranging from 20 MW to 50 MW, will start operation in 2016 and will add 1,500 MW to the grid's total capacity before next summer, as has been announced by the ministry [19]. The new plants are part of the government's larger plan to expand the use of renewable energy resources to

generate 20% of the country’s total electricity production from renewables by 2020 with a total investment cost of $13.5 billion.
The feed-in tariff system was approved by the government in September 2015 after lengthy studies to determine a fixed tariff for energy produced from projects under the new system. The system allows any person or company, public or private, to generate electricity from wind and solar energy and sell it to the national grid that will definitely help expansion of renewable energy usage. According to the government plan, 65 % of the country’s electricity should come from solar-powered power stations by 2050.
Streets lights in several parts of the country are now powered by solar-powered photovoltaic cells. Some cities have started installing the technology on the roofs of buildings in an effort to introduce solar power gradually as a main source of energy. The Ministry of Electricity and Energy has announced that thousands of buildings in Upper Egypt currently use solar-powered photovoltaic cells as their main source of electricity.

Initiatives for increased use of renewble energies

In the majority of North African countries, significant reforms of legislative, institutional and regulatory frameworks have been carried out over the past few years with a target to promoting renewable energies and energy efficiency.

1. *Collaboration:*

Egypt has a good track record in international cooperation in the energy sector in general and in the wind energy development in particular. To complement the efforts at national level and remove obstacles associated with weak technical, institutional and financial capacities, it is important to strengthen partnerships between countries and specialized national businesses while taking international experience and knowhow as a basis. A number of current initiatives such as the Mediterranean Solar Plan (MSP) [20], the Euro-Mediterranean partnership, the agreements that exist between the European Union (EU) and some countries of North Africa, the DESERTEC project or the initiatives running under the AMU (COMELEC, North African platform for scientific and university research in the field of renewable energies) and the Arab League, are all forums for joint action and consultation, that may improve technical and financial effectiveness in the field of renewable energies [21].

North African countries have defined ambitious strategic objectives and launched large-scale integrated programmes on the basis of their solar and wind capacities, which have expected advantages that involve reduction of greenhouse gas emissions, exchange of experiences and the transfer of technology, local industrial development and the improvement of human capital.

2. *Research and Development*

Research and Development in Egypt follows a clear strategy to combine technology transfer with local adaptation in order to provide advice to local companies and manufacturers on:

- innovative and new materials, processes and applications,
- new and potential improvement to existing processes, durability and cost competitiveness of the systems,
- technology validation in the field with feedback on the performance, operation and costs, as well as
- support for incubation and start ups.

In this context, the Supreme Council for Research Centers [3] and the Clean Energy Committee developed and declared a clear strategy for research and development in the area of renewable energy.

3. *Human Resource Development.*

The key to development of wind and solar manufacturing industries is the ability to acquire technically qualified manpower according to international standard. Some capacity already exists in Egypt in wind manufacturing. However, there are considerably further skill requirements in solar manufacturing and services. Egyptian scientists work on various aspects of energy, including conventional fossil fuels as oil and natural gas, biofuels, solar, wind and hydroelectric energy. Building of capacities that stimulates the sharing of scientific knowledge and best practices, promotes the development of energy policies, supports pilot initiatives and provides technical assistance. Capacity building covers a wide range of skills and capabilities needed by the government agencies, equipment suppliers, financial middlemen, energy efficiency and energy consumers’ service providers. In each of these areas capacity building should draw upon the international experience, resources and funding in a practical manner.

The Science and Technology Development Fund [22]

The main science and technology plan in Egypt focuses on progressing towards knowledge based economy targeting an annual economic growth of at least 8-9% to sustain its development. Re-structuring of science and technology governance is a first step that involves a national initiative for human resources development. While national priority areas are identified for project funding, a national initiative for informal education and innovation is encouraged.

As a result of a complete reform for the Science and Technology (S&T) governance system in Egypt, carried out by the Ministry of State for Scientific Research, a Higher Council for Science and Technology (HCST) and a Science and Technology Development Fund (STDF) were established by presidential decrees number 217- 2007 and 218- 2007, respectively [22]. The main goal of the HCST is to strategically plan for the utilization of scientific research for economic and societal development. The science, technology and innovation system in Egypt comprises of the National Council of Scientific Research and Education (NCSRE), the Ministry of Scientific Research (MOSR), the Academy of Scientific Research and Technology (ASRT), the Science and Technology Development Fund (STDF) as well as Research Institutions and Universities.

