d·i·e

Deutsches Institut für
Entwicklungspolitik

German Development
Institute

Studies

Building Domestic Capabilities in Renewable Energy

A case study of Egypt

Georgeta Vidican

Building domestic capabilities in renewable energy

German Development Institute (DIE)

The German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE) is a multidisciplinary research, consultancy and training institute for Germany's bilateral and for multilateral development cooperation. On the basis of independent research, it acts as consultant to public institutions in Germany and abroad on current issues of cooperation between developed and developing countries. Through its 9-months training course, the German Development Institute prepares German and European university graduates for a career in the field of development policy.

Dr. Georgeta Vidican is a Senior Researcher at the German Development Institute (DIE), in the Competitiveness and Social Development Department. She finished Applied Sociology (MSc) from University of Massachusetts Boston, and Urban Planning (MSc) from Massachussets Institute of Technology (MIT). She holds a PhD degree from MIT in International Development and Regional Planning. After obtaining her doctorate in 2008, she worked as Assistant Professor at Masdar Institute of Science and Technology in Abu Dhabi, until 2011. Her main areas of research and expertise are development policy, low-carbon development, innovation systems and private sector development.
E-Mail: Georgeta.Vidican@die-gdi.de

Studies
Deutsches Institut für Entwicklungspolitik 66

Building domestic capabilities in renewable energy

A case study of Egypt

Georgeta Vidican

DIE-Forschungsprojekt *„Zukunftsfragen der Entwicklungspolitik nach 2015; Teilprojekt 4: Klima / Low-Carbon Development / Privatsektor“*

Bonn 2012

Studies / Deutsches Institut für Entwicklungspolitik
ISSN 1860-0468

Die deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://dnb.d-nb.de abrufbar.

The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data is available in the Internet at http://dnb.d-nb.de

ISBN 978-3-88985-503-9

Tulpenfeld 6, 53113 Bonn
☏ +49 (0)228 94927-0
🖷 +49 (0)228 94927-130
E-Mail: die@die-gdi.de
http://www.die-gdi.de

Contents

Tables

Figures

Boxes

Abbreviations

AOI	Arab Organization for Industrialization
ASRT	Academy of Scientific Research and Technology
AUC	American University of Cairo
BMBF	German Federal Ministry for Education and Research
BMU	German Federal Ministry for Environment, Nature Conservation and Nuclear Safety
BMWi	German Federal Ministry of Economics and Technology
BMZ	German Federal Ministry for Economic Development and Cooperation
BOO	Build-Operate-Own
CIM	Centrum für international Migration und Entwicklung
CMRDI	Centre for Metallurgical Research and Development Institute
CO2	Carbon Dioxide
CSP	Concentrated solar power
DAAD	German Academic Exchange Service
DDC	Desert Development Centre
DIE	Deutsches Institut für Entwicklungspolitik / German Development Institute
DII	DESERTEC Industrial Initiative
DISEM	DESERTEC Institute for Studies on Socio-Economic Development and Employment in MENA
DLR	German Aerospace Centre
DUN	DESERTEC University Network
EETC	Egyptian Electricity Transmission Company
EEUCPRA	Egyptian Electric Utility and Consumer Protection Regulatory Agency
EGP	Egyptian pound
EGPC	Egyptian General Petroleum Corporation
ENCPC	Egyptian National Cleaner Production Centre

EPC	Engineering, procuring and construction
ERC	Energy Research Centre
ETTIC	Egypt Technology Transfer and Innovation Centres
EU	European Union
FIT	Feed-in-tariff
GAFI	General Authority for Investment
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GW	Gigawatt
HCST	Higher Council for Science and Technology
HTF	Heat transfer fluid
HVDC	High-voltage-direct-current
IIT	Indian Institute of Technology
IMC	Industrial Modernization Centre
IPPs	Independent Power Producers
ISCC	Integrated Solar Combined Cycle
JCEE	Egyptian German Joint Committee on Renewable Energy, Energy Efficiency and Environmental Protection
KfW	Kreditanstalt für Wiederaufbau / German Bank for Development/Reconstruction
kWh	Kilowatt hour
LPG	Liquefied Petroleum Gas
MED-EMIP	Euro-Mediterranean Energy Market Integration Project
MENA	Middle East and North Africa
MHESR	Egyptian Ministry of Higher Education and State for Scientific Research
MIFT	Egyptian Ministry of Industry and Foreign Trade
MNEs	Multinational Enterprises
MoEE	Egyptian Ministry of Electricity and Energy
MSP	Mediterranean Solar Plan
MW	Megawatt
NREA	National Renewable Energy Authority

NREL	National Renewable Energy Laboratory
NRC	National Research Centre
NSF	National Steel Fabrication
OCI	Orascom Construction Industries
OEM	Original equipment manufacturers
O&M	Operation and maintenance
PPA	Power Purchase Agreement
PSDP	Egyptian-German Private Sector Development Program
PV	Photovoltaics
RCREEE	Regional Centre for Renewable Energy and Energy Efficiency
REMENA	Masters Program on Renewable Energy and Energy Efficiency for the MENA
RENAC	Renewable Energy Academy
RFQ	Request for quotation
R&D	Research and development
SEC	Supreme Energy Council
STDF	Science and Technology Development Fund
SWEG	Sewedy Wind Energy Group
SWP	Stiftung Wissenschaft und Politik / German Institute for International and Security Affairs
S&T	Science and technology
TWh	Terrawatt-hours
UAE	United Arab Emirates
UNESCO	United Nations Educational, Scientific and Cultural Organization

Executive Summary

The wide availability of renewable energy resources in the Middle East and North Africa (MENA) is central to several large-scale European initiatives to generate clean energy in countries of the southern Mediterranean and import some of it to Europe via a pan-regional 'super grid' of high-voltage-direct-current (HVDC) lines. The 'DESERTEC' concept, initiated by Germany, is the flagship project. This concept is based on the reasoning that large investments and technology transfer efforts could allow the MENA countries to produce enough energy from renewable sources to satisfy not only their rapidly increasing demands for energy but also those of Europe.

Despite the inherent challenges and the high investment costs, the benefits to European countries – satisfying increasing energy demand, mitigating climate change and expanding markets – are evident. But realizing these positive outcomes requires the MENA countries' firm commitment to transforming the regional energy system. To implement a concept such as DESERTEC, the MENA countries must be willing and able to share in the ownership of the vision. This could happen if the renewable energy sector becomes a channel for local industrial development, private sector competitiveness and a source of employment and capacity building.

In the aftermath of the Arab Spring, the MENA region is facing enormous developmental challenges, especially in terms of unemployment and social inequality. In addition, most of the MENA countries have long relied on a social contract that maintained social stability through heavy state intervention and the distribution of rents – at the expense of social equality and private sector competitiveness. To address these problems, strategies for economic growth must include innovative social policies and job creation schemes. To support a developmental pathway where renewables play a significant role, a new incentive structure (defined by a new social contract) is needed. The new social contract requires measures such as reforming the energy subsidy scheme, deregulating the energy sector and supporting competitiveness in the private sector.

Within the MENA region, Egypt is a particularly interesting case study for several reasons. It is the most populous country, with a large domestic market. More importantly, Egypt is one of the most industrialized countries in the region, with several sectors that can compete internationally. Egypt is also regarded as a strategic political mediator and a historically important partner for European countries. While Egypt's has limited fossil fuels, its renewable energy resources abound. Nevertheless, renewable energy currently represents just a small fraction of the energy mix. There appears to be great potential for the utilization of Egypt's renewable resources to generate electricity, thereby boosting exports and economic development. This study aims to explore the possibilities of harnessing Egypt's untapped potential for development.

In order for Egypt to achieve these goals, policies must be aimed at localizing the renewable energy supply chain and strengthening technological capabilities at various levels. However, the process of acquiring and expanding technological capabilities does not happen in a vacuum: it is greatly influenced by the institutional structure and dynamics of the local development process. Hence, it is necessary to focus on the political ecocomy in order to examine the underlying interests, incentives and institutions that enable or prevent change.

Our analysis is framed by the following research questions:

(1) Which parts of the wind and solar value chains offer the best prospects for generating local benefits in terms of private sector development and building local capabilities?

(2) What institutional and political obstacles impede the domestic benefits?

(3) What policy recommendations could be proposed to national policy-makers and international cooperation agencies to support this development process?

The data used to examine these research questions was collected using two approaches: conducting semi-structured interviews conducted with key stakeholders in Egypt's renewable energy field, and consulting secondary literature on technological potential, socioeconomic and institutional aspects, as well as on the political economy of the MENA region.

Domestic technological capabilities in renewable energy

Central to this analysis is a critical assessment of Egypt's local technological capabilities in renewable energy (i. e. CSP and wind power) with respect to the manufacture of parts and components and the performance of associated services (production and project execution capabilities), as well as knowledge creation and research and development (R&D) potential (or innovation capabilities).

We find that although local production and project execution capabilities do exist for wind power and CSP in several areas, major investments and strategic efforts are needed to increase the technology content of localized manufacturing and associated services. The domestic wind power sector is more developed than the CSP sector because of lower costs, existing partnerships for technology transfer, local investments made by Egyptian companies, and the presence of complementary industries (i.e. steel and electric cables). More stable and expansive local and regional markets would further contribute to the development of Egypt's wind power sector. The CSP sector in Egypt is less developed partly because of the less ambitious targets set for solar deployment and also the higher costs. Yet CSP's potential for seawater desalination could provide the Egyptian market with the potential for adaptive R&D and the formation of niche markets. Innovation capabilities are needed to increase local companies' participation in more technology intensive activities in the value chain. Research activities are scattered because no national technology strategy has been developed to direct research funds towards this field.

Production and project execution capabilities

The wind-power sector

Wind energy offers high potential for localizing manufacturing. This is mainly because the size of the core components (e.g. towers and blades) requires that manufacturers be located close to the market to reduce transportation costs. If Egypt were able to develop a comparative advantage in wind manufacturing, it could assume an important position in the MENA market (and for regions in Africa) where manufacturing capabilities for wind energy components are limited.

In general, significant potential exists for the local manufacture of components, including those with higher technological content, such as gearboxes and blades. Initially, practical know-how must be acquired by licensing technology from foreign partners or by acquiring shares in foreign companies – although indigenous manufacturing capabilities do exist that facilitate the transfer and absorption of technology. This is primarily due to the presence of well-established, globally active industries that manufacture steel, transformers, cables and electrical auxiliaries.

Despite quality challenges, there is great potential in Egypt for manufacturing wind towers locally. Tower manufacturing facilities – with export potential – already exist. In addition, local wind energy engineers claim that know-how for blade manufacturing can be sourced locally by drawing on the experience of creating fibreglass materials for boat construction. Metal casting and forging, which figure prominently in the manufacture of turbines and rotors (including the hub, shaft and generator), are sizable industries in Egypt. But despite the apparent potential for localizing the manufacture of key components of wind energy technology, investment plans are stalled because of the current political instability and economic downturn.

Despite production and project execution potential, local companies appear to be at a disadvantage in the current tendering process for wind projects. First, because the Electricity Law has not yet been approved, provisions for local content are not yet specified or enforced in the bidding process. Second, since most projects in the pipeline need international financing, the prerequisite of sizable experience automatically excludes local companies that are trying to enter the market. It is therefore necessary for policy tools to stimulate increased local content in manufacturing so that local industry can succeed. Bringing different stakeholders to the table to discuss how policy options would impact their investment plans could reduce ambiguity about policy outcomes and improve the targeting of the proposed incentive mechanisms.

With regard to project execution capabilities, project management and engineering continue to be mostly carried out by foreign companies and consultants. Concerted national efforts in training and education at various levels, as well as partnerships with foreign companies and organisations are needed to build local knowledge capabilities. Fortunately, the presence of large local project developers facilitates the acquisition of know-how in these areas. The participation of local companies has been especially beneficial in procurement (choosing, coordinating and supervising suppliers and construction contractors) and in the 'embodiment of physical capital' (site preparation, construction and plant erection).

To draft the roadmap for training, education, R&D and private-sector expansion, it is necessary to first assess the types of jobs that are required to develop a sector in an emerging market. To this end, we have examined job profiles in the value chain of wind energy and discovered that although basic skills do exist, significant investment and strategic programs are needed to expand all levels of local knowledge that is specific to wind energy. In particular, knowledge is limited in the specialized non-engineering jobs, such as project managers, environmental engineers, lawyers and economists with expertise in renewable energy. Therefore, concerted efforts are needed to integrate renewable energy and sustainability in the educational curriculum in various disciplines and educational levels. Investment in R&D is also crucial. While formal qualifications are important, equally important is the practical/project experience that is acquired through market expansion. These efforts need to be guided by a national technology strategy and a stable institutional framework.

Concentrated solar power (CSP)

In comparison to that for wind-power energy, the concentrated solar power (CSP) market – which is just beginning to develop in Egypt and worldwide – indicates that the technology is less mature and requires higher capital costs. Because CSP technology is restricted to a few players in Europe and has a more integrated value chain than that of wind energy, the MENA countries might have greater difficulties in acquiring the necessary know-how. Yet this situation could also create opportunities for new market entrants to exploit the potential for innovation in general – and for technological innovation in particular. More international cooperation will be needed to help Egypt increase its local technology content.

For CSP, most local content has been provided through engineering, procurement and construction activities. But given the existing manufacturing base in Egypt, local companies could potentially be active in other parts of the value chain, too – albeit in more limited ways in the short term, when compared with the wind energy sector.

The main raw materials (steel, concrete and cement) needed for CSP parts and components are available locally. These materials are mostly used for construction and civil-engineering works performed by engineering, procuring and construction (EPC) contractors that are usually large construction and steel firms. In this sector, Egypt has a comparative advantage over other North African countries because of the presence of construction companies with automated production, quality certification and high-tech tools that could supply CSP plants with support structures.

Another raw material widely used in the CSP industry is glass. However, local companies currently produce glass with higher iron content than that needed for CSP technology. We find that even if local glass producers are skilled at transforming glass and producing high-tech mirrors, it is not clear that they are also able to coat CSP mirrors according to the specifications for use in harsh desert conditions. There is hardly any local R&D activity of the sort needed to overcome technological barriers in these areas (i.e. knowledge acquisition for developing more technology intensive CSP components and technology adaptation to local conditions). Hence, joint ventures that offer extensive technical assistance and knowledge transfer are required for learning this manufacturing process.

Two other CSP components face high entry barriers: the parabolic trough receiver and the heat transfer fluid (HTF). High capital costs are required for manufacturing these two components. In addition, because of the high technology content, there are significant know-how barriers to producing them locally. Nevertheless, as shown by the experience of the CSP industry in Spain and the USA, when the market is large enough and also predictable, foreign companies will set up manufacturing facilities close to the market. This could represent a first step towards know-how transfer to Egypt.

As in the Egyptian wind-energy industry, local CSP plants' project development and implementation capabilities (project execution capabilities that call for environmental scientists, atmospheric scientists and consultants) are also underdeveloped. Some of the related activities (such as procuring land and obtaining permits) are currently provided by local agencies. Local company involvement is critical in project execution services since they involve working with government agencies, community members and organizations, utility companies and other stakeholders. Moreover, significant knowledge transfer, on-the-job training and experience are essential for operation and maintenance (O&M) activities. Power plant operators must attend specialized training programs and undergo extensive on-the-job training for the systems they use. In Egypt, such training courses are limited, which means that in order to acquire such knowledge, local project developers now have to rely on foreign technology providers.

Innovation capabilities

The term "innovation capabilities" refers to the skills needed to create new products or processes, with the specific skills required by the novelty of the new technology. This covers activities ranging from pure science to advanced development. In developing countries, however, innovation is more broadly defined to refer not only to "new-to-the-world" technologies, but also to the technological adaptation of mature technologies to local environmental conditions, and to indigenous innovations. In Egypt, there is no vision of supporting the development of innovation capabilities along with creating a local renewable energy industry. This has several reasons: First, the lack of a national renewable energy industry strategy has prevented drafting a roadmap for technology research that would highlight strategic areas for research in the technical and non-technical domains. Second, universities and research organizations are rarely included as stakeholders in national discussions about strategic economic and industrial development, which leads to a mismatch between the skills of the graduates and the needs of the industry. Third, collaborations between universities and the private sector are limited. There are few incentives for academics to engage in commercialization and collaboration with the private sector; within the private sector there is a general perception that universities do not add value to their activities; and universities lack the entrepreneurship and industrial liaison programs that could support effective networks for collaboration.

In order to create a culture of academic entrepreneurship that builds on stronger ties between the university and industry, a change is needed in the work norms of university scientists. In the Egyptian university system, there is low mobility of academics between industry and academia, although such experience is important for supporting the development of new industries and fostering innovation. A change in attitude with respect to the role of universities within the larger economy would greatly help industry and academia draw closer and enhance local innovation capabilities.

Additionally, despite the existence of some educational and research initiatives regarding renewables, most are focused on engineering rather than on socioeconomic and political issues. Given the socio-economic challenges to development that confront the MENA region, we argue that local universities and research institutes should place equal emphasis on improving education and research in these fields. Platforms for international research collaborations on related aspects should also be further developed, in the form of 'centres of excellence' or similar organizations.

Political economy perspectives regarding the expansion of technological capabilities

Enhancing local technological capabilities for solar and wind power requires concerted efforts to create alliances between various interest groups and stakeholders. We argue that to support the transition to renewable energy, the social contract needs to be rewritten to aim at a more effective allocation of energy subsidies, less constrained decision-making regarding renewable energy and a shift to developmental relations between the state and private sector. Large and inefficient energy subsidies act as disincentives for domestic and international investors who might want to invest in renewable energy. These government subsidies also drain resources that could be used for other goals, such as supporting market creation or making social investments. The lack of a domestic market means that local companies can't risk investing, while the absence of a clear vision of how to integrate renewables into the energy system and the economy hinders efforts to build technology capabilities at various levels. Generally speaking, the social contract of recent decades has become increasingly challenged – not just in Egypt, but in most non-oil producing countries as well. It is necessary to review the social contract and find new societal solutions. Conservative estimates put energy subsidies in Egypt at about 6 percent of the Gross Domestic Product (GDP) (World Bank 2011). Large trade-offs exist with respect to welfare-spending items, and there is ample documentation about the inefficient distribution of these subsidies. The energy subsidy scheme must be reformed, not just to reduce renewable energy's cost disadvantage, but also to improve Egypt's financial sustainability.

Other countries' experiences with subsidy reforms indicate that when such processes are applied consistently, they can be socially and politically acceptable. Transparent policy plans, as well as explanations of the rationale behind removing the subsidies, are crucial for making the process a success. A carefully drafted program to compensate the poor for price increases is also essential. Instruments that can be used to compensate lower income groups include cash transfers, increases in the minimum wage and pensions, and higher spending on health and education. In light of the political uncertainties, three elements are important in the policy-making process: commitment to reform, multilevel coordination and consistent efforts to legitimize the governance structure.

With respect to state–business relations, when considering how to change a clientelistic and predatory state to a developmental state where state–business relations enhance growth, emphasis must be placed on introducing performance-based management in the public and private sectors, as well as on developing well-organized business networks that could become part of the renewable-energy value chain. As the ‘embedded autonomy’ concept argues, success largely depends on political elites being accessible to, and working closely with, entrepreneurs and firms. Therefore, more emphasis should be placed on developing institutions to ensure coherence and stability in policy-making.

Policy recommendations

The main recommendation for Egyptian policy-makers is that they disseminate a new narrative emphasizing the irrationality of the energy subsidy regime (as a basic barrier to the deployment of renewable energy and to the efficient use of energy) and mobilize alliances between various groups to make renewable energy viable for Egypt. The next recommendation is for policy action in several areas: developing a renewable energy strategy and a technology roadmap; reforming the fossil-fuels subsidy regime; unbundling the services of the New and Renewable Energy Authority (NREA); developing the supply chain; expanding education and training in renewable energy; expanding renewable energy R&D.

With its great expertise in this field, Germany has a lot to offer Egypt and to other MENA cooperation partners in terms of institutional expertise, capacity building and technological know-how. This is critical because employment, economic diversification, private sector development, and building technological capabilities are the principle challenges confronting the MENA countries. Germany could further enhance its competitive advantage in the sector through increasing its cooperation on renewable energy. But to achieve this goal, Germany must speak with one voice through a ‘whole-of-government’ cooperative strategy in the field of renewable energy, whilst also aligning itself with European-level initiatives.

1 Introduction[1]

1.1 Renewable energy from the MENA region

Pressured by climate change and the need for energy security, strategic-policy debates in the European energy sector have started to explore the potential for clean energy generation in the Middle East and North Africa (MENA). The wide availability of renewable energy resources in the MENA region (solar irradiation and wind speed) is central to several large-scale European initiatives to generate clean energy from the southern Mediterranean countries and import part of it to Europe via a pan-regional "super grid" of high-voltage-direct-current (HVDC) lines. The "DESERTEC" concept, initiated by Germany, is the flagship project.[2] This concept is based on the argument that large investments and massive technology transfers could enable MENA countries to produce enough energy from renewable sources to satisfy both their quickly growing demands for energy[3] and those of Europe,[4] hence contributing to reaching CO2 emission-reduction targets and reducing dependency on fossil-fuels both north and south of the Mediterranean.[5] Such a project is likely to ultimately create win-win opportunities for both European and MENA countries, paving

---

1 This study benefited from extensive comments and suggestions from Tilman Altenburg, Hubert Schmitz, Markus Loewe, Andreas Stamm and Imme Scholz.

2 Other related European initiatives are the Mediterranean Solar Plan (MSP), which focuses on developing a policy framework for such regional collaborations, and the Euro-Mediterranean Energy Market Integration (MED-EMIP), which aims to assess the conditions needed to interconnect with European markets. More detail on these cross-national initiatives can be found in Erdle (2010).

3 Existing projections estimate that the MENA electricity consumption will rise from 350 Terrawatt-hours (TWh)/year in 2008 to 680 TWh/year in 2020 and 3500 TWh/y in 2050 (Erdle 2010).

4 DESERTEC would satisfy 15% of Europe's electricity demand, mainly through solar energy imports of about 700 TWh/year from 20 to 40 locations in the MENA region (Trieb / Müller-Steinhagen 2007; Trieb et al. 2012).

5 An indication of the abundance of renewable-energy resources in the region: *"[E]ach year, each square kilometre of land in MENA receives an amount of solar energy that is equivalent to 1.5 million barrels of crude oil. A concentrating solar collector field with the size of Lake Nasser in Egypt (Aswan) could harvest energy equivalent to the present Middle East oil production"* (Trieb / Müller-Steinhagen 2007).

the way to unprecedented energy-market integration between the two regions (DESERTEC 2008). In spite of the associated challenges and high investment costs, the benefits for European countries are evident in terms In spite of the associated challenges[6] and high investment costs, the benefits for European countries are evident in terms of satisfying growing demands for energy, climate change mitigation and market expansion. But in order for these positive outcomes to materialize, the MENA countries need to commit to transforming the regional energy system. Therefore, the main concern when assessing the future success of such visionary initiatives is: *What do MENA countries stand to gain from such initiatives?* Implementation of a concept such as DESERTEC requires the MENA countries' interest as well as their ability to share in the ownership of the vision. This can happen if the renewable energy sector becomes a channel for local industrial development, private sector competitiveness, and a source of employment and capacity building.

The development challenges confronting the MENA region in the aftermath of the Arab Spring are enormous, especially in terms of unemployment[7] and social inequality. While unemployment statistics for the MENA region seem inconsistent, some sources claim that in 2010 in Egypt, approximately 25 percent of adults with a tertiary degree were unemployed, with 18 percent of this cohort unemployed in Morocco and 22 percent unemployed in Tunisia (World Bank 2011). In addition, for decades, most countries have relied on a social contract that aimed to maintain social stability through heavy state intervention and the distribution of rents – at the expense of social equality and private sector competitiveness. These problems require that economic growth strategies have strong social-policy and job-creation components. For this reason, the driving force for expanding the renewable energy sector in the MENA region is not its agenda for climate change mitigation, but rather the promise it holds for job creation and revitalization of the private sector. Support for a developmental pathway where renewables

6 See Komendatova (2012) for a discussion of risks associated with investing in Concentrated Solar Power (CSP) in MENA.

7 In Egypt an estimated 60% of the youth is no longer part of the labour force (unemployed or dropped out) (UNDP 2010). Even more alarming is that among educated youth unemployment is still higher.

play a significant role requires a new incentive structure defined by a new social contract. This new social contract would require such acts as reforming the energy subsidy scheme, deregulating the energy sector and supporting private sector competitiveness.

Within the MENA region, Egypt is a particularly interesting case to examine for several reasons. With over 80 million inhabitants, Egypt is the most populous country, with a large domestic market. More importantly, Egypt is one of the most industrialized countries in the region,[8] in which several sectors are able to compete internationally (e.g. construction and telecommunications).[9] In addition, from a cultural and geopolitical perspective, *Egypt is viewed as "the most representative and relevant voice among the Arab countries"* (Schlumberger 2004, 97). It is seen as a strategic political mediator, and a historically important partner for European countries. While Egypt's fossil fuel resources are limited, its renewable energy resources abound. Located in the "sunbelt region", Egypt has one of the highest levels of solar irradiance in the world (DLR 2005). The coasts of the Mediterranean Sea and even more, of the Red Sea, present one of the strongest wind resources worldwide (DLR 2005). Nevertheless, renewables currently represent only 1 percent of the energy mix (Müller / Marmian / Beerepoot 2011). It appears that untapped potential exists for utilizing these resources to generate electricity[10], and to stimulate economic development.[11]

In this study we examine the prerequisites for Egypt to become an important regional player in renewable energy industrial and technological development. Although other MENA countries indicate strong commitment to

---

8 The industrial sector's share in Egypt's GDP, 37 percent, is the highest in North Africa, with the exception of Algeria, where the oil and gas sector dominates the economy (CIA World Factbook 2011).

9 Interestingly, however, the share of graduates with B.A. degrees in science, technology and engineering is lower in Egypt than in other North African countries (UNESCO 2004).

10 Electricity trade between Europe and Egypt is expected to be limited, primarily because of difficult grid connections both across the Mediterranean Sea as well as inland (around the Mediterranean Sea) (Interviews with Deutsche Gesellschaft für Internationale Zusammenarbeit [GIZ] / Regional Centre for Renewable Energy and Energy Efficiency [RCREEE], November 2011; Cairo).

11 This issue is not only characteristic of Egypt. Recent evidence shows that extensive untapped potential for 'green exports' exists in developing countries (Dutz / Sharma 2012).

renewables, Egypt's technical and industrial capabilities and large market potentials could significantly increase the longterm regional impact in terms of economic growth and industrial development. This study explores the possibilities of harnessing Egypt's untapped development potential.

1.2 Building domestic technological capabilities in renewable energy in Egypt

In order for Egypt to build its technological capabilities in renewable energy, policies should aim at localizing the supply chain for renewable energy (solar and wind) and improving technological capabilities at different levels. The term "capabilities" can take different meanings, depending on which activities, processes and actors it describes (Bell 2007). For clarity, we use Amsden (2001) who groups technological capabilities into: production capabilities (the skills needed to transform inputs into outputs); project execution or implementation capabilities (the skills needed to expand capacity); and innovation or R&D capabilities (the skills needed to design entirely new products and processes) (see Table 1–1 for a more detailed description of these components). From this perspective, the process of 'building up' capabilities also takes into account the time dynamics between these categories.

The process of acquiring and expanding technological capabilities does not happen in a vacuum, however: the institutional structure and dynamics that shape the local development process greatly influence the process. For that reason, adding a political economy layer to the analysis affords a more nuanced view of the prerequisites for developing a local renewable energy industry. Such a study makes it possible to penetrate the formal structures and reveal the underlying interests, incentives and institutions that enable or prevent change. The political economy layer can be defined as having several elements.[12] In our study, we pay particular attention to the evolving dynamics between the alliances of stakeholders who are for and those who

12 Nash / Hudson / Luttrell (2006) and the U.K. Department for International development (DFID 2009) define political economy as having the following elements: state–society relations; distribution of power; interests and incentives facing different groups in society; formal institutions and informal social, political and cultural norms shaping human interactions, political and economic processes; values and ideas impacting public policy.

Table 1–1: Technological capabilities

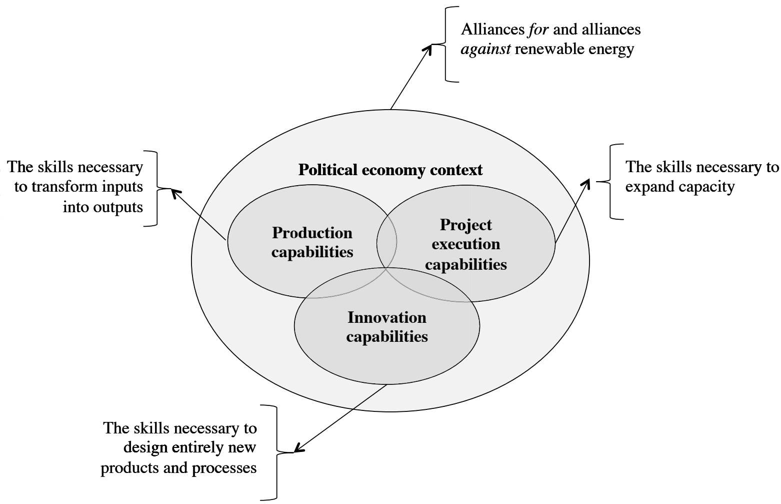
Production capability	Project execution capability	Innovation capability
Production management	Personnel training	Pure science
Production engineering	Pre-investment feasibility studies	Basic science
	Project execution	Applied research
	– Project management	Exploratory research
	– Project engineering	Advanced development
	– Procurement	
	– Construction, machinery production, plant erection	
	– Start-up of operations	

Source: Amsden (2001)

are against the development of renewable energy. We discuss these evolving dynamics through the dimension of the existing state–society social contract, as shown by the pervasiveness of energy subsidies, extensive public sector employment, constrained decision-making, and the nature of state–business-sector alliances. It is especially important for the MENA countries to examine the process of building technological capabilities through the political economy lens, operating as they do in patrimonial-capitalism systems and rentier states (Schlumberger 2004), where concerns about cronyism/favouritism, rent-seeking, inapt institutions and legal settings dominate discussions about development policy.

Figure 1–1 illustrates such an integrated approach to development, where the expansion of production capabilities for industrial development, project execution capabilities and innovation capabilities are examined within the overall political economy context.

Figure 1–1: A simple depiction of an integrated development approach



Source: Adapted from Amsden's (2001) conceptualization of technological capabilities

To capture this complex undertaking and offer a multi-layered perspective on the development of the renewable energy sector in Egypt, the following research questions frame our analysis:

(1) Which parts of the wind and solar value chains offer the best prospects for generating local benefits in terms of private sector development and building local capabilities?

– What capabilities exist?

(2) How can the required capabilities be built up? What institutional and political obstacles need to be overcome to reap the domestic benefits?

(3) What policy recommendations could be made to national policy-makers and international cooperation agencies to support this development process?

In this study we are concerned with two renewable energy technologies: concentrated solar thermal power (CSP) and wind power (see Box 1-1 for a brief introduction to these technologies). Nevertheless, Egypt should focus on all solar technologies (not only CSP) because solar photovoltaics (PV) is important for both small-scale and large-scale solar installations and the job creation impact is also higher (IRENA 2011). The DESERTEC technology portfolio is also expanding beyond CSP and wind. Since solar PV is a more mature technology, it could provide more entry points for developing countries. Future studies on Egypt could examine the local potential for solar PV.

CSP, a less mature technology, is suitable for harnessing solar energy from desert areas for several reasons: first, uninhabited desert allows the technology to be deployed on a large scale, thereby potentially reducing costs; second, as the only solar technology that can store energy, it can better cover peak energy demand; and third, since one of its applications is solar seawater desalination, CSP can help address the energy-water nexus that is of great concern to the MENA countries. The use of CSP for water desalination opens up opportunities for niche markets where Egypt could benefit from its early-mover advantage – if the political will is expressed in longterm vision and the capacity for strategic implementation.

Compared with CSP, wind energy is a more mature technology, which means it is less expensive, with more accessible know-how. Hence the potential for localization is higher, as demonstrated by the relatively large deployment rates in the MENA region. Nevertheless, for Egypt to successfully compete in the wind energy technologies segment the Egyptian industry must be cheaper (but of the same quality) than the other MENA countries; this therefore becomes a challenging undertaking despite the relative ease of entering the wind energy market.[13]

13 A similar challenge also exists with respect to solar PV technologies that have enjoyed significant cost reductions over the past decade. Nevertheless, the technological knowledge in the manufacturing process is relatively complex and high-end innovations (to improve efficiency, concentrate light, etc.) are needed to further reduce costs. But, solar PV presents a wide range of applications for electricity generation, cooling, irrigation etc. Hence, national strategies for renewable- energy deployment should consider a wide range of technologies.

Box 1-1 Concentrated solar thermal power (CSP) and wind power technologies briefly explained

Concentrated solar thermal power (CSP)

CSP power plants produce electricity by converting concentrated direct solar irradiation into energy. Unlike photovoltaic cells or flat-plate solar thermal collectors, CSP power plants cannot use the diffuse solar irradiation caused by clouds and particles scattering direct sunlight because that cannot be concentrated. The energy conversion process has two parts: solar energy is first concentrated and converted into usable thermal energy, then a conventional steam turbine converts that heat into electricity.

There are two main types of concentrating solar collectors: line-focusing systems (parabolic trough collectors and linear Fresnel collectors) and point-focusing systems (solar towers and solar dishes). The most advanced kind of CSP technology, the parabolic trough collector, consists of a receiver, mirrors, a metal support structure, pylons and foundations. Parabolic-shaped and faceted mirrors – that are coated with a layer of reflective silver – concentrate sunlight into the absorber tube that is coated with an anti-reflective layer to readily transmit sunlight and is surrounded by an evacuated glass tube. The absorber tube and the encasing glass tube make up the "receiver". The curved mirrors and the receiver are the most technology-intensive components. Innovations in parabolic trough collectors focus on reducing costs in the assembly and production processes, creating lighter collector structures made of new materials, and using new heat-transfer fluids (e.g. molten salt and direct stream).

One main advantage of solar thermal power plants over other renewable-power technologies is the option of using molten salt, oil, sand or concrete to store energy. Another advantage of CSP technology is its application for seawater desalination, which is critical for the MENA countries that face growing problems of water scarcity.

The CSP market is highly concentrated, with a few companies located in Europe (Germany and Spain), the USA and, increasingly, in Asia. Greater deployment is expected to lead to cost reductions and higher technological improvements.

Source: World Bank (2011)

Wind power

Wind power – produced using wind turbines to harness the wind's kinetic energy – is gaining popularity worldwide as a large-scale energy source, although it currently provides less than 1 percent of global energy consumption. Wind turbines can operate continuously, unattended and requiring little maintenance, with 120,000 hours of active operation over a design lifetime of 20 years.

Wind turbine rotors generally consist of three blades whose speed and power are controlled by either stall or pitch regulation.[14] Rotor blades are manufactured from composite materials using fibreglass (glass-reinforced fibre) and polyester, or fibreglass and epoxy, sometimes combined with wood and carton. The energy captured by steadily rotating blades is transferred via a gearbox and drive train to an electrical generator. The generator can also be coupled directly to the rotor in a 'direct drive' arrangement. The gearbox, generator and other parts of the control equipment are housed within a protective nacelle. Tubular towers that support the nacelle and rotor are usually made of steel and taper from the base to the top. Apart from the turbines, the other main components of a wind farm are the foundations to support the turbine towers, access roads and infrastructure needed to export the electrical output to the grid network.

Commercial wind turbine manufacturing started in the 1980s using Danish technology. By 2010, the top 10 companies in terms of market share were Danish (Vestas), Chinese (Sinovel Wind Group, Goldwind, United Power), American (GE Wind Energy), German (Enercon, Siemens Wind Power), Indian (Suzlon Group) and Spanish (Gamesa).

Improvements are continually being made in the amount of energy that wind turbines can capture from the wind. Innovations are expected in terms of more powerful rotors, larger blades, improved power electronics, better use of composite materials and taller towers.