STDF's main goal is to promote Science, Technology, and Innovation (STI) through funding scientific research and technological development in a way that supports the complete cycle of innovation. STDF’s operations are governed by a vision of an educationally, economically, and technologically developed Egypt and a strong belief in the fundamental role of STI to drive these developments and consequently improve the quality of life for all Egyptians.

In order to fulfill STDF’s vision of “better science for better life” it is aimed at improving Egypt’s contribution to global scientific advancement, developing its scientific and technological intellectual capital, and increasing the contribution of science and technology in developing Egypt via a *knowledge-based economy*. The STDF has been found as a governmental entity that helps building capacities in terms of infrastructure and human resources with an annual budget of $100 million. It is under the umbrella of the Egyptian Ministry of Scientific Research and is therefore considered as the focal point to solve national challenges from an R&D perspective. The STDF obliges itself to ensure funding of science and technology addressing the priority areas set by the Higher Council for Science and Technology. The STDF supports and develops Egyptian research and innovation capabilities to ensure the integration of science, technology and innovation elements in national strategies with the aim of bridging the gap between industry and academia as well as develop a better understanding of best practices on all levels of research that the STDF is closely working on with other ministries in Egypt.

Egypt’s Science and Technology priority areas include [22]

1. Energy Resources
   - Technology Transfer of Wind Turbines.
   - Concentrated Solar Power.
   - Photovoltaic thin films with Nanotechnology.
2. Water and Environment
   - Non-Traditional Water Resources Management.
   - Desalination with renewable energy sources.
3. Food and Agriculture
   - Increasing yield of economic crops.
   - Increasing marine aqua-culture of fishes.
4. Health
   - Combating Hepatitis C virus disease.
5. Space, Remote sensing and ICT
   - Earth observation and Climate Change.
   - Super-, grid-computing and data mining.

Any Egyptian affiliated to an Egyptian research institution, university, non-governmental organization (NGO) or a Joint Stock Egyptian company (SAE), having well-documented scientific research and development activities is eligible for funding by STDF in accordance with governing rules and regulations of governmental funding [2]. Collaboration between research institutions and industry is highly encouraged in STDF programs. The STDF has several programs that particularly tackle challenges associated with emerging technologies. Capacity building grants (Figure 2) include young researchers’ grants as well as reintegration grants for young scientists who have completed their Ph.D.s abroad and wish to establish a research facility in their home instituions in Egypt. Short Term Fellowships also supported by STDF would guarantee a continuation with their host abroad or with any other potential international collaborator. Research support grants are offered as seed money for a certain high value project or as a proof of concept for new branches of research. Interdisciplinarity is encouraged and workshops can be funded for brainstorming purposes and industry- academia interactions.

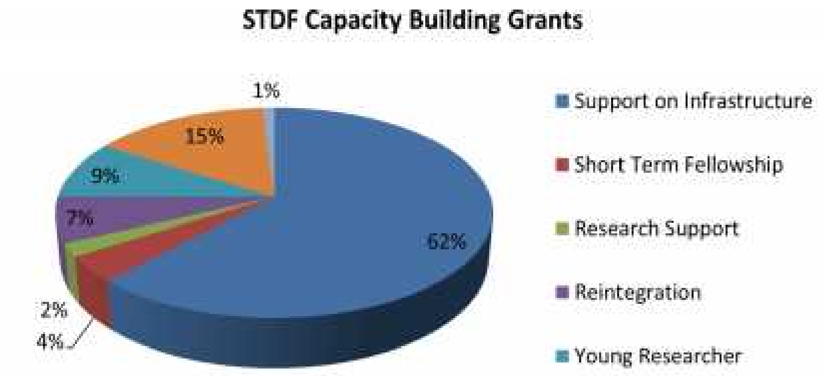

Figure 2: Distribution of STDF Capacity Building Grants

A special emphasis is put on innovation grants by STDF (Figure 3) that support Egyptian innovators from the early stages of formulating concepts for novel technologies and new processes, to the stage of developing new technologies, processes and products. This grant includes alleviating the technological risk and effectively transferring knowledge and technology to endusers. This grant supports technology development through prototyping or pilot-scale demonstration; provides wider access, extends and builds partnerships, and strengthens links between academia and industry.