Source: EWEA (2006)

In this study we address the critical issues in this multidimensional development process. While some aspects can be examined in depth here, others will require future research. For instance, the question of localizing the supply chain for CSP and wind power has already been examined in the MENA context, which permits us to complement the existing literature with our

14 *"There are two basic approaches used to control a wind turbine in high wind speeds: pitch-control and stall-control. In pitch-controlled turbines, an anemometer mounted atop the nacelle constantly checks the wind speed and sends signals to a pitch actuator, adjusting the angle of the blades to capture the energy from the wind most efficiently. On a stall-regulated wind turbine, the blades are locked in place and do not adjust during operation. Instead, the blades are designed and shaped to increasingly 'stall' the blade's angle of attack with the wind to both maximize power output and protect the turbine from excessive wind speeds."* (Source: http://www.horizonwind.com/about/ftkc/howdoeswindturbinework.aspx, accessed on February 20, 2012.)

research and offer an up-to-date discussion of the local potential. Since earlier studies have only marginally appraised innovation capabilities, our assessment is likely to make a valuable contribution to understanding local capabilities. Nevertheless, more research will be needed in order to delve deeper into the type of knowledge that is locally available as well as the specific mechanisms that could be used to forge collaborative networks in the academic and R&D fields. Lastly, while political economy aspects are at the core of the transformation process, they are also the hardest to grasp and document. Therefore, in this study we mainly attempt to hypothesize relationships between various factors, provide tentative evidence and open up venues for future research.

The data used to examine these research questions was collected using two approaches: Semis-tructured interviews were conducted with key stakeholders in Egypt's renewable energy field between 16 October and 4 November 2011 (government officials, policy-makers, local and international private sector companies, professionals in R&D organizations, educational institutions and members of civil society, such as environmental and renewable energy activist groups). A list of interviewees is provided in Annex 1. The information gathered in interviews was then complemented with relevant studies on the technological potential, socioeconomic and institutional aspects, as well as the political-economy context of the MENA region.

1.3 Laying out the argument

Chapter 2 offers a brief overview of the renewable energy targets set by the Egyptian government, as well as the size of the markets for solar and wind energy.

In **Chapter 3** we address the first research question by performing a critical assessment of local capabilities in renewable energy (CSP and wind), both in terms of production (of parts and components) and of project execution capabilities. Local capabilities in renewable-energy related services are important, not only as a source of employment, but also for sustaining the development of a local market. Localizing the value chain for solar and wind power can also generate linkages and spillovers for related sectors. In the first section we examine the nature of local private sector involvement in the CSP and wind value chains. Then we examine which parts of the value chain for solar and wind power offer the best prospects for generating local benefits in terms of local manufacturing and employment.

Expanding the participation of local companies in more technology intensive activities in the value chain requires innovation capabilities. These are critical for enabling developing countries to leapfrog with respect to energy technologies, and incorporate available technologies into their development processes (Goldemberg 1998). We do not just refer to capabilities needed to develop 'new-to-the-world' technologies. We also assess capabilities required for making incremental improvements to existing technologies, as well as for adapting to local environmental conditions (heat, sand and water scarcity), and disseminating, maintaining and using these technologies. Increased knowledge and R&D capabilities are likely to lead to higher absorptive potential, which in turn makes it possible to localize benefits from international collaborations that are envisioned by concepts like DESERTEC. The role of adaptive R&D in helping developing countries enter green technology markets and reduce the technological distance between them and more advanced countries has not yet been adequately investigated (Popp 2011). Therefore, in the second section we assess existing education and training, as well as R&D programs at local universities and research institutes, and identify potential gaps in the knowledge-capacity-building process. We also discuss barriers to building innovation capabilities. We argue that one of the main challenges in this area is the lack of incentives and limited experience of public research institutions (universities and research institutes) in collaborating with the private sector. Lastly, we examine the challenges to the transfer of renewable energy technology to developing countries. This assessment will contribute to understanding the type of policies needed in Egypt, where adaptive R&D and technology transfer will play a large role.

While local capabilities do exist (as shown in the analysis in Chapter 3), various hurdles prevent this potential from expanding to a level that would allow Egypt to become an industrial and technological hub for renewable energy in the MENA region. In **Chapter 4** we apply the political economy lens to assess why this potential has not yet been met and begin to discuss solutions for overcoming problems of implementation. Given that policy effectiveness requires good governance, the links between governance and renewable energy industrial development deserve further study (Popp 2011). We argue that most of the challenges to renewable energy development in Egypt are found in the social contract that shaped the governance system and the incentive structure for decades. We briefly introduce the main elements of this social contract (pervasive energy subsidies, cosy state–business relations and excessive regulation) and argue that a new social contract is needed. Then we examine how these various elements appear to create disincentives for integrated development of the renewable energy sector.

We tackle these issues from different angles. First, we assess the pricing challenge that the energy subsidy system poses to the development of the renewable-energy market and industry. Most importantly, energy subsidies distort incentives for renewable energy deployment. Without supportive policies and a long-term national strategy,[15] the investment risks are just too high for the private sector. Second, centralization of authority and over-regulation create coalitions of interest that are often just rent-based relations and result in underdeveloped organizational capacity at the policy-making and implementation levels. An examination of how to overcome this challenge could offer insights to capitalizing on existing capabilities and what is needed to form development-oriented coalitions between different interest groups. Third, the general presumption is that exclusive business–state relations lead to a deterioration of democratic ideals, economic efficiency and social welfare (Maxfield / Schneider 1997), as shown in rent-seeking and corrupt practices (Krueger 1974; Bhagwati 1982).Although such allegations do abound in Egypt, there is also evidence that these relations are not always corrupt and that they can even lead to positive development outcomes (Amsden 1989; Maxfield / Schneider 1997; Moore / Schmitz 2008). Drawing mainly on the concept of 'embedded autonomy', we explore how, within Egypt's emerging renewable energy sector, relationships that tend towards rent-seeking can be transformed into development-oriented coalitions of interest.

Following the analysis of existing capabilities and the challenges to expanding them, **Chapter 5** distils the findings and identifies policy recommendations for policy-makers in Egypt, as well as for German international cooperation. Recommendations are presented for several strategic areas identified in the study.

15 KfW commissioned Lahmeyer International to conduct a study between 2011 and 2012, "Combined Renewable Energy Master Plan for Egypt" aiming to develop an integrated strategy for wind and solar energy in Egypt; at the time of writing this report, its results were not yet available.

2 Renewable energy in Egypt's energy system

In light of increasing energy demand, dwindling natural gas resources, electricity blackouts and population growth, the Egyptian Government put renewable energy on its agenda. In 2008, the Ministry of Electricity and Energy (MoEE) set the 2020 target of 20 percent electricity generation from renewable energy. In order to reach this target, several technologies are being considered, with concerns about cost and resource availability favouring some technologies over others. Wind energy has been prioritized over solar energy because of its lower cost (see Table 2–1 for average cost levels). For purposes of comparison, the average domestic power-generation cost (given the power generation capacity structure, including hydro, natural gas and fuel oil) has been 0.3 Egyptian piasters per kWh (USD 0.05/kWh) (JCEE 2012). See Annex 2 for current electricity tariffs in Egypt by consumer type.

The MoEE is aiming to install 7.2 Gigawatt (GW) of wind power in Egypt by 2020. In 2001, 5 Megawatt (MW) of wind energy was installed and by 2011, a total of 545 MW wind capacity had been installed along the Red Sea coast. Several other projects are in preparation (see Table 2–2). However, any future installed wind capacity will be limited by space availability and

Table 2–1: Status of renewable energy technologies: characteristics and costs

			USD/kWh
On-shore wind	Turbine size:	1.5–3.5 MW; Rotor diameter: 60–100 meters	0.05–0.09
Rooftop solar PV	Peak capacity:	2–5 kW peak	0.17–0.34
Utility-scale solar PV	Peak capacity:	200 kW–100 MW	0.15–0.30
Concentrating solar power (CSP)	Plant size:	50–500 MW (trough), 10–20 MW (tower)	0.14–0.18
	Types:	Trough, tower, dish	(Trough)

Source: REN21 (2011)

environmental considerations,[16] which is one reason why initiatives such as DESERTEC stress the need for more aggressive targets for solar energy. Egypt's plans for solar energy are less ambitious than those for wind energy, with a 2017 target for the installed capacity of 100 MW of CSP and

Table 2–2: Existing and future wind energy projects in Egypt

Stage of the project	Capacity (MW)	Foreign partner
Completed	545	Various partners
Under implementation	200	
– By the NREA	200	Germany & EU
– With the private sector	120	Italcementi (Italy)
	250	(Build-Operate-Own, or BOO, in the Gulf of Suez, by 2014)
	1,000	(BOO, pre-qualification documents)
In the pipeline	220	Japan
(Land has been allocated; permits have been obtained; financing has largely been secured)	120	Spain
	200	UAE (Masdar)
In preparation	180	Spain
(Projects have been announced; necessary documents and financing are being obtained)	200	Germany & EU
	200	Japan
Total	**3,235 MW**	

Source: Presentation by the New and Renewable Energy Authority (NREA) at the 10th World Wind Energy Congress, Cairo, 30 November 2011, and the NREA (2010)

16 Environmental impact studies found that the Gulf of Suez is a major bird migration corridor, which could affect local wind parks, that is, regulation requiring shutting down wind plants in some areas during certain periods of the year would result in higher operation costs. (Interview with NREA and Orascom Construction Industries (OCI), Cairo, October–November 2011.)

40 MW of PV. As of this writing, 20 MW of CSP have been installed within the Kuraymat 140 MW Integrated Solar Combined Cycle (ISCC), which represents about 20 percent of the 2017 target, and 0.1 percent of the worldwide total installed CSP capacity (GTM 2011). Considering that Egypt has one of the highest levels of direct solar irradiance, this figure for installed capacity is negligible (DLR 2005). More ambitious targets must be set for solar energy deployment in order to capitalize not only on the potential for energy generation, but also on the potential for jobs creation that is anticipated from renewable energy (IRENA 2011).

To achieve 7.2 GW of installed wind capacity by 2020, the MoEE (through its agency, the New and Renewable Energy Authority (the NREA, discussed in Chapter 4) aims to develop 33 percent of the capacity (2,375 MW) with financial assistance from international agencies and the Egyptian Ministry of Finance, and guarantees from the Central Bank of Egypt. The rest of the wind capacity target, 67 percent (4,825 MW), is to be developed by the private sector (with domestic and international investors). More than 6,000 km^2 of land have been allocated for wind projects.

The development process is two-fold. First, the NREA organizes a competitive bidding process for Build-Operate-Own (BOO) projects (with long-term Power Purchase Agreements, or PPA, of 20 to 25 years). The process aims *"to attract highly qualified international developers with strong financial status and high capacity for technology transfer"* (Amer 2009). A point system will be used to promote local manufacturing, although details about its implementation are not yet available.[17] Second, a feed-in-tariff (FIT) based on the competitive bidding process results will be determined in 2013, with the government's commitment to purchase the generated electricity. The 15-year FIT is intended to support only small and medium developers with project capacities of 50 MW or less (Amer 2009). The NREA is currently proposing incentives to stimulate private-sector engagement in the emerging renewable energy sector, that include: permits and land-use agreements; custom-duty exemptions; higher points for local-content provision in the bidding process; PPAs in foreign currency; Central Bank guarantees; carbon credits; and power generation licences from the national utility company. Several of these provisions are included in the New Electricity Law (see Box 2–1), which is currently being discussed in

17 While competitive bidding has been implemented in other national contexts (e.g. India and South Africa), concerns exist regarding management of the bidding process and possible corruption, especially when the selection process has not been clearly explained.

Parliament (the Law was approved by the State Council in 2008, but only accepted for parliamentary review in 2011). Therefore, some of these incentives are not yet operational, which means that private-sector investors are precluded from making large investments. Given the recent political changes and Egypt's long transitional period, no major regulatory decisions about the renewable energy sector are expected in the short or medium terms.

Box 2–1: Egypt's proposed 'New Electricity Law'

The New Electricity Law of Egypt is likely to include several mechanisms that could stimulate the deployment of renewable energy. Chapter 4, Section 1 of the proposed law addresses renewable energy in five articles (45–49):

– *Competitive tenders for the construction of wind farms to be operated by the NREA or the EETC.* Article 45 states that the Egyptian Electricity Transmission Company (EETC) could conduct Requests for Quotation (RFQ) for the construction of wind farms that it would operate, selling the electricity generated to the EETC at a price proposed by the regulatory agency and agreed by the Cabinet of Ministers. Under the proposed tender-evaluation process, companies who can prove local production of some or all of the wind-system components would receive additional points.

– T*ake-or-pay contracts for renewable electricity generation, governed by long-term purchase power agreements* (PPAs). Article 45 allows any investor to build, own and operate a renewable energy power plant, and sell the electricity to the EETC at a generic price set by the Cabinet of Ministers – in a long-term PPA. The EETC would have to pay for the generated electricity even if it didn't want to use it.

– *The EETC will be responsible for connecting new renewable schemes to the grid*. Article 46 obliges the transmission and distribution utilities to inter-connect their networks with renewable electricity generating stations and to cover the costs of investments to improve their networks.

– *A special fund will be established to help pay for electricity generated from renewable schemes – "The fund for the development of electricity production from renewable energies."* Articles 47 to 49 state that this fund, operating under the Cabinet of Ministers, would provide support to the EETC for purchasing available electricity for renewable-energy generators. The fund would be financed by: (a) savings accrued by thermal energy generators that preclude gas and oil purchases; (b) grants, donations and contributions; and (c) returns on the fund's investments.

Source: Elsobki / Wooders / Sherif (2009)

3 Domestic technological capabilities in renewable energy

There is little debate about the fact that the absence of, or limitations to, technological capabilities undermines national strategies for sustainable development based on renewable energy technologies (UNCTAD 2011). In this chapter, we perform a critical assessment of Egypt's local technological capabilities in renewable energy (CSP and wind power) with respect to the manufacture of parts and components and associated services (production and project execution capabilities), as well as knowledge creation and R&D potential (innovation capabilities). Table 3–1 explains in detail how our analysis conceptualizes technological capabilities, based on Amsden (2001).

Localizing the value chain for solar and wind power can create linkages and spillover effects in other related sectors and can be an important source of employment. Depending on the domestic manufacturing and knowledge base, some parts of the value chain are easier to localize than others – at least in the short run. This chapter's analysis allows us to identify entry points for Egypt's local private sector and ways to enhance adaptive R&D and technology transfer.

In section 3.1 we assess the potential for localizing manufacturing and associated services in Egypt along the CSP and wind energy value chain. We find that although in several areas local production and project execution capabilities do exist for wind power and CSP, significant investments and strategic efforts are needed to expand the localization of manufacturing and associated services with higher technology content. The domestic wind energy sector is more developed than that of CSP because of partnerships for technology transfer, local investments by Egyptian companies and the presence of complementary industries (i.e. steel and electric cables). Prospects for a more stable and larger local (and regional) market could help develop the Egyptian wind energy sector. The CSP sector is less developed partly because of its less ambitious solar deployment targets and its higher costs. Nevertheless, the experience gained from the development of the first CSP plant in Egypt shows that local capabilities do exist in engineering, procurement and construction (EPC) activities, steel structures and some electrical components. The Egyptian market has potential for adaptive R&D and the formation of niche markets because of CSP's potential use in seawater desalination, which is greatly needed by the water-scarce local environment.

Table 3–1: Technological capabilities – a more detailed explanation

Production capability[1]

Production management – oversee the operation of established facilities

Production engineering[2] – provide the information required to optimize the operation of established facilities, including the following:

1. Raw-material control: sort and grade inputs, seek improved inputs
2. Production scheduling: coordinate production processes across products and facilities
3. Quality control: monitor conformance with product standards and upgrade them
4. Trouble-shooting: seek solutions to problems encountered in the course of operation
5. Adaptations of processes and products: respond to changing circumstances and increase productivity
6. Repair and maintenance of physical capital: on a regular schedule and whenever necessary

Project execution (investment capability)

Personnel training – impart skills and abilities of all kinds

Pre-investment feasibility studies – identify possible projects and ascertain their viability based on alternative design concepts

Project execution – establish or expand facilities, including the following:

1. Project management: organize and oversee activities involved in project execution
2. Project engineering: provide information needed to make technology operational in a particular setting, including the following:
   - Detailed studies (make tentative choices among design alternatives)
   - Basic engineering (supply core technology in terms of process flows, material and energy balances, specifications for principal equipment, plant layout)
   - Detailed engineering (supply peripheral technology in terms of complete specifications for all physical capital, architectural and engineering plans, construction and equipment installation)
3. Procurement (choose, coordinate and supervise hardware suppliers and construction contractors)

Table 3–1 (cont.): Technological capabilities – a more detailed explanation
4. Embodiment in physical capital (accomplish site preparation, construction, plant erection, manufacture of machinery and equipment) 5. Start-up of operations **Innovation capability** The skills needed to create new products or processes, based on the novelty of the new technology: 1. *Pure science:* the search for intrinsic knowledge 2. *Basic research:* the search for radically new technology 3. *Applied research:* the search for differentiated products 4. *Exploratory research:* the search for refinements of differentiated products 5. *Advanced development:* the search for the optimum manufacturability of refined differentiated products
Notes: [1] These activities refer to the operation of manufacturing plants; similar activities pertain to the operation of other types of productive facilities. [2] This term is used more broadly to include all the engineering activities related to the operation of existing facilities, encompassing product design and engineering as generally used in reference to industrial production.
Source: Amsden (2001, 4)

Innovation capabilities are needed in order to expand local companies' participation in more technology-intensive activities in the value chain – which does not only refer to the capabilities needed for developing "new to-the-world" technologies. Instead, we seek to assess the knowledge and research capabilities required for incremental improvements to existing technologies as well as the adaptation, dissemination, maintenance and use of these technologies. Technology transfer is critical in the early stages, which means that strengthening local knowledge and R&D capabilities can well lead to increased learning capacity and absorptive potential, which in turn permits the internalization of benefits from international collaborations. As Popp (2011) argues, *"When adjustments are necessary to fit new technologies to* *local market conditions, it is the recipient countries that will be best-positioned to do this research."* Since this is a relatively recent area of inquiry, more research is needed to understand the potential impacts of adaptive R&D and the conditions needed to enable developing countries to expand such knowledge.

In this study we cannot examine the local potential for innovation and adaptive R&D in great detail. But using our insights gained in interviews and from secondary literature, in section 3.3 we identify potential gaps in the capacity building process in Egypt's academic and research environment. We also assess the nature of relationships of these organizations with the private sector. We find that research activities in the field of renewables are scattered because no national technology strategy has been developed to guide research funds towards this field. Although educational programs are limited, efforts are being made to integrate this field into the curricula of local universities. We find that collaborations between industry and academia (which has significantly contributed to the success of the renewable energy sector in Germany, for example) are very weak in Egypt. Strategic efforts are required to develop successful examples of cooperation between these stakeholders that could redefine Egypt's entrepreneurial culture.

3.1 Production and project execution capabilities

In this section we assess the capabilities of Egypt's wind power and CSP sectors, and discuss areas with potential for expanding local manufacturing and associated services. In the first phases of developing a local industry, reliance on foreign expertise and investment is essential. However, it is critical to intensify technology transfer as a means of supporting the local industry's move up the technological ladder, and also to implement effective supplier development programs. Box 3-1 provides an overview of the main programs for developing a renewable energy industry that are under the umbrella of the Ministry of Industry and Foreign Trade (MIFT).[18]

---

18 The name of the Ministry has changed several times in the past year as a result of political instability and changes in leadership. The name used here dates from December 2011.

Box 3–1: A Brief overview of the role of the Ministry of Industry and Foreign Trade (MIFT) in supporting the development of the renewable energy industry

The MIFT's industrial development strategy plays an important role in supporting the development of the renewable-energy sector. However, since the 2011 protests, the Ministry's leadership has changed several times, which has diminished its effectiveness. Loewe (2011a) provides a detailed discussion of MIFT programs and activities and its strategy for industrial development. Here we draw on Loewe's overview of the different industrial policy tools and mechanisms, and the interviews we conducted in 2011 to highlight the mechanisms of the industrial strategy that are most relevant for the development of the renewable energy sector.

One core component in Egypt's industrial development strategy is the technological upgrading of the industrial sector. The main instrument used to achieve this goal is the Egypt Technology Transfer and Innovation Centres (ETTICs) that were created to focus on increasing operational efficiency, as well as technological upgrading and quality improvements. The ETTICs have been assigned to specific industries (such as food-processing, furniture production, marble and quarries) to which they offer technical assistance and consultancy services. While several private-sector companies that we interviewed claimed that these centres have benefited the local industry somewhat, most believe that the services they offer are too basic and that greater focus should be placed on technological innovation. More importantly, no such centre exists for the renewable energy sector – which companies we interviewed that operate in that sector consider to be important, especially because solar and wind technologies cut across various industries (e. g. glass, steel, electronics and construction). The Egypt National Cleaner Production Centre (ENCPC) is an example of a program that spans several industries, but its focus is on energy efficiency improvements in the industrial sector. Our interviews (with the private sector and policy-makers) revealed that the ENCPC is perceived as one of the most successful ETTICs. However, because of the private sector's very limited knowledge with respect to energy efficiency, the ENCPC claims that most of their activities are focused on raising awareness and improving resource management in various sectors. Their next steps will be technological upgrading and the introduction of more innovative practices. Similar initiatives for the renewable energy sector (focused on wind and solar technologies) could contribute to increasing the coherency of what is currently a rather disjointed sector.

The Industrial Modernization Centre (IMC), created in 2000 under the guidance of, and with financial assistance from, the EU (EUR 250 million or 59 percent of the IMC's budget), is the core component of Egypt's industrial-development-strategy. The IMC have been tasked to manage the "Egypt Industry Modernization Program", which is intended to: (i) achieve higher rates of industrial output growth, (ii) boost the productivity of industrial enterprises, and (iii) improve the technological profile of exports. The IMC's services for the private sector are mostly in the form of training for workers, senior manage-ment and entrepreneurs; quality management; upgrading of information and communication technology systems; innovation; research and development; technology transfer; and export market development. The IMC reimburse entrepreneurs for up to 90 percent (95 percent in Upper Egypt) of the cost of the training courses.[19]

The IMC's "Energy Efficiency, Renewable Energy and Environmental Protection Program"[20] may be the only support program in Egypt that is specifically concerned with renewable energy. However, its effectiveness has not yet been proven, since most companies know nothing about it, nor have they benefited from its services. Given the existence of various initiatives, it is more urgent to increase their visibility and improve their efficacy than to create more pro-grams.

The IMC also run three specialized programs: the "National Supplier Development Program", the "Clusters Development Program", and the "1,000 New Factories Program". The supplier development program, which follows a value-chain approach, is a mechanism for upgrading and modernizing local suppliers to major multinational companies that operate across different sectors in Egypt, such as General Motors, Mercedes and Procter and Gamble. Interviews with IMC staff and private companies suggest that the IMC programs have helped provide funding and expertise for skill upgrading in various sectors, but that new mechanisms need to be created to address the requirements of the renewable energy sector. Ways to extend these services so as to support local development of the renewable energy sector should be seriously considered.

Another program running in collaboration with the MIFT that is financed by the German Ministry for Economic Cooperation and Development (BMZ) is the Egyptian–German Private Sector Development Program (PSDP), established in

19 One concern regarding this high level of cost reimbursement is that entrepreneurs might not have sufficient incentives to make the most of these training programs. More research is needed to understand how these funds are managed.

20 The renewable-energy part of the program aims to: provide information on renewable energy sources in Egypt; provide access to information available at the IMC; conduct feasibility studies related to various renewable energy sources; stimulate, propose and participate in discussions on the topic; and provide technical assistance for potential producers of renewable energy sources who seek the work licences required in accor-dance with regulations for the Egyptian electricity market (IMC 2011).

2005 for a period of nine years. Relying on technical assistance from the GIZ, the PSDP focuses on enhancing competitiveness in the private sector through innovation and improved conditions in the value chain across several industries. More details about the program can be found at: www.psdp-egypt.info. The PSDP's activities are very much in the realm of sustainable development, but do not directly address CSP and wind energy.

The assessment of technological capabilities for wind and solar energy relies on semistructured interviews conducted with private sector representatives in Egypt as well as on earlier studies about local manufacturing capabilities in renewable energy in the MENA region. The first assessment of local potential for the manufacture of parts and components (for solar and wind energy) and for related service provisions was conducted in 2006 by Egypt's Industrial Modernization Centre (IMC 2006). More recently, the World Bank (2011) commissioned an assessment of the local manufacturing potential for CSP in five countries in the MENA region that offers a preliminary inventory of existing capabilities for this technology. The German Federal Ministry for Economic Development and Cooperation (BMZ), through its implementing agency, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), also commissioned a study about local industrial development for PV and wind energy in Egypt (Sawin / Mastny 2010). These three studies provide additional secondary data for our analysis.

The value chains for wind energy and CSP will be examined separately for manufacturing and deployment following the approach used by Lema et al. (2011). We also assess local expertise, potential gaps and ways to enhance the local knowledge base with respect to project execution, as in Table 3-1.

3.1.1 The wind power sector

Egypt's wind power sector has grown significantly, primarily driven by its lower cost, more mature and lower cost technology (as compared to CSP), the wind resources along the coast Gulf of Suez (which are among the best in the world), and the availability of land with low alternative economic value. International financiers have also been more interested in developing a local market in wind power technology than in CSP. These conditions have been supported by ambitious national plans to deploy wind energy, as is evident in the MoEE's renewable energy target of 20 percent by 2020, of which 12 percent is wind energy. With almost 550 MW of wind-energy installed capacity (with financial and technical assistance from Germany, Denmark, Spain and Japan), Egypt now produces 57 per-cent of all the wind energy generated in MENA. Yet there is still a lot of underutilized potential. Based on its national renewable energy target, Egypt aims to reach a total of 7.2 GW installed wind power by 2020 (see Chapter 2).

Development on this scale requires large investments. But expectations of local jobs creation are high, especially if the Egyptian industrial policy decides to support creating added value through the local manufacture of parts and components.[21] For example, the General Authority for Investment (GAFI) claims that an annual investment of approximately USD 59 million would be necessary to build local blade manufacturing facilities large enough to supply 400 MW per year, while an annual investment of some USD 147 million would be needed for tower manufacturing, which would provide employment to 400 workers (GAFI 2010). The Gabal El-Zait wind park to be developed on the Red Sea coast, which is still in the feasibility phase, is expected to cost USS 800 million, generate 350 GWh annually and employ up to 40 workers for plant operation and maintenance, on top of more than 100 workers needed to construct the wind farm (GAFI 2010). Egypt's existing wind energy farms employ 110 engineers and operation and maintenance specialists (60 at El-Zafarana Wind Farm and 50 at the Hurgada Wind Farm)[22] (ILO 2011). While these prospects for job creation may seem insignificant in light of Egypt's huge unemployment figures, if Egypt can realize its potential to become a regional hub for the renewable energy industry in MENA and Africa, many more jobs could be created. Besides the direct employment in wind farms and the construction industry, local manufacturers and suppliers of equipment will also experience job creation.[23] In light of the Government's targets for wind energy, it is estimated that 75,000 jobs will be created by 2020 (El Sewedy 2009).

---

21 A recent report by IRENA (2011) that compiled data about employment in the renewable energy sector shows that for both solar and wind energy, most jobs are to be found in construction and manufacturing, as well as in services.

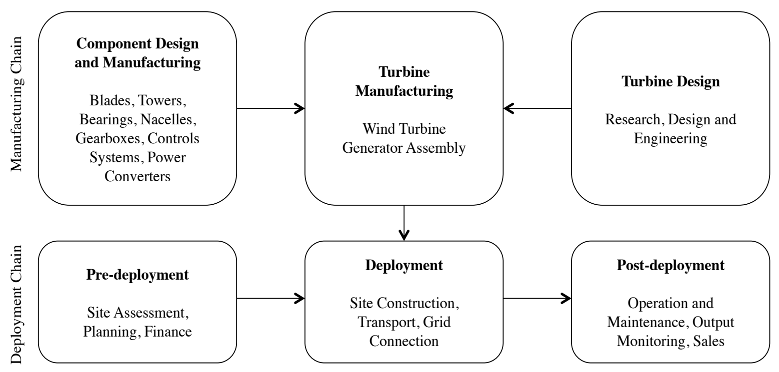
22 The first commercial wind farm, with a capacity of 9 GWh/year, was established in 1993 at Hurgada, while the first large wind park in Egypt was established (in 1999) at Zafarana, which because of its outstanding wind characteristics, is considered to be one of the best wind-farm sites in the world (ILO 2011, 283).

23 The issue of regional integration and specialization should be considered, given that Morocco and Tunisia have made serious commitments to creating renewable energy sectors. Future research should address national strategies for developing comparative advantage in these technologies.

Figure 3–1 describes the wind industry value chain, divided into categories of manufacturing and deployment, so that associated services can be more clearly identified. According to the NREA, 30 percent of the equipment used in existing wind projects is produced locally, and the percentage could be increased to 70 percent (NREA 2011). There is great potential for manufacturing most components locally, including those with higher technological content, such as the gearbox and blades. Initially, know-how is to be acquired by licensing technology from foreign partners or by acquiring shares in foreign companies. Nevertheless, as we discuss below, indigenous manufacturing capabilities do exist – well-established industries with global experience that manufacture steel, transformers, cables and electrical auxiliaries – that can facilitate technology transfer and absorption. In Chapter 5, we explore one of the main remaining challenges – how to enable and expand these capabilities.

The main constraints to local market development are the limited domestic market and low quality of locally produced parts and components.[24] Clearly, supplier development programs could help improve local manufacturers' abilities to supply the emerging wind energy market.

Figure 3–1: The wind energy industry value chain (simplified)



Source: Lema et al. (2011). Arrows indicate flows of goods and services between functions in the chain.

24 For example, the quality of the welding rods is substandard, which is why about 90% of the local market has to use imports (Sawin / Mastny 2010, 36).

3.1.1.1 Local capabilities for production and project execution

Wind energy offers high potential for localizing manufacturing. This is mainly because the large size of the core components (e.g. towers and blades) requires manufacturers to be located close to the market so as to reduce transportation costs. In addition, the worldwide growth of the wind market has stretched the supply of towers (IEA 2008). Although manufacturers prefer to produce locally, it is not feasible to establish production facilities for every market. As indicated by the large increases in global trade in the last few years, there is profit to be made in exporting wind turbines and components (David 2009, 20). This suggests that if Egypt could develop a comparative advantage in wind energy manufacturing, it could service the regional emerging markets; Egypt's wind industry could play an important role in the MENA market (and for regions in Africa), where manufacturing capabilities for wind energy components are limited.

Wind power is a capital intensive technology, in which initial capital costs are the determining factor in the cost of generation. Between 1980 and 2004, the cost of wind turbines decreased by a factor of four, but then increased by 20 to 80 percent – mainly due to the tight supply of towers and other components, as well as the high prices for steel and copper (IEA 2008). This suggests that local manufacturing of most of the wind turbine components would probably lower the cost of wind energy, especially since prices of steel and copper are comparatively low in Egypt (Khan 2010).

Among the components of the wind turbine, the tower is the least technologically specific part. Nevertheless, although wind tower manufacturing *"is similar in many ways to other metalwork, it differs in size (and thus handling and transportation), quality (in terms of welding and surface treatment), and assembly on site"* (Sawin / Mastny 2010, 35). In particular, "manufacturing quality is a key issue and needs to achieve zero tolerance in material, welding and assembly activities" (Sawin / Mastny 2010, 35). Only a few manufacturers are capable of producing the large bearings needed for wind turbines (David 2009). The international gearbox market is also very concentrated, largely controlled by a few OEMs (David 2009). [25]

25 The main companies supplying gearboxes are Siemens, Suzlon and Moventas, but a few other smaller companies are entering the market (David 2009).

Box 3-2: Production methods for the main components of a wind turbine

Companies manufacturing parts and components (original equipment manufacturers, or OEMs) typically have unique designs for wind turbine nacelles (i.e. the housing for all the generating components in a wind turbine, including the generator, gearbox, drive train and brake assembly) and produce them in-house (e.g. Vestas, Gamesa and Enercon). Only a few wind turbine manufacturers license their designs, while several companies contract out nacelle manufacturing. Blades and towers are either produced in-house or supplied from outside. Nacelles, blades and towers are shipped directly from the manufacturing plant to the construction site.

Nacelles: Nacelle components – large bearings, castings/forgings, gearboxes and generators – are either produced in-house or supplied from outside to the OEM's specifications, and are assembled at the nacelle plant in less than a week.

Blades: Wind turbine blades are advanced in design but labour-intensive in the manufacturing process (e.g. adding layers of fibreglass to blade molds and finishing the blade edges). OEMs usually have unique designs for their blades; in most cases, outside suppliers produce them to specification. It takes about a week to produce a blade.

Towers: OEMs design the wind turbine towers. Towers usually have three sections, each consisting of metal rings that are thickest at the bottom of the tower and are conical in shape since the towers taper slightly from the base to the top. During the manufacturing process, plate sheets are cut, rolled into cones and welded into rings that are then welded together and painted. Platforms, ladders and other accessories are added before shipping.

Nacelles, blades, and towers are shipped from the plant to the construction site, where the project developer installs them. Trucks are the most common method of transport. Although rail- and barge-shipping are less expensive and can circumvent the complicated permitting process for shipping heavy and oversized products across multiple national borders, because they rarely have a direct connection to the construction plant, they are less often used.

OEMs note that potential suppliers often are unfamiliar with the large size of wind turbine components and their reliability and quality requirements. This results in an extensive qualification process that can take two to three months for simple parts and 12 to 15 months for more complex parts. Some companies have on-site representatives at suppliers around the world to ensure quality standards.

Source: United States International Trade Commission (David 2009)

Despite quality challenges, because of Egypt's large steel industry, local manufacturing potential is high for this component.[26] Two of the steel and construction companies have already developed tower production capabilities: DSD Ferrometalco[27] and Orascom Construction Industries (OCI).[28] The Arab Organization for Industrialization (AOI),[29] which has trained a team of engineers in wind plant design and manufacturing, is another local company interested in being part of the wind industry value chain, mostly for small wind turbines for such applications as water pumping.

The El-Sewedy Group, one of the largest family-owned companies in Egypt, is the only local company that has heavily invested in building local manufacturing capacity for wind turbine components and acquiring know-how. El-Sewedy is an Egyptian conglomerate that mostly produces cables, transformers, communications and electric equipment, and has distribution and manufacturing facilities worldwide. In 2004, with EU financial support, El-Sewedy started to explore their potential involvement in the renewable energy sector (interview with the Sales Director of the wind energy division at El-Sewedy; Cairo, October 2011). This led to the creation of the

26 With almost 2 million tonnes of steel exports in 2006, Egypt is among the top 10 players in the steel-exporters market (Nasr 2007). Al-Ezz Dekheila Steel Co. is the largest steel company in Egypt and the Middle East. Nevertheless, since the fall of the Mubarak regime, Egypt's steel industry has suffered from corruption scandals involving the Al Ezz Group, the largest steel company. It is not yet clear how much these political scandals have affected capacity.

27 DSD Ferrometalco, established in 1979, is one of the largest steel manufacturing and construction companies in the MENA region. It is a subsidiary of DSD STEEL GROUP GmbH, which is owned by DSD STEEL CONSTRUCTION AG in Germany. DSD Ferrometalco supplied towers to Egypt's very first wind park in Zafarana.

28 OCI belongs to the Orascom Group (Orascom Telecom is another company). Orascom, perhaps the largest business in Egypt, belongs to the politically well-connected Sawiris family. OCI contracts and implements large-scale government and infrastructure projects. *"Among others, the Orascom Group holds the exclusive local rights in Microsoft, McDonald's and other international brand names, apart from controlling the country's largest private construction, cement making, and natural gas supply firm, Egypt's largest private tourism developments, as well as an arms import establishment."* (Schlumberger 2004, 102)

29 AOI is specialized in building military equipment, but is searching to enter new markets, with the manufacture of parts and components for wind and solar energy a potential entry point. Because of the high investment costs and their low ability to absorb investment risks, no major plans have yet been announced.