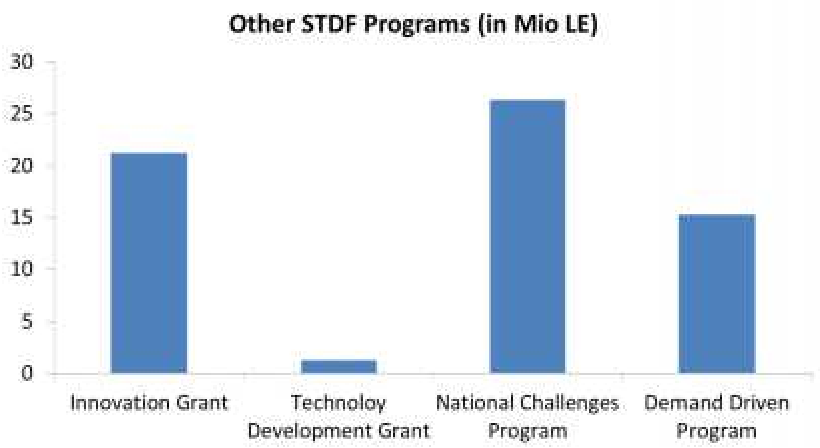

Figure 3: Other STDF programs (Funds in Mio LE)

Proposals submitted to this grant are subjected to two different levels of evaluation:

i. Scientific and technical evaluation, and
ii. Feasibility, validity and economic evaluation.

Assessment is undertaken by panels of independent scientists and policy makers with special expertise in technology development. Applicants have to note that, if a proposal passes the scientific and technical evaluation, the principal investigaor (PI) of the proposal is required to deliver a presentation of the proposal in a private interview.

The selection criteria rely on [22]:

- Novelty; the quality of the idea that makes it a new or unique approach
- Technical merit; the scientific and engineering principles on which the idea is based
- Feasibility and validity
- Potential impact; expected future impact on Egypt’s innovation power, industry, economic development, and/or socioeconomic situation
- Society and market need
- A track record of success in the field for the applying institution(s), the PI and the project team
- An applied research plan with clear objectives, milestones and expected measurable outcomes, as well as
- Governmental and/or private sector collaboration and investment interest.

The Higher Council of Science and Technology declared in August 2009 renewable energy as one of Egypt's five National Research priorities. In line with this strategic orientation, the Science and Technology Development Fund (STDF) launched targeted R&D calls on Renewable Energy (Figure 4).

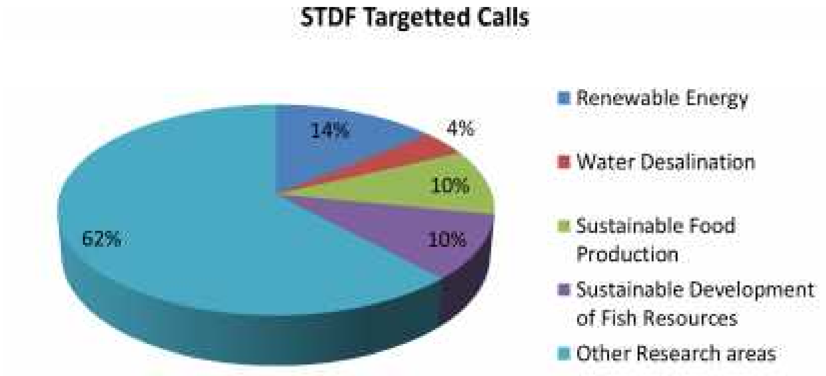

Figure 4: Field distribution of STDF targeted calls

These targeted calls would support the advancement of the sector on a knowledge and technical basis. In particular, a solar power plant can be conceptually divided into two parts: the solar field and the traditional power block with each component representing almost equal share in the project cost. The key components of solar field are the metal support structure for mounting, the mirrors and the receivers. Egypt has the industrial base for manufacturing most of CSP components but would require a comprehensive plan for transfer of specialized technologies that can be financially supported by any of the above-mentioned STDF ftnding schemes.