Sewedy Wind Energy Group (SWEG), a tower manufacturing facility that is a joint venture with the German manufacturer SIAG Schaaf Industries AG that currently has 30 percent of the global market. According to SIAG staff, the factory in Egypt works to the same specifications and delivers the same quality as the manufacturing facility in Germany. SWEG broke ground on a new wind facility in 2008; by March 2010 it was able to supply the market (interview with the SIAG Head of Marketing; Cairo, November 2011).[30] The facility, which currently produces 120 steel towers per year, is going to be expanded to a capacity of 400 towers per year. The internal components for a wind tower (ladder, ducts and platforms) are also produced locally in partnership with SIAG (interview with the SIAG Head of Marketing; Cairo, November 2011).

SWEG is also establishing a turbine manufacturing facility, and has already set up a blade factory.[31] Its engineers claim that part of the know-how for blade manufacturing can be sourced locally because of the experience of building fibreglass materials for boat construction (Interview with the SWEG Sales Director; Cairo, October 2011). Glass-reinforced plastic, used for wind turbine blades, also has already been manufactured locally – for bathtubs and water pipes (which are about the size used for rotor blades) (Sawin / Mastny 2010: 38). It appears that the local market for blade production would not be restricted by technology or size, but rather by the quality of industrial design and production (Sawin / Mastny 2010, 38).

However, despite the apparent potential for localizing the manufacture of key components of wind energy technology, investment plans are stalled because of Egypt's economic downturn and political instability. It is difficult to enter export markets without having a strong track record in the domestic market (Interviews with SWEG representatives; Cairo, October 2011). However, SWEG's partnership with SIAG allows them to supply other emerging wind energy markets, such as Romania and the USA (SIAG 2011).

---

30 SIAG Schaaf Industries AG has manufacturing facilities in three other countries besides Germany and Egypt: the Czech Republic, France and the USA.

31 According to our 2008 interviews, SWEG has started negotiations with an undisclosed blade manufacturer for a technology transfer partnership (Interview with the SWEG Marketing Manager and Sales Director; Cairo, October 2011). Because the Egyptian market has been developing so slowly, they have halted investment and postponed know-how acquisition. The manufacturing facility in Egypt is 70% completed, with plans for training and staff hiring ready to be implemented.

SWEG has plans to operate across the entire value chain of the wind industry – including project development and operation and maintenance (O&M). Their experience in manufacturing cables, transformers and other electrical components allows them to also enter the balance-of-systems part of the value chain. SWEG representatives claim that they "know what and from where to source", which offers them a clear advantage in localizing the manufacturing part of the value chain. Nevertheless, some components still must be imported: steel sheets of the width and thickness required for tower manufacturing are not available locally and there are no plans to produce them in the near future (Sawin / Mastny 2010, 36). The amount of foreign know-how needed to produce these components with the right quality standards and competitive prices remains an open question. As Amsden (2001, 5) notes, the nature of technology makes knowledge difficult to acquire even with technology transfer agreements.

Of all the wind-turbine components, the gearboxes (and blades) are the most technologically specific. Hence, it is more difficult to transfer know-how via licences for wind turbine components than for wind towers. In our interviews, SWEG argued that they have had no luck in their proposed partnerships to Nordex and Gamesa with the aim of acquiring know-how for turbine manufacturing (Interviews with SWEG representatives; Cairo, October 2011). Their alternative source of technology transfer for the wind turbine was a company who has the know-how but is not a market leader: In 2007 SWEG acquired a stake (first 30 percent and then as much as 90 percent) in the Spanish company, MTorres, as a way of obtaining the know-how for manufacturing the gearless wind turbine[32] (Interview with SWEG representatives; Cairo, October 2011).

To acquire knowledge related to wind technology, as a local (and regional) market leader in the sector, SWEG has invested heavily in training personnel, both in-house and with their partners in Spain and Germany. They have also sent several engineers abroad for up to four months and developed training courses to learn the industry's entire value chain (Interview with SWEG representatives; Cairo, October 2011). SWEG now believes it has considerable expertise, with their employees being able to "speak wind," as the Sales Director put it.[33]

32 Because the gearbox alone costs about 10 % of the wind turbine, SWEG decided to develop the manufacture of gearless wind turbines specifically for the MENA region.

33 SWEG also claims that two of its engineers were hired by Vestas and Gamesa – which shows that their training and expertise meet international standards.

However, because the market has been slow to develop in Egypt, SWEG is now only manufacturing in Spain and put on hold its plans to build a local manufacturing facility in Egypt. Most of their technical staff has left or been shifted to the commercial and marketing departments (Interview with the SWEG Sales Director; Cairo, October 2011). However, some engineers have been retained for wind farm design. The slow market development in Egypt, retarded by the Arab Spring and a lack of strong political commitment towards renewables, has limited SWEG's operations and investment plans since 2010.

The metal casting and forging industries are important in both turbine and rotor manufacturing (including the hub, shaft and generator body). In Egypt, these industries are sizable, which means that for them wind energy is a potentially large market.[34] The Ministry of Higher Education and State for Scientific Research (MHESR) has created the Centre for Metallurgical Research and Development Institute (CMRDI) to assist with technological development and technology transfer for the industry. CMRDI also aims to create a cluster of companies operating in this sector, assess existing manufacturing capabilities and potential niche markets and create linkages with local and international universities and research institutes by acting as a "matchmaker" (Interview with CMRDI; Cairo, November 2011). The initiative principally aims to assist local producers improve quality and enhance their innovation capabilities.

Despite such initiatives, which are not specifically aimed at supporting the development of a local wind energy industry, local companies appear to be at a disadvantage in the current tendering process for wind projects (Interview with SWEG representatives; Cairo, October 2011). First, the New Electricity Law has not yet been passed, which means that local content provisions are not yet specified or enforced in the bidding process. Second, most projects in the pipeline are to be developed with European (or international) financing, which means that the prerequisite of considerable experience – of at least 1,000 MW installed capacity – to reduce investment risks automatically excludes local companies from trying to enter the market through the competitive-bidding process.

34 Local companies such as Helwan Iron Foundries (the military factory number nine, affiliated with the Ministry of Military Production), United Company for Foundries, and Modern Casters are examples of potential local producers for such components, or Al Ahram and Tawakol for local foundries (Sawin / Mastny 2010, 36).

Policy tools for stimulating higher local content are needed to help the local industry get started. According to our interviews with local companies (SWEG, Orascom and Sphinx Glass; Cairo, October 2011) and NREA representatives (Cairo, October 2011), a presidential decree temporarily removed customs duties for imports of renewable-energy components (which previously ranged between 2 and 5 percent) with the intent of supporting local production (assuming that to begin with, companies would largely have to import various parts and components). Yet some local companies found that this provision hurt those who invested in local production facilities. SWEG argued that custom duties should be reinstated because local capabilities exist and without the customs duties, it cost more to produce and assemble different components locally than to import the complete product from abroad (Interview with SWEG representatives; Cairo, October 2011). More consideration should be given to the impact such regulations have on local producers. Bringing the various stakeholders to the table to discuss how policy options impact their investment plans might reduce ambiguity with respect to policy outcomes and improve targeting of the proposed incentive mechanisms. India, for example, has successfully used customs and excise duties that favour importing components of wind turbines over complete machines, thereby supporting local industry creation (Lewis 2007).

Nevertheless, especially in the current tense and uncertain political environment in Egypt, the relationship between the 'state' and the private sector is unpredictable. Following the fall of the Mubarak regime, local companies aiming to enter niche markets sense a lack of support from the government (i. e. the MIFT and the MoEE) (Interview with SWEG representatives; Cairo, October 2011). Following the wave of corruption cases involving former Mubarak cabinet members and the business elite, those still in government are said to be extremely cautious, avoiding as direct contact with the private sector because they fear charges of favouritism (Interviews with SWEG, NREA, AECAPROMENA, Sphinx Glass, Fraunhofer Egypt; Cairo, October–November 2011). The SWEG Sales Director argued that this aspect is especially important in the SWEG case: Because SWEG is now the only company making real efforts to develop local manufacturing capabilities, any government incentives for local manufacturers would appear to favour SWEG and therefore raise suspicions of corruption. While this issue does not pose problems for companies that rely on export markets (such as El Sewedy or OCI), it is a big challenge for companies trying to enter new markets. This illustrates the critical political economy framework conditions in which industrial development takes place. We will discuss this more in Chapter 4.

Various policy mechanisms have been used to support the development of a local industry. But examples of developing countries pursuing such policies for the benefit of creating a local renewable energy sector are rare. China and India's experience with developing local manufacturing capabilities for wind energy technologies could be instructive for other countries seeking to pursue this end – despite their unique conditions (mega-populations, manufacturing experience and enormous demand for energy). Box 3-3 shows some of the policy mechanisms used by China and India to support the development of a local industry. A comparison of these two cases is interesting because China and India have essentially pursued different strategies regarding the use of local content specifications and wind energy pricing, yet each country has been able to establish a successful, internationally competitive local industry. However, both governments pursued integrated and coordinated approaches between the different stakeholders, with the goal of developing a local industry and stimulating employment as well nurturing acquisition of technological capabilities to support their economies in the catching-up process. The strategic approaches for industrial development and take-off in the wind energy sector have evolved over time in both China and India; while initially, licensing and foreign direct investment were important, in the catching-up process, R&D partnerships and the acquisition of foreign firms have become increasingly important (Lema / Lema 2012).

Box 3-3: Policy choices for wind-turbine development in China and India

Wind energy technologies have been successfully integrated into economic catching-up processes in China and India, in particular since 2006. By 2011 China had become the global leader in terms of installed wind energy capacity, and India is now the world's fifth largest wind power market (Walz / Delgado 2012). The main differences in the policy support mechanisms for local manufacturing in China and India are: (1) China's reliance on local content requirements to encourage locally sourced wind turbines and (2) India's focus on demand-driven industrial development.

The local-content requirement in China (mandating that 70 percent of the turbine content be made in China) encouraged several foreign-owned companies to shift their manufacturing to China (Lewis 2007). As a result of this policy (which mandated the usage of domestic technology either by specifying a share or through particular sourcing rules), Chinese-owned turbine manufacturers (primarily the top three companies: Goldwind, Sinovel and Dongfang Electric) were able to cover 77 percent of the local market (Lewis 2007; Walz / Delgado 2012). In December 2009, the local content requirement was abolished (Walz / Delgado 2012). Another important policy for supporting local manufacturing in China has been public procurement. In 2006, three Chinese ministries jointly released the "Provisional Measures for the Accreditation of National Indigenous Innovation Products" to prioritize products identified as "indigenous" intellectual property for government procurement and key national projects (Walz / Delgado 2012). Furthermore, the Ministry of Finance issued a regulation on import tax and a customs-duty exemption for wind-turbine components – but only for those with capacities larger than 2.5 MW and for standalone components (converters, bearings and controls) that could not be produced in China (Walz / Delgado 2012). At the same time, almost USD 50 billion of the U.S. Economic Stimulus Package was allocated to green projects, following a circular jointly released by nine government organizations (Walz / Delgado 2012).

With regard to the promotion of local wind-turbine manufacturing, India has generally been much more hands-off than China by not mandating the use of local content in domestically installed wind turbines. India's local manufacturing industry, led by Suzlon, seems to have emerged organically as companies shifted their facilities to India to meet the demands of the local market. Policies supporting its development included customs and excise duties on imported components, a national certification program and standardized guidelines to ensure grid compatibility with planned developments for wind energy (Lewis 2007; Walz / Delgado 2012). Demand-driven policies, such as tax incentives, feed-in-tariffs and federal generation-based incentive schemes for grid connected wind projects, have created incentives for first-movers like Suzlon, as well as for second-tier companies, to invest in building local capabilities. Over a dozen companies are now manufacturing wind turbines in India. Domestic manufacturing capabilities are well established. In addition to Suzlon (with a 69 percent market share in 2008), Indian's local market is served by RRB Energy Limited (a 9.6 percent market share in 2008) as well as a number of smaller players (8.5 percent market share) (Walz / Delgado 2012).

With respect to technology development strategies, although in the early stages both countries relied heavily on technology licensing, there were differences in how much their main companies – Goldwind in China and Suzlon in India – relied on licensed technology. Both companies opted to pursue multiple licensing arrangements with established companies and second-tier companies, as well as company acquisition. Building on the experience gained from international technology transfers, Suzlon has formed many overseas subsidiaries in partnership with foreign-owned companies, either to manufacture a specific component (such as the gearbox and blades) or to undertake collaborative R&D (in Germany and Netherlands). Suzlon has also established its international headquarters in Denmark, the major industrial centre for the wind turbine industry. This international presence allows the Indian wind energy sector to access cutting-edge technology. As a result, Suzlon is currently capable of assembling wind turbines with ratings between 350 kW and 2.1 MW, and manufacturing components such as rotor blades, tubular towers, control panels, generators and gearboxes (Walz / Delgado 2012).

In China, Goldwind's licensing arrangements with Repower allowed it to jump into the wind-turbine industry with little indigenous knowledge (Lewis 2007). It has subsequently signed licensing arrangements with other companies (such as Jacobs and Vensys Energiesysteme GmbH) to learn about larger turbine designs (Lema / Lema 2012; Walz / Delgado 2012). Such arrangements provided the transfer of know-how, enabling Goldwind to make innovations on the transferred knowledge (Lewis 2007). While so far, Goldwind has relied only on licensed technology, Suzlon went beyond the licence model to purchase majority control of several wind turbine technology and components suppliers. Therefore, another difference in the two countries' technology development strategies is how they positioned themselves with respect to domestic and global-learning networks. More recently, China has aggressively pursued R&D collaborations with Denmark in the area of wind turbine design (Delman / Chen 2008).

To summarize the above discussion, Table 3-2 takes each part of the value chain and shows existing capabilities, those under development, and those not present. It is important to note that, with the exception of EPC activities, basically just two firms manufacture locally, SWEG and OCI. Also, while SWEG representatives suggested that efforts are currently underway to enhance wind-turbine research, design and engineering capabilities, such activities are limited.

Table 3–2: Capabilities for wind energy system manufacturing in Egypt

Value chain stage		**Local production and project execution capabilities**		
		Existing	**Developing**	**Not currently present**
Component design and manufacturing	Towers	SWEG and OCI		
	Blades		SWEG invested in blade manufacturing but stopped local operations	
	Bearings			
	Nacelles		SWEG acquired capabilities for manufacturing and assembly by acquiring MTorres in Spain.	
	Gearboxes			The wind turbine that SWEG is developing through MTorres is gearless
	Controls systems	SWEG through the larger El-Sewedy Group		
	Power converters	SWEG through the larger El-Sewedy Group		

Table 3–2 (cont.): Capabilities for wind energy system manufacturing in Egypt				
Value chain stage		**Local production and project execution capabilities**		
		Existing	**Developing**	**Not currently present**
Turbine design	Research, design and engineering		Technology transfer through SWEG's acquisition of MTorres	
Turbine manufacturing	Wind turbine, generator assembly		SWEG through the larger El-Sewedy Group	
Pre-deployment	Site assessment, planning, finance		SWEG and OCI	
Deployment	Site construction, transport, distribution of electricity	SWEG and OCI		
Post-deployment	Operation and maintenance (O&M), output monitoring, sales	SWEG and OCI		
Source: Based on literature and field interviews in Cairo in 2011				

The deployment side of the wind energy value chain includes activities related to site assessment, planning, finance, site construction, transportation, grid connection, operation and maintenance (O&M), monitoring and sales. Local capabilities in the downstream value chain, especially in deployment and post-deployment activities are also available (see Table 3-2). For example, wind resources for Egypt have been assessed by the NREA, the Egyptian Meteorological Authority and Riso National Laboratory, which resulted in a 'national wind resource atlas' project financed by the governments of Egypt and Denmark.

As far as project execution capabilities are concerned (see Table 3-1), our findings in Egypt suggest that project management and engineering continue to be largely performed by foreign companies and consultants (with respect to conducting feasibility studies, studies for selecting among design alternatives, performing environmental assessment studies, etc.). Building local knowledge capabilities in these activities requires concerted national efforts in training and education at different levels, as well as partnerships with foreign companies and organizations. This is especially important because, given the very nature of technology (which makes knowledge acquisition difficult), firms are reluctant to sell or lease their cutting-edge intangible assets (Amsden 2001). Such challenges have also been observed in the development of the renewable energy industry in India and China, where technology leaders have refrained from transferring know-how because of concerns about losing their competitive edge (Lewis 2007).

The presence of large project developers, such as OCI (with their affiliated companies, such as National Steel Fabrication, NSF), facilitates the acquisition of know-how. Local companies' participation has benefited project execution, especially procurement (choosing, coordinating and supervising suppliers and construction contractors) and the 'embodiment of physical capital' (site preparation, construction and plant erection). SWEG has also acquired knowledge about O&M and project development through their various partnerships. OCI, however, has already been involved in O&M activities for local wind farms (i.e. at the Zafarana wind farm) and are leveraging their activities in the solar industry (as we discuss in section 3.2.2 on the CSP sector). Initial knowledge transfer has been facilitated through joint-venture agreements with foreign companies. After commissioning, the NREA will perform the post-deployment activities for the wind farms currently installed. But extensive training is required to enhance local capabilities with respect to service provision (i.e. project execution capabilities). While large companies such as OCI and SWEG manage to develop inhouse training programs, it would be helpful to offer more focused training through vocational education courses or programs such as those developed by the IMC for other sectors.

3.1.1.2 Job profiles for the emerging local market

Assessing the types of jobs needed to develop a sector in an emerging market is essential for drawing up the roadmap for training, education, R&D and private-sector expansion. To this end, assessing the job profiles along the value chain can provide the type of information that policy-makers need to pursue a comprehensive development approach. In the more mature markets of EU countries, almost 60 percent of all wind-sector jobs (approximately 156,000) are in manufacturing wind turbines and components (EWEA 2009). Yet jobs in specialized services are also important, especially those related to project execution capabilities (defined in Section 3-1). In Spain, for instance, 30 percent of the jobs have been in manufacturing companies, 34 percent in installation, O&M and repair companies, 27 percent in promotion and engineering companies and 9 percent in other branches (AEE 2007).

In Egypt, there are not many wind-energy consultants (Interviews with Egytec, Ain Shams University, Fraunhofer Egypt, InWent Egypt; Cairo, October–November 2011) that could provide knowledge about project development and design, problem solving, wind resources and environmental impact assessments, and so forth. Since the market has been relatively slow and driven by donors and large foreign companies, no local need for these services has emerged. However, as the market grows, such expertise is expected to be in demand.

Table 3-3 provides a brief description of job profiles for different types of companies along the wind-energy-sector value chain, and in corroboration with findings from interviews with stakeholders in Egypt, it illustrates where potential gaps exist in the local skills set. This profile is preliminary because an in-depth survey of the labour market is still needed to identify the skills gap at different professional levels. Yet the overall assessment shows that while basic skills do exist, significant investment and strategic programs are needed at all levels to expand local wind-specific knowledge. In particular, knowledge is limited in non-engineering specialized jobs (such as project managers, environmental engineers, lawyers and economists with expertise in renewable energy, etc.). As Amsden (2001, 15) argues, *"[E]ven if technology is transferred, diffusion from one enterprise to another may be imperfect and depends on an advanced level of skills on the buyer's side."* It is therefore crucial to strengthen local companies' absorptive capacity to adapt, manage and expand acquired knowledge. Augmenting absorptive capacity requires concerted efforts to integrate renewable energy and sustainability in the different disciplines and levels of education, as well as to invest in R&D. While formal qualifications are important, equally important is the accumulated practical/project experience that results from market expansion. Such efforts have to be guided by a national technology strategy and a stable institutional framework.

In collaboration with the NREA, in 2009, the Regional Centre for Renewable Energy and Energy Efficiency (RCREEE) in Cairo developed a comprehensive training workshop on wind parks that focused on the principles for selecting locations, designing farms, operations and financial feasibility (ILO 2011). However, most training efforts are conducted in-house or on-the-job and relatively small-scale – which is insufficient in view of the targets for wind energy deployment and the anticipated demand for jobs in this sector. The NREA is responsible for training workers in the maintenance and operation of wind farms, and its financial constraints have been identified among the main obstacles blocking proper training programs for workers in this sector (ILO 2011, based on interviews conducted at the NREA in March 2010).

Table 3–3: Wind energy job profiles and existing skills in Egypt

Company type	Field of activity	Main job profiles	Availability in Egypt
Manufacturer	Wind turbine producer, including manufacture of major sub-components and assembly factories	Highly qualified chemical, electrical, mechanical & materials engineers dealing with R&D issues, product design, management and quality control of production process	Basic skills available (not specific to wind energy); significant investment needed in knowledge transfer, training, education and R&D skills
		Semi-skilled and non-skilled workers for production lines	Available, providing some on-the-job training is offered
		Health and safety experts	Available
		Technical staff for O&M and repair of wind turbines	Available only in large companies (i.e. SWEG and OCI); training and knowledge transfer needed to expand these skills
Developer	Manage tasks related to the development of wind farms (planning, permits, construction, etc.)	Project managers (engineers and economists) to coordinate the process	Limited
		Environmental engineers and other specialists to analyse environmental impacts of wind farms	Limited

Table 3–3 (cont.): Wind energy job profiles and existing skills in Egypt

Company type	**Field of activity**	**Main job profiles**	**Availability in Egypt**
Developer (cont.)	Manage tasks related to the development of wind farms (planning, permits, construction, etc.) (cont.)	Programmers and meteorologists for wind energy forecasts and prediction models	Knowledge within the NREA and the Egyptian Meteorological Authority but significant knowledge transfer required
		Lawyers and economists to deal with legal and financial aspects of project development	Limited
		Other supporting staff (including administrative, sales managers, marketing and accounting)	Available
Construction, repair and O&M	Construction of wind farms, regular inspection and repair activities	Technical staff for O&M and repair of wind turbines	Limited to main players who provide in-house training and acquire the know-how
		Electrical and civil engineers for coordination of construction works	Available, but specific training is required
		Health and safety experts	Available

Table 3–3 (cont.): Wind energy job profiles and existing skills in Egypt

Company type	**Field of activity**	**Main job profiles**	**Availability in Egypt**
Construction, repair and O&M (cont.)	Construction of wind farms, regular inspection and repair activities (cont.)	Specialists in transport of heavy goods	Available, if additional training provided
		Electricians	Available
		Technical staff specialized in wind turbine installation, including activities in cranes, fitters and nacelles	Limited, with exception of in-house training and knowledge transfer provided at SWEG and OCI
		Semi-skilled and non-skilled workers for construction process	Available
		Other supporting staff (including administrative, sales managers and accounting)	Available
Independent power producers (IPP), utilities	Operation of wind farms and sale of electricity produced.	Electrical, environmental and civil engineers for plant management	Limited
		Technical staff for the plant O&M (if this task is not subcontracted)	Available only in SWEG and OCI following training and knowledge transfer

Table 3–3 (cont.): Wind energy job profiles and existing skills in Egypt			
Company type	**Field of activity**	**Main job profiles**	**Availability in Egypt**
Independent power producers (IPP), utilities (cont.)	Operation of wind farms and sale of electricity produced (cont.)	Health and safety experts	Available
		Financiers, sales and marketing staff to deal with the sale of electricity	Limited
		Other supporting staff (including administrative and accounting)	Available
Consultancies, legal entities, engineering, financial institutions, insurers, R&D centres and others	Various specialized activities linked to the wind energy business	Programmers and meteorologists for the analysis of wind regimes and output forecasts	Limited
		Engineers specialized in aerodynamics, computational fluid dynamics and other R&D areas	Limited
		Environmental engineers	Limited
		Energy policy experts	Limited
		Experts in social surveys, training and communication	Marginally available

Table 3–3 (cont.): Wind energy job profiles and existing skills in Egypt

Company type	Field of activity	Main job profiles	Availability in Egypt
Consultancies, legal entities, engineering, financial institutions, insurers, R&D centres and others (cont.)	Various specialized activities linked to the wind energy business (cont.)	Financiers and economists	Available, provided that specific skills and knowledge are developed
		Lawyers specialized in energy and environmental matters	Limited
		Marketing personnel and event organizers	Available

Source: Adapted from EWEA (2009), including author's assessment of skills availability in Egypt (based on interviews and literature research)

As this first assessment of gaps in existing skills suggests, more systematic collection of data on the knowledge base of the workforce is needed. Existing organizations such as the Egyptian Observatory for Education, Training and Employment[35], could potentially coordinate such a process and create a skills development strategy. As ILO (2011, 277) argues, one of the main challenges in Egypt is the "lack of coordination between multiple ministries and agencies working in education and training, and businessmen and those working on environmental issues." Acknowledging this problem and working toward its resolution is crucial.

To summarize, in Egypt, the manufacturing potential for parts and components, as well as associated services in wind energy, is relatively high, although it is now concentrated in two local companies (primarily SWEG, but also OCI). These companies, active in both the manufacturing and deployment parts of the value chain, have developed international collaborations for technology transfer (especially SWEG). Yet most of the design and engineering is being done abroad. These companies are also currently working with an array of local suppliers, offering promising prospects for wind energy in Egypt. SWEG has managed to enter export markets (i.e. exporting wind towers, construction and O&M services) but the company is constrained by the slow development of a local market and fierce international competition. Given the nature of wind energy technology (large components which incur high transportation costs), it is important that some parts be manufactured close to the market. Should the Egyptian (and regional) wind market pick up, it would become possible for Egyptian companies to play an important role, specifically in the manufacture of towers, but also potentially in other turbine components (such as blades). More technological capabilities are needed to enter the turbine design part of the value chain, which, at least initially, requires greater reliance on international technology providers. Project development, plant management and other specialized activities linked to wind energy project execution should be further expanded locally.

35 *"The Egyptian Observatory for Education, Training and Employment was established with the aim of creating a dynamic information system for employment and training in Egypt in order to offer accurate and updated data about both the supply and demand sides of the labour market. This data informs decision-makers, employers and individuals about the current and future needs of different skills and disciplines in the labour market. It enables decision-makers to devise policies and systems of education, training and employment. It also helps individuals choose the kind of education and training that is compatible with both their needs on one hand and with the current and future needs of the labour market on the other hand."* (Source: http://www.idsc.gov.eg/Projects/Projects_Details.aspx?id=12; accessed on December 15, 2011)

To a certain extent, the starting conditions in Egypt appear similar to those in China and India, where one large company drove local industry development and made notable efforts to acquire know-how through technology licensing, acquisitions and international partnerships. The ability of local companies, such as SWEG, to integrate the local supply chain can cut the cost of wind turbines, as in the cases of Goldwind and Suzlon (in China and India, respectively). Yet in both China and India, ambitious and consistent policies driven by clear national strategies were decisive for the creation of sizable local wind energy markets. As discussed earlier, a major hurdle for the development of a local wind industry is found in the realm of political economy, especially with respect to the current social contract and the nature of state–business relations. We elaborate on these aspects in Chapter 4.

3.1.2 Concentrated solar thermal power (CSP) sector

The CSP[36] market in Egypt, and also worldwide, which is in the very early stages of development, reflects a less mature technology (as compared to wind and solar PV) and also higher capital costs requirements. There are several reasons, however, why CSP is the core technology of the DESERTEC concept: (a) the sun provides an almost inexhaustible source of energy; (b) the technology offers storage potential so that the electricity generated can be delivered on demand and better satisfy peak electricity needs; (c) larges-cale deployment contributes to reducing costs, which can benefit the entire industry; (d) CSP technology is most suited to the centralized electricity generation model in the MENA region; (e) CSP can potentially be used for water desalination, thereby helping solve the region's water energy nexus challenge. While CSP currently costs more than other solar technologies, in the next 10 to 20 years, economies of scale and high investments are likely to make CSP competitive with wind, nuclear and coal (Hernandez-Moro / Martinez-Duart 2012; Komendantova et al. 2012).

Yet despite the fact that Egypt has one of the world's highest direct solar irradiation levels (DLR 2005), its national targets for solar energy deployment are less ambitious than for those for wind energy (primarily because of higher investment costs and difficulties in acquiring know-how, as we

36 CSP power plants produce electricity by converting concentrated direct solar irradiation into energy. The process of conversion has two parts: concentrating the solar energy and converting it into usable thermal energy, and converting heat into electricity. (See Box 1-1 for more details about the technology.)

will discuss later). By 2020, only 4 percent of the energy is expected to be solar-generated (both CSP and PV). To reach this goal, the NREA has set an intermediary target of 100 MW of CSP for 2017. The Kuraymat Integrated Solar Combined Cycle (ISCC) plant that was commissioned in October 2011, with an installed capacity of 140 MW of which only 20 MW is from CSP, is the first plant of its type in Egypt. Given the high potential for exporting clean energy to Europe (which is central to the DESERTEC and MSP projects), CSP will probably play a larger role in the energy mix in Egypt and the MENA region. Morocco has recently signed an agreement under the DESERTEC umbrella to deploy 500 MW of solar energy (mostly CSP) in several phases.[37] Tunisia and Jordan are also embracing this technology. The DESERTEC project's goal is to export 15 percent of the renewable energy produced in the MENA region to Europe via HVDC lines. Exporting from Egypt is technically challenging because of the depth of the Mediterranean Sea. Alternative options for exports of renewable energy from Egypt, such as exporting natural gas in amounts equal to the renewable energy produced, are therefore being considered (Interview with NREA, Energy Research Centre at Cairo University; Cairo, October 2011).

CSP technology know-how is concentrated in a few players, mainly in Spain, Germany and the USA, while new markets are emerging in the MENA region and in Asia. It appears that the value chain for CSP is quite integrated (Gereffi / Dubay 2008), which suggests that it might be difficult for emerging players to access the know-how and exploit the potential for technological innovation. In any case, greater international cooperation will be needed to increase the technology content. As we discuss later, some parts of the value chain include activities which can be localized more easily than others – civil works, mounting structure, and glass and mirror manufacturing – thereby providing entry points into the CSP industry.

The three main types of CSP technology[38] – parabolic trough, linear Fresnel collector and dish sterling[39] – concentrate solar irradiation in different ways. The more mature parabolic trough technology has been most widely deployed because it is more efficient, with corresponding lower costs. But the linear Fresnel technology is likely to achieve greater local content

37 Nevertheless, as per the latest discussions, the technology focus question remains open because of difficulties funding CSP projects. However, the first phase will consist of CSP power plant, while later phases might also include solar PV technology.

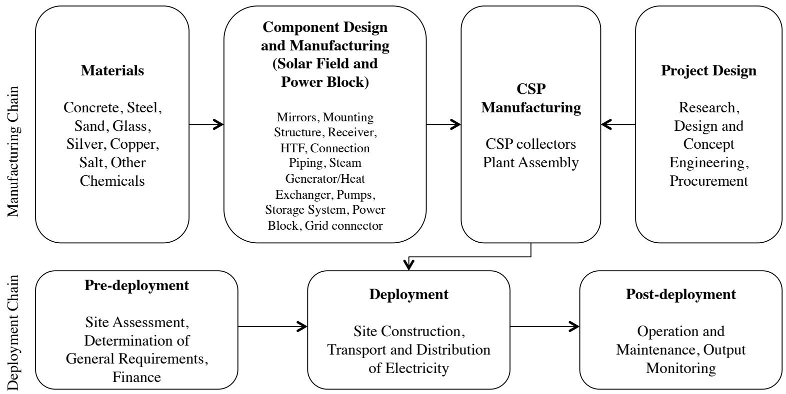
38 The World Bank study (2011) briefly describes and contrasts these three CSP technologies.

39 For arid environments, one main advantage of the sterling-dish CSP technology is its dry cooling (World Bank 2011, 37).

because *"it is more open to redesign and adaptation to local conditions"* (World Bank 2011, 35).[40] However, more research is needed to assess these benefits and trade-offs from using these CSP technologies.

Figure 3-2 provides a basic description of the CSP industry value chain. Given the considerable potential for generating electricity from CSP power plants in the MENA region, the World Bank commissioned a study (conducted by the Fraunhofer Institute and Ernst & Young) to assess local CSP manufacturing potential in five MENA countries (World Bank 2011). Along with findings from interviews with key industry players that we conducted in Egypt in 2011, these assessments provide background information on the CSP value chain and identify local industrial potential. As discussed in the case of wind energy industry (see Section 3.1.1), a key requirement for developing a local CSP industry is a sizable and steadily growing market, which is difficult in Egypt at this time.

Figure 3–2: The CSP industry value chain (simplified)



Source: Adapted from Lema et al. (2011) and the World Bank (2011). Arrows indicate flows of goods and services between functions in the chain.

40 The main advantages of linear Fresnel collectors over the parabolic trough are: they use cheaper, standardized flat mirrors, require less steel and are installed more quickly, thus entailing less mirror-glass breakage; the maintenance is lighter, and they require less land (World Bank 2011, 35).

The expected benefits from the development of a local CSP industry include job creation, export opportunities and economic growth – although more research is needed to determine the real impacts. In their ambitious scenario, the World Bank (2011) has estimated that by 2025, in five MENA countries (Algeria, Egypt, Jordan, Morocco and Tunisia), the number of permanent local jobs in the local CSP industries could range between 64,000 and 79,000 (45,000 jobs in the construction and manufacturing sectors, plus 19,000 jobs in operation and maintenance).[41] Given Egypt's massive unemployment, the forecast does not seem very impressive, but in light of the possibility of Egypt becoming a regional hub for manufacturing and technology development, the job impact could be significantly higher.[42] Unlike for the wind energy sector, for the Kuraymat CSP project in Egypt, local EPC contractors have provided most local content in the EPC related activities (see Table 3-4). The existing manufacturing base means local companies potentially have roles to play in other parts of the value chain – although in comparison with the wind energy sector, this is more limited in the short-term.

3.1.2.1 Local capabilities for production and project execution

The solar-field components (receiver, reflector, mounting structure, piping, heat transfer fluid, or HTF) are the most capital and technology intensive and constitute the largest share of the value chain (38.5 percent) (World Bank 2011, 8). Yet our interviews with private sector companies revealed possible opportunities for local manufacturing all along the value chain.

The raw materials most used to manufacture CSP parts and components (steel, concrete and cement) are available locally because of the sizable steel and cement industries (e.g. Al-Ezz Dekheila Steel Co., Sinai Cement Company, Misr Cement Qena and Misr Beni Suef Cement).[43] However, like

41 These estimates assume that by 2020, the home market volume of the five countries will amount to 5 GW and that the export of components will reach a volume corresponding to 2 GW installed CSP capacity. They also assume that the rapid development of national CSP promotion plans, that international initiatives will be heavily represented and/or that private investors will be active in the region (World Bank 2011, 121).

42 An interesting question for a separate study is whether employment gains from expanding the local CSP industry in Egypt would be at the expense of other MENA countries that are also seeking to increase their roles in the renewable energy sector.

43 Egypt has the second largest cement production capacity in the MENA region (after Iran), and is an important player on the global market (Global Investment House 2009).

other countries in the region, Egypt has to import crude steel. Local production capacity does not yet cover the growing demand from the construction sector. Steel, concrete and cement are mostly used for construction and civil works performed by EPC contractors, who tend to be large firms in the construction and steel industries (World Bank 2011, 84). In comparison with other North African countries, Egypt has a comparative advantage in this sector, with Orascom Construction Industries (OCI) and its affiliated companies, such as National Steel Fabrication (NSF). OCI/NSF was the EPC contractor for the Kuraymat ICCS plant (the German companies Fichtner Solar and Flagsol were project engineering subcontractors), and it is going to participate in solar energy projects in Morocco and Tunisia (Interview with OCI's Deputy Manager; Cairo, November 2011). El-Sewedy also has the capabilities to manufacture high-quality metallic structures. All these companies have automated production, quality certification and high-tech tools, and according to the World Bank study, could supply CSP plants with support structures (World Bank 2011, 84).