The government has also encouraged local production of wind turbine components. A typical wind energy project has four distinct components: wind towers, nacelle and enclosed turbine, blades and rotors and the balance of the plant accounting for 15%, 40%, 20% and 25% of the project cost, respectively. In Egypt there is some existing capacity in each of these areas. Electrical components (cables, transformers) and wind turbine towers have been mostly produced by local companies. Egypt has the capability to manufacture towers and the majority of the "balance of system" items. Together, these account for around 75% of the investment costs of wind. It is estimated that using locally-manufactured components as much as possible would reduce system costs by 10–15% in the short term; possibly increasing to 25% in the longer term as the local supply chain is better integrated [23]. Bearing these numbers in mind, the STDF is particularly seeking to promote research that tackles these aspects in its rich diversity of offered funding programs.

Conclusions and Recommendations

The Egyptian government has recognized that the availability of sustainable power supply is fundamental for economic development as well as for attracting investments by the private sector. The government has therefore a clear policy of securing a reliable power supply to contributors to the countrie's economy. To meet the rapidly growing electricity demand, the government has successfully expanded the power supply capacity from 17000 MW in 2003 to about 25000 MW in 2010. Despite this rapid expansion, the installed capacity is viewed rather insufficient to meet demand. The increasing use of fossil fuels in the power sector has awakened a strong interest in the variety of the energy mix particularly the development of renewable energy resources. Implementation of energy audits and surveys, enforcing energy efficiency standards, promoting R&D and dissemination of advanced energy technologies, facilitating market penetration and commercialization of high-efficiency equipment, and mobilizing financial support for energy efficiency projects is a must. In an attempt to coordinate various aspects of energy efficiency the Supreme Energy Council established through a decree in June 2009 an Energy Efficiency Unit at the Cabinet of Ministers to coordinate, guide, support and monitor all energy efficiency activities in the country. The unit includes members of eight ministries representing the end user sectors such as Transport, Housing, Tourism and Trade & Industry, and the supply sectors such as Electricity and Petroleum. It has a good basis for developing the required technical and managerial skills.

The Ministry of Electricity and Energy as well as NREA have often emphasized their support for the increased local contribution of renewable energy facilities. Moreover, an additional consideration is the development of human resources while drawing upon the country's educational and vocational facilities, as well as utilizing the abundant international assistance. The strategy considers and is already partly implemented:

- designing and offering courses in solar and wind technologies by engineering colleges with financial assistance from the government;
- courses for technicians offering technical training for field installations and follow-up service network; and
- introducing a governmental fellowship program to train selected engineers and scientists in wind and solar energy in world class institutions abroad. This is supported by STDF under programs of bilateral cooperation, or institution to institution arrangements.

Egypt has developed niches of excellence that are appropriate to orienting themselves towards clean technologies. The country has a solid base of high quality universities with strong R&D capacity in the core sciences of relevance for clean technologies such as nanotechnology, engineering and material sciences. A well coordinated public-private partnership on the Egyptian side would enable the country to take advantage of both private and governmental facilities in other countries particularly Europe. Cooperation should be implemented at the level of research organizations as well as industry partners.

A draft Electricity Law was also prepared in 2008 that particularly aims at facilitating the construction of wind and solar plants through market liberalization, private sector participation and financial support. In particular, the new law provides for the establishment of a "Fund for Development of Power Generation from Renewable Energies (RE Fund)" [24]. This Fund is providing the resources that the transmission company needs to purchase renewable energy through feed-in tariffs which are expected to be higher than the cost of conventional electricity generation.

The financial risk for investors is reduced through guaranteed long-term power purchase agreements. The goal is to have the private sector contribute 2500 MW by 2020. The intention is to target highly qualified international developers with strong financial status and high capacity for technology transfer. Also, local manufacturing will be privileged by promoting proposals having higher shares of locally manufactured components.

It is recommended to make full use of available funding proramme like the ones offered by STDF and the RE fund, to establish a network for centers working on renewable energy, exchange knowledge and expertise and to transfer experience among experts of the field.

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