Another raw material widely used for the CSP industry is glass. Of interest for CSP is 'float glass', which, can be transformed into flat mirrors (solar tower or linear Fresnel) and bent into parabolic mirrors (World Bank 2011, 75). As the World Bank study reports, Algeria and Egypt have the only float glass production capabilities in the region.[44] According to Sphinx Glass (Interview with its Marketing Manager; Cairo, October 2011), the production capacities are underutilized, so there is both potential for exports and interest in emerging markets, such as that for CSP. Also, according to the Egyptian Chamber of Building Materials Industries, two float glass production lines were added in 2010 (each with a capacity of 150,000 to 200,000 tonnes), making Egypt a net exporter of this product (Global Investment House 2009).[45]

It is important to note that local companies currently produce glass with a higher content of iron than CSP technology requires ('green glass' as com-

44 The lack of float glass production capabilities in Tunisia, Morocco and Jordan is related to high prices for energy and low local demand for float glass (World Bank 2011, 76). The report claims that demand for float glass is rising in Morocco and Egypt, but opening local production lines without any export markets might not be justified.

45 The main glass companies in Egypt are: Sphinx Glass, Dr. Greiche Glass, Egyptian Glass Company and Saint Gobain.

pared to 'white glass'). While not all countries produce float glass, glass transformation industries (such as mirror producers) are present in all MENA countries (World Bank 2011, 79). Dr. Greiche Glass, a local Egyptian glass company that produces high quality mirrors, has made investments to enable it to enter this market segment, but do not yet produce the quality needed for the CSP industry (Hauptstock 2010).[46] As the World Bank report states, and our interviews with local companies confirm, even if local MENA glass producers are skilled at transforming glass and producing high-tech mirrors, some doubts remain about their capabilities to coat CSP mirrors with the specifications needed for harsh desert conditions (e.g. sand storms) (Interviews with Sphinx Glass and El Sewedy; Cairo, October 2011). The World Bank study explains that manufacturing laminated mirrors (which perform better in the desert) is a highly complex process. Mirror bending to CSP specifications for the parabolic trough technology is also a challenge for local companies, meaning that joint ventures are needed for local companies to learn this manufacturing process, which also requires extensive technical assistance and knowledge transfer (World Bank 2011, 79). But China and India's experience in developing local wind energy industries has shown that there are other effective mechanisms for technology transfer (Lewis 2007).

Yet for the glass industry's investment into upgrading production lines to CSP specifications to be lucrative requires significant annual growth in the local market. The World Bank (2011, 81) calculates that this annual increase should be approximately 400 Megawatt (MW) of solar capacity for flat mirrors and 250 MW for parabolic mirrors. CSP technologies that require float glass (i.e. Fresnel technology) might provide an easier entry point into this market segment for local companies.[47] A representative of Saint Gobain has suggested that thin-film photovoltaic modules, which are more resistant to heat[48], would be suitable products for float glass manufacturing companies (Richard 2011).

46 Hauptstock (2010) states that Dr. Greiche Glass is currently developing its own mirror design: 24 of their original designs for CSP mirrors (the mirror surface amounts to 2.25 m2 with a bending depth of 2 cm) will be used for a testing plant to be built at the Energy Research Centre of Cairo University.

47 However, because the technology is less mature, securing funding for such projects might be even more difficult than for parabolic troughs.

48 Saint-Gobain Solar claims that Egypt could attain more than 80% local content – producing the panels and other auxiliary components, and the civil works– for thin-film photovoltaic technologies (Richard 2011).

Two other CSP components face high entry barriers: the parabolic-trough receiver and the HTF (World Bank 2011; Interviews with Dr. Adel Khalil and Dr. Mohamed Elsobki, Cairo, November 2011). Manufacturing these two components requires high capital costs, and because the technology content is also high, there are significant know-how barriers to producing them locally. Technological knowledge is concentrated in a few market leaders such as Schott Solar, which are not willing to license their technology at this time (Interview with Dr. Adel Khalil; Cairo, November 2011). Several other critical components such as the power block, storage system and steam generator/heat exchanger are also imported (World Bank 2011; Discussion with EPC contractor at the Kuraymat plant; Cairo, November 2011). Nevertheless, as the experience of the CSP industry in Spain and the USA shows, if the market is large enough and predictable, foreign companies are willing to set up manufacturing facilities close to the market; this could represent a first step towards know-how transfer.

As discussed by the World Bank (2011, 85), piping and insulation systems are not unique to CSP plants. In Egypt, several local companies seem to have the know-how for providing these components for a CSP plant: El Nasr Steel (one of the largest manufacturers and exporters of steel pipes in the Middle East), Alkamac and United Company for Manufacture Metal Pipes (World Bank 2011).

To sum up, local companies could initially engage in assembling steel structures, metallurgical processes (i.e. anti-corrosive dip galvanizing), supplying some electronic components and cables (from large local companies such as El Sewedy), piping and insulation, EPC activities and at a later date mirror production. However, large investments in the production of CSP collectors can only be justified by a large local/regional market (Interview with Sphinx Glass; Cairo, October 2011), which would allow foreign companies to set up operations in Egypt. The involvement of a local EPC contractor – such as OCI to partner with a foreign investor – is key to facilitating local companies' entry into the CSP value chain.

CSP is an immature technology that requires technological adaptation to the MENA environmental conditions to address issues related to dust, high temperatures, scarce water (needed for cooling) and storage. Therefore, potential niche markets exist for Egypt and other MENA countries – in terms of technological catch-up and developing competitive advantage. Yet in these areas, there are no local R&D activities to overcome technological barriers (i.e. with respect to acquiring knowledge to develop more technology-intensive CSP components and adapting technology to local conditions). Technology transfer is therefore critical for expanding the manufacture of products and services with higher technological content. The absorptive capacity of the emerging industry must also be strengthened through capability building efforts (education and training) as well as through supply chain development programs for raising quality and securing supply, and product-certification activities. Collaborations of universities (or research organizations) and the private sector are rare in Egypt. However, OCI –the EPC and O&M contractor for the Kuraymat CSP plant – is currently working with Helwan University, in collaboration with an Italian company, to develop a pilot plant for desalination using CSP technology. Other companies, such as Sphinx Glass and Saint Gobain, have their design and R&D facilities abroad, with no plans to develop R&D programs with local partners (Interview with Sphinx Glass; Cairo, October 2011).

In the Kuraymat plant, about 40 percent of the value of the solar field was generated locally. It is expected that in future projects this share could rise to 60 percent (NREA 2011). Civil works, steel mounting structures (Egyptian subcontractors delivered the prefabricated welded steel parts, which were assembled on site by OCI), electrical cables, grid connection, the EPC responsibility (strongly supported by Fichtner Solar and Flagsol, which resulted in significant knowledge transfer) and O&M, were all done by the local industry, that is, by OCI. Localizing these activities resulted in significant cost reductions.[49] OCI, one of the largest private players in Egypt, belongs to the Sawiris family of industrialists, who own the Oras-com Group.[50] OCI, with a turnover of USD 4.5 billion, USD 500 million worth

49 According to the World Bank (2011, 67–68), aside from the vacuum receiver and the collector manufacturing of the collector, the most costly parts of the CSP value chain are the solar-field installation of the solar field and its maintenance (especially the replacement of mirrors, receivers, and the water for washing the mirrors) are the most costly parts of the CSP value chain.

50 The Orascom Group of companies owned by the Sawiris family includes: Orascom Telecom, Orascom Development and Orascom Construction Industries (OCI).

of equipment, and more than 88,000 employees (56,000 employees in construction alone) is the largest construction company in the MENA region.[51] OCI is active in both infrastructure and investment projects across the MENA region and abroad.

OCI bid for the Kuraymat CSP plant against four other contractors. But because OCI was able to mobilize a higher share of the supply chain for deployment (due to their extensive experience with local subcontractors), their tender was more competitive (Interview with OCI; Cairo, November 2011). NSF, an Orascom subsidiary, was one of the main subcontractors hired for the CSP plant. Flagsol GmbH,[52] a joint venture between Solar Millennium AG and Ferrostaal AG in Germany, provided the technology for the plant design, steel fabrication for the parabolic trough and technical advice regarding assembly.

As a local EPC contractor, OCI ensured the extensive involvement of local subcontractors, although not in the most technology intensive parts of the value chain. This collaboration model could be replicated in other projects in Egypt and the larger region (Interview with OCI; Cairo, November 2011). For example, OCI (again collaborating with Flagsol) has pre-qualified to perform EPC activities for the 125 MW CSP plant in Morocco and for a 50 MW CSP plant in Jordan (OCI interview). As Table 3-4 illustrates, local potential is highest in EPC activities, while significant investment is needed to expand local capabilities for manufacturing CSP parts and components.

---

51 OCI operates under three separate brands: Orascom Construction contracts for large industrial and infrastructure projects, mainly in MENA; the BESIX Group (a Belgian company in which OCI has 50 percent equity) undertakes major commercial, industrial and infrastructure projects throughout Europe, northern and central Africa and the Middle East; and Contrack International (an American company acquired by OCI) pursues institutional projects in the Middle East and Central Asia.

52 Flagsol GmbH offers expertise throughout the entire value chain of large-scale solar thermal power plants with a power output of 50 to 250 MW – from project development and financing to the turnkey construction as a general contractor (see: www.flagsol.com).

Table 3–4: Capabilities for CSP system manufacturing in Egypt

Value chain stage		Local production and project execution capabilities		
		Existing	Developing	Not currently present
Materials	Concrete, steel, cement, sand, glass, silver, copper, salt and other chemicals	Local companies such as Al-Ezz Dekheila Steel Co., and Sphinx Glass		
Component design and manufacturing	Mirrors		Several glass and mirrors local manufacturers	
	Mounting structures	Companies such as NSF and El-Sewedi		
	Receiver			
	HTF			
	Connection piping and insulation	Companies such as Alkamac and El Nasr Steel		
	Steam generator/heat exchanger			
	Storage system			
	Power block		NSF	
CSP manufacturing	CSP collectors		Dr. Greiche Glass has invested in developing CSP collectors.	

Table 3–4 (cont.): Capabilities for CSP system manufacturing in Egypt

Value chain stage		Local production and project execution capabilities		
		Existing	**Developing**	**Not currently present**
CSP manufac-turing (cont.)	Plant assembly	OCI and other subcontractors		
Project design	Research			
	Design and concept engi-neering			
	Procurement		OCI	
Pre-deployment	Site assess-ment			
	Determination of general requirements			
	Finance			
De-ployment	Site construc-tion	OCI		
	Transport and distribution of electricity		Egyptian Electricity Transmissi-on Company	
Post-de-ployment	Operation and maintenance (O&M), output moni-toring and sales		OCI with know-how transfer from inter-national partners	

Source: Based on literature and field interviews in Cairo in 2011

3.1.2.2 Job profiles for the emerging local market

Analyses of job profiles for the CSP sector are not as widely available as those for wind energy and solar-PV technologies. However, there appears to be great similarity in terms of the skills needed for the solar sector in general (Gereffi / Dubay 2008). CSP's job-growth potential is in both component manufacturing and plant assembly. The National Renewable Energy Laboratory (NREL) estimates that every 100 MW of installed CSP creates approximately 455 construction jobs (Soddard et al. 2006 in Gereffi / Dubay 2008). As Gereffi and Dubay (2008) argue, during a power plant's operational phase, permanent jobs are created in areas such as administration, operation, maintenance, service contracting, maintenance, spare parts and equipment, and solar-field parts replenishment. The NREL calculates that CSP parts generate some 94 operation and management jobs per 100 MW, whereas conventional coal and natural gas plants the same size generate between 10 and 60 permanent jobs, and CSP costs for operation and maintenance are 30 percent lower (Gereffi / Dubay 2008).

Most jobs in the solar industry require specialized training – just as in the wind sector. The US Bureau for Labor Statistics reports that most solar-related jobs require specialized higher education degrees (Hamilton 2011). Engineers (in materials science, chemistry, electrical engineering, mechanical engineering and industrial engineering) are the most sought-after professions in the solar sector. For industrial production managers, college degrees in business administration, management, industrial technology or engineering are needed (Hamilton 2011). Our interviews in Egypt suggest that these knowledge domains are not well supported in the Egyptian education system, where university and vocational school curricula focus on theoretical knowledge rather than on practical applications for renewable-energy technologies (Interviews at Ain Shams University, Cairo University, El-Sewedi, German Technology Solar Systems; Cairo, October-November 2011).

Just as for the wind-energy industry, in Egypt, local skills relating to CSP project development and implementation (project execution capabilities of environmental scientists, atmospheric scientists and consultants) are also underdeveloped. Some related services (such as procuring land and obtaining permits) are currently carried out by the NREA, which will need a larger set of actors as the market expands. It is critical to have local companies provide services for project execution because it is necessary to work with government agencies, community members and organizations, utility companies and other stakeholders.

Given Egypt's well-developed construction sector, the skills necessary for rolling out a CSP plant are considered adequate (Interview with OCI; Cairo, November 2011). Nevertheless, for O&M activities, significant knowledge transfer, on-the-job training and experience are essential. Power plant operators must attend specialized training programs and undergo extensive training about their specific systems (Interview with OCI; Cairo, November 2011). In Egypt, such training courses are limited, so local project developers rely on foreign technology providers to acquire such knowledge.[53]

To summarize, analysis of Egypt's CSP value chain shows that compared with wind energy, it currently displays a lower capacity for localization. CSP technology is less mature (hence more expensive) and more knowledge intensive (in manufacturing and EPC). Nevertheless, for some components and services there is potential to add value locally, and concerted efforts could expand local companies' participation along the supply chain. After know-how was transferred from international players (Fichtner Solar and Flagsol), the Egyptian construction company OCI was able to perform EPC and O&M activities for the CSP local plant in Kuraymat. Egypt currently has manufacturing experience in industries such as glass and mirrors, steel structures and certain electric components (especially cables) that could supply the CSP sector. Nevertheless, significant investments and technology transfer are needed to enable these industries to develop the technical specifications required for the more specialized CSP components (e.g. receivers and the curved/bent mirrors needed for parabolic troughs). It is unlikely that to begin with, local content for the CSP industry could be more than EPC and O&M activities on the deployment side, and supply of steel structures and cables on the manufacturing side.

At this time, Egypt's commitment to local market creation is limited, as reflected by the small share of CSP in the renewable energy target for 2020. A national renewable energy strategy with greater emphasis on solar technologies would send positive signals to potential investors. As discussed in the next section, while it is difficult to enter a market already dominated by

---

53 The German training organization, RENAC – Renewables Academy, which conducts training programs abroad on various aspects of renewable energy, has developed a course on "Grid Integration of Renewables in Egypt". This program, funded by the German Ministry for Economic Cooperation and Development (BMZ), focuses on capacity building at the managerial and engineering/technical levels for integrating large amounts of renewable electricity into the Egyptian energy grid (Source: http://www.renac.de/projekte/egypt-re-grid/, accessed on 31 October 2012).

a few large players, Egypt might be able to develop niche markets by adapting existing technologies to local environmental conditions (i.e. the need for dry-cooling because of water scarcity; using different technologies, such as sand, for energy storage; more effective cleaning techniques because of the large amount of dust).

3.2 Innovation capabilities

Innovation capabilities, as defined earlier (see Table 3-1), refer to "the skills necessary to create new products or processes, the type of skills depending on the novelty of the new technology", including activities ranging from pure science to advanced development.[54] In developing countries, however, context innovation is defined more broadly to refer not only to 'new-to-the-world' technologies, but also to the technological adaptation of mature technologies (products and services) to local environmental conditions, as well as indigenous innovations (Lundvall et al. 2009; OECD 2010).[55]

This aspect is particularly important when assessing entry points for wind power and CSP in Egypt and other developing countries. The leaders in renewable energy technology are concentrated primarily in Europe (Germany and Spain) and the USA. But environmental conditions in these countries are very different from those in the MENA region, which otherwise offers some of the greatest potential for solar and wind energy generation. This is especially true for solar technologies because the high heat, dust and sand of the desert environment reduce their efficiency (Mani and Pillai 2010; Sulaiman et al. 2011). Moreover, the region's problematic water energy nexus calls for solar technologies that are less water intensive (i.e. that use dry-cooling) (Dersch / Richter 2007; Carter / Campbell 2009).[56] Therefore, technology adaptation and incremental innovation for specific Egyptian conditions could offer Egypt entry points in the renewable energy sector (Popp 2011).

54 Lester (2005, 6) also defines *"capabilities for innovation"* as the *"ability to conceive, develop, and/or produce new products and services, to deploy new production processes, and to improve on those that already exist"*.

55 Lanjouw / Mody (1996) find that most environmental patents in developing countries have been submitted for incremental innovations that aim to adapt technologies that were developed elsewhere for their local environment.

56 Carter and Campbell (2009) argue that a CSP plant with conventional wet-cooling systems uses two to three times more water than coal-fired power plants. For arid regions, such as deserts, such technologies would be highly unsustainable in the long run.

Innovation capabilities are also crucial to enabling developing countries' pursuit of 'energy leap-frogging' (Goldemberg 1998)[57] – shifting from an energy development path that relies on conventional fuels to a new path that incorporates the broad utilization of energy technologies (Lewis 2007). To this end, enhancing innovation capabilities is key – both for building-up know-how to support local industrial development, and for enabling emerging economies to move up the technological ladder and cultivate their competitive advantages in renewable energy.

Local learning and adaptation to maximize the benefits of technology transfer (i.e. absorbing foreign know-how) and R&D investments are critical aspects of this process (Amsden 2001, 51). Archibuchi / Pietrobelli (2003) argue that importing technology without also adopting policies to support technology cooperation strategies, does not much benefit local learning. This concern has become evident in newly industrialized countries such as China and India, where *"indigenous competences in science and technology fields related to green technologies are increasingly a prerequisite for the successful absorption of green technologies"* (Walz / Delgado 2012). Moreover, Lema / Lema (2012) argue that for emerging economies such as China and India, "conventional" technology transfer mechanisms (in the form of licensing and foreign direct investment becomes less relevant; instead, "unconventional", more active mechanisms, such as foreign firms acquisition and overseas collaborative R&D, are more likely to support the process of catching-up.

The recently observed change in the way innovation is organized in developed countries, "the organisational decomposition of innovation and global distribution of innovation activities"[58] (Schmitz / Strambach 2009), could facilitate the acquisition of technological capabilities and enable developing

57 Goldemberg (1998) defines 'leap-frogging' as the process by which developing countries avoid the steps taken by industrialized countries through incorporating models and efficient technologies early in the development process.

58 Schmitz / Strambach (2009, 232) list the following factors that explain the emerging shift in the global distribution of innovation activities: the return migration of engineers, scientists and managers; big state and private investment in higher education; low wages for highly educated workers (compared with OECD countries); the insertion of local firms in global value chains; the colocation (clustering) of local firms and support institutions in the developing world; the increasing significance of lead markets in Asia and Latin America; governments "trading market access for technology"; the willingness of governments and foreign enterprises to experiment with collaborative arrangements; and the enormous financial resources that government agencies and enterprises can mobilize to buy technology or research teams.

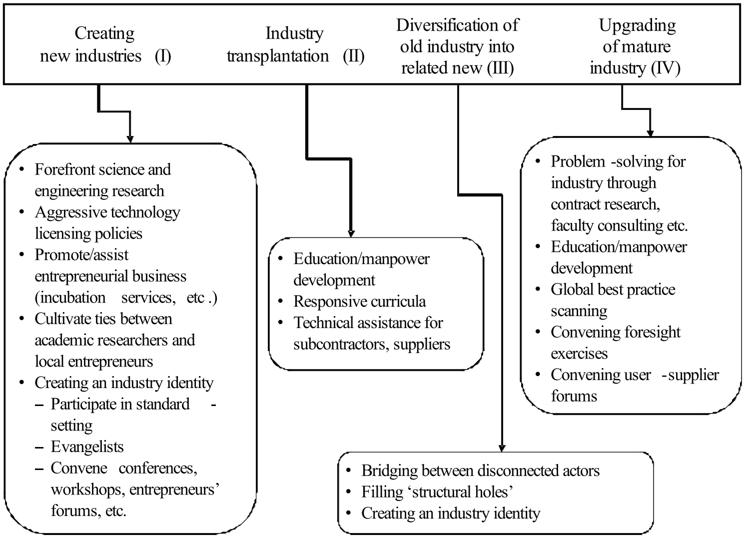
countries to participate in innovation. Specifically, *"innovation activities that used to be carried out in-house by innovating firms themselves are carried out by independent suppliers of knowledge-intensive business services or are transferred to key suppliers"* (Schmitz / Strambach 2009). In principle, organizational fragmentation facilitates the geographical dispersal of innovation activities to other parts of the globe, which means that countries like Egypt could capitalize on such opportunities. But most likely, the extent to which Egypt and other developing countries will be able to build on these possibilities will depend on these countries' absorptive capacity in specific sectors, as well as on the amount of time needed to expand this capacity.

Because the absorption of advanced technologies and the development of competences for further innovation in order to bring them to international markets are closely interwoven (Nelson 2007), it is necessary to have an innovation system that can enhance these capabilities. In advanced economies, universities and research organizations (i.e. national research laboratories) are basic to the innovation system that drives the process of acquiring technological capabilities through close interaction with other stakeholders (i.e. the private sector and government) (Mowery 2004; Lester 2005). But equally important, especially for the catching-up process, is the development of capabilities for learning and innovation within firms (rather than public R&D) (Nelson 2011). However, in most sectors in less developed countries, building basic capabilities, underpinned by education and public R&D, remains a priority (Lema / Lema 2012).

The role of public research institutions (i. e. universities and national laboratories) in the industrial transformation process varies significantly depending on the initial conditions and the growth pathway to be pursued. Lester (2005, 29) refers to four "innovation-led growth pathways": creating new industries, industry transplantation, diversifying an old industry into a related new industry, and upgrading a mature industry (see Figure 3–3). According to this assessment, when a new industry is created (or transplanted from elsewhere), as in Egypt's solar and wind energy industries, universities are involved in more than teaching: they conduct pioneering science and engineering research; pursue aggressive technology licensing policies; promote/assist entrepreneurial businesses (with incubation services, etc.); cultivate ties between academic researchers and local entrepreneurs; and create an industry identity through participating in standards setting and convening conferences, workshops, entrepreneurs' forums, etc. (Lester 2005). Needless to say, such involvement requires a basic change in academic culture (towards more transparency and collaboration with research institutes, the private sector and the government, as well as a greater focus on entrepreneurship), which must be guided by strong vision and a strategic roadmap. In Egypt, however, there is no vision for supporting the development of innovation capabilities in line with efforts to create a local renewable energy industry.

In the next sections we discuss both sides of the process of acquiring innovation capabilities – the supply side (education and research activities) and the demand side (the potential for identifying niche markets for innovation). First, we provide a brief overview of Egypt's main educational and research programs that aim to enhance the renewable-energy knowledge base and innovation capabilities. We then give a preliminary discussion of the opportunities for acquiring innovation capabilities offered by the global distribution of innovation activities and the organizational decom-position of innovation. We also highlight the most important challenges to acquiring innovation capabilities and suggest areas for improvement. We focus on some

Figure 3–3: University roles in alternative regional innovation-led growth pathways



Source: Lester (2005)

core issues in this section but further investigation is needed with respect to the education and research environment in Egypt. A more in-depth assessment would allow for more nuanced policy recommendations.

3.2.1 Renewable energy education and research

While several universities offer engineering education in Egypt, the focus tends to be theoretical, with limited emphasis on R&D and applied knowledge (Interviews at Ain Shams University, Cairo University, German Technology Solar Systems, SWEG, Fraunhofer Institute Cairo; Cairo, November 2011). Education and research activities on sustainability and renewable-energy technologies are also inadequate (Interviews at Cairo University and Ain Shams University; Cairo, November 2011), although efforts are beginning in this direction. Small research programs on renewable-energy technologies, in particular solar energy, are concentrated at a few universities such as Ain Shams University, Cairo University, Helwan University and Alexandria University. Funding for research programs primarily comes from the Egyptian Science and Technology Development Fund (STDF) and from European Union (EU) research programs. The main drawback of these funding programs is that they are short-term and often have no follow-up in collaborative projects, either national or international (Interviews at Ain-Shams University; Research, Development and Innovation Program at MHESR, Cairo, November 2011).

In addition, as the Assistant Minister for Scientific Research at MHESR mentioned in a strategy meeting attended in November 2011,[59] because of a lack of clarity regarding the research areas that are most relevant to renewables (a relatively new domain of knowledge in Egypt), concerns exist about possible replication or redundancy in the research efforts that could result in bigger gaps in other areas. Such a concern has also been associated with the lack of coordination between research centres and institutes on one hand, and the private sector on the other (Kheir-El-Din 2005). To ameliorate this situation, a research agenda (consisting of a technology and R&D roadmap) needs to be closely coordinated with an industrial- and market-development strategy for the renewable energy sector (solar and wind). Such a roadmap would identify which technologies (CSP, solar PV and wind power) are best suited to Egypt's existing and potential technological capabilities and its industrial structure,

59 The meeting, meant to initiate discussion about drawing up a technology and R&D roadmap for renewable energy in Egypt, benefited from the participation of several stakeholders: DLR, Cairo University, REMENA, DESERTEC University Network, Helwan University, Fraunhofer ISE in Germany, and Fraunhofer Institute Cairo.

and how to target support programs for R&D and knowledge creation in these areas.

Not only does Egypt have no national strategy for renewable energy technology, but also most universities have no coherent educational program geared towards renewables and sustainable development. Ain Shams University is currently setting up a three-year Masters program on Sustainable Energy and Engineering (Interviews with faculty for Mechanical Engineering, Chemical Engineering and Electrical Engineering; Cairo, November 2011). With support from the Egyptian Government and the German Academic Exchange Program (DAAD), and in collaboration with Kassel University in Germany, Cairo University offers a joint Masters program on Renewable Energy and Energy Efficiency for the Middle East and North Africa region (REMENA) that aims to provide technical and managerial knowledge in the field of renewable energy and energy efficiency to students from Germany and the MENA countries. This program laid the foundation for integrating specific training modules on CSP (and other renewable energy technologies) into the curriculum.[60] While the program now focuses on general knowledge regarding some aspects of renewable energy such as technology and policy, R&D and the political economy of renewable energy development are not emphasized. Given the slow development of Egypt's market, it also remains to be seen if REMENA graduates will find employment in the emerging local job market for renewable energy.[61] Cairo University's Energy Research Centre (ERC), which features the greatest expertise on renewable energy technologies in Egypt, also offers training modules on various aspects of renewable energy and acts as a consulting agency for different stakeholders, including the private sector. Helwan University, too, has developed research activities in the field of renewable energy, mostly coordinated by Prof. Dr. Amr Amin, who has participated in several EU funding competitions.

60 Other international university collaborations, although not focused on energy issues, include the Technical University Berlin that is opening a campus in El Gouna (sponsored by the Sawiris family, owners of Egypt's largest family-owned business, Oras-com), the German University in Cairo and the Egypt–Japan University of Science and Technology.

61 Because of the sluggish market for renewables in Egypt, recent graduates from the program are now seeking employment in Germany (Interview with Dr. Adel Khalil, the REMENA program director from Cairo University; Cairo, November 2011). Another cause for concern is the lack of German applicants for their second batch of students, which could be due to the limited market and political instability in the MENA region. This could negatively impact the REMENA program's planned cross-regional exchange (Interview with Dr. Adel Khalil, the REMENA program director from Cairo University; Cairo, November 2011).

By funding development cooperation, international players have also initiated several capacity building efforts. The German Aerospace Centre (DLR) leads the efforts related to CSP energy technologies and has developed the enerMENA program (see Box 3-4) to support knowledge

Box 3–4:	**enerMENA – A program for the implementation of solar-thermal-power-plant technology in North Africa**

The enerMENA program, funded by the German Foreign Ministry, was initiated and is run by the Institute of Solar Research at the German Aerospace Centre (DLR), a pioneer in shaping the DESERTEC concept. The project aims to develop CSP-related training materials, and addresses institutions and key persons from R&D, educational institutions and the public and private sectors who are active in CSP technology development in the MENA region. The project has three targets: the analysis and optimization of CSP plants; the dissemination of CSP technology; and the multiplication of local know-how.

Analysis and optimization of CSP plants

In addition to enerMENA, DLR also conducts on-site measurements during the construction of solar thermal power plants in North Africa to train local personnel to evaluate the quality of manufactured collectors, and also to provide valuable data to improve the quality of the collector field.

Dissemination of CSP technology

In order to support the development of a market for CSP technology in North Africa in general, and also to initiate or foster local industry participation in this technology, enerMENA will encourage local institutions – backed by DLR experts who will provide training and qualification – to serve as contact points for project development. A network of eight meteorological stations will also be established in North Africa.

Multiplication of know-how

The enerMENA project offers educational material on CSP technology to universities, training centres and high schools in the local language. Professors and teachers take part in workshops held to analyse the material and adapt it to their needs.

Partners in the MENA region include: the Moroccan Agency for Solar Energy, the National Office of Electricity (Morocco), Ecopark Borj-Cedria (Tunisia), CRTEn Technopole de Borj Cedria (Tunisia), the National Energy Research Centre (Jordan), the Energy Centre at the University of Jordan, University of Jordan, NEAL–New Energy (Algeria) and Cairo University (Egypt).

Source: DLR, http://www.dlr.de/sf/desktopdefault.aspx/tabid-235/12081_read-28723/ (accessed on January 20, 2012) development through MENA university channels. These training/educational modules have been approved and implemented in Morocco, Algeria and Tunisia, but in Egypt, the approval process has been stalled in the MHESR for about a year (Interview with Dr. Adel Khalil; Cairo, November 2011)

Developing and disseminating such programs could help reduce gaps in the specialized skills and knowledge that are very important for emerging technologies such as CSP. There is a critical lack of engineering education (in materials science, environmental engineering, mechanical engineering and chemical engineering) that focuses on solar and wind energy and adapting the specifications to the harsh desert conditions (water desalination, cleaning techniques, solar water pumps, etc.). Promoting adaptive R&D and supporting technology transfer could be especially valuable for developing countries as new markets emerge for renewable technologies (Popp 2011).

Equally important are the non-engineering disciplines that have been heavily neglected – locally and in international collaborations – as several interviewees confirmed (Interviews with InWent Egypt, DAAD Cairo, Cairo University; Cairo, November 2011). In 1979, Germany's Federal Ministry for Education and Research (BMBF) and the MHESR signed a long-term agreement on Bilateral Cooperation in Science, Research and Technology, which led to the establishment of the German Egyptian Research Fund.[62] In 2007, a new bilateral initiative was begun, the German-Egyptian Year of Science and Technology, that is intended to stimulate cooperation in six main areas: materials science, water, renewable energy sources, biotechnology, health research, and social sciences and humanities.[63] Primary emphasis is on the engineering and technical fields (Interview with DAAD Cairo; Cairo, November 2011).[64]

---

62 The areas of collaboration are: materials, environmental and climate research, physical and chemical technologies, biotechnology, aquaculture and health research. (Source: http://www.bmbf.de/en/5859.php, accessed on 22 February 2012)

63 Source: http://www.bmbf.de/en/5859.php, accessed on 22 February 2012

64 Recognizing this gap, the 2012 German Egyptian Research Fund call for proposals focuses on promoting bilateral cooperation in the social sciences and humanities to support the process of democratic transformation and socio-economic development in Egypt. (Source: http://www.stdf.org.eg/files/ENG-GERF-CALL-HUMANITIES_IB_STDF_BMBF_final_Version_12%2012%202011.pdf – accessed on 22 February 2012)

Social sciences (e. g. business management, economics and law) are equally important for Egypt to be able to expand the local benefits of investments in renewable energy. Innovation – in the form of new business models and policy mechanisms – is needed to adapt project development models to the local institutional environment. To fill this gap and support capacity building for the proposed renewable energy mega-projects (i.e. DESERTEC and MSP), the DESERTEC Foundation has proposed two programs: the DESERTEC University Network (DUN) and the DESERTEC Institute for Studies on Socio-Economic Development and Employment in MENA (DISEM) (see Boxes 3–5 and 3–6). Although not yet fully developed (especially DISEM), these programs are meant to create a platform for cross-Mediterranean regional collaboration in education and research in the field of renewable energy policy and technology.

Box 3–5: The DESERTEC University Network (DUN)

The DESERTEC Foundation, in cooperation with the Tunisian National Advisory Council for Scientific Research and Technology, founded DUN as a platform for scientific cooperation around issues related to DESERTEC. Besides the non-profit DESERTEC Foundation, founding members include 18 universities and research facilities from MENA. Additional European institutes complement the network and promote the transfer of knowledge.

DUN's objectives:

- International collaborations between public and private academic and scientific institutions aimed at helping to implement the DESERTEC concept
- Education of skilled professionals, particularly in desert countries (soon to be among the world's biggest producers of renewable energy), as a way of helping to maximize those countries' share of the value creation
- Research and education to continually improve the production, installation and operation of future DESERTEC energy systems

DUN's scope:

- Electricity-generation technologies (particularly solar and wind) and research about new technologies with economic and environmental benefits
- Technologies for transmitting electricity over medium and long distances, and smart grids
- Socioeconomic impacts of the large-scale generation of electricity from renewable energy
- Renewable energy for water desalination and water treatment

DUN's activities: – Networking with regional and international organizations – Bringing together professionals from industry, science and politics in workshops and conferences – Advising governments and organizations on the DESERTEC Concept and its implementation
Source: http://www.dunet.org, accessed on 11 February, 2012

Box 3–6: The DESERTEC Institute for Studies on Socio-Economic Development and Employment in MENA (DISEM)
In 2011, Dr. Gerhard Knies, one of the brains behind the DESERTEC concept, proposed the creation of a study centre to produce knowledge on technology and concepts of sustainable development. Employment and industrial development are critical to the development of civil societies in the rapidly growing and transforming MENA region. In the vision of its founders, the DESERTEC concept can transform the production of water, food and energy from these countries' deserts into sources of employment and socioeconomic development. The proposed DISEM, that is intended to benefit the MENA region, should be sufficiently independent to develop concepts and formulate advice for civil societies, governments and the private sector with open-minds and scientifically. DISEM should communicate with existing regional governmental organizations like MSP and RCREEE, while remaining fully independent. Although it is still in the conceptual phase, DISEM could become the basis of a Centre of Excellence for knowledge on sustainable societal development in the Mediterranean. The DESERTEC Foundation is working closely with DUN to develop the Institute. To select DISEM's focus areas, a 'task force' has been appointed, with members from development-oriented research institutes in Germany and MENA, such as the DIE, the SWP, Wuppertal Institute, Jordan University of Science and Technology and Alexandria University.
Source: Knies (2011)

Aside from universities, it is also crucial to have research institutes and centres of excellence that can 'translate' basic/theoretical knowledge into applied and commercialized results, or focus on enhancing the socioeconomic benefits from renewable energy. Examples of such organizations that have made major contributions to the development of renewable energy technology and policy are the Fraunhofer Institutes in Germany and the National Renewable Energy Laboratory (NREL) in the US. These research institutes are located at the intersection between academia and the private sector, with researchers who move easily between these three spheres, can understand their individual demands and communicate them to policy-makers (see Boxes 3–7 and 3–8).

Box 3–7: The Fraunhofer Institutes

The Fraunhofer Society (Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V. – "Fraunhofer Society for the advancement of applied research"), Europe's largest application-oriented research organization, operates more than 80 institutes across Germany and around the world, each of which focuses on a different field of applied science. Most of its 18,000 staff members are qualified scientists and engineers. Roughly 60 percent of the Fraunhofer budgets are generated through contractual research with industry and publicly-financed sources, and the rest is institutional funding from the German state governments (Abramson 1997). As a consequence, the Fraunhofer-Gesellschaft operates in dynamic equilibrium between application-oriented fundamental research and innovative development projects.

The Fraunhofer-Gesellschaft develops products and processes right up to commercial maturity. Individual solutions are sought in direct contact with the customer. The Fraunhofer-Gesellschaft seeks to transform scientific expertise into practical applications, developing solutions of direct practical value to technical and organizational problems and contributing to the wide-scale implementation of new technologies. The Fraunhofer-Gesellschaft offers an important source of innovative know-how for small and medium-sized companies that do not maintain their own R&D departments. Research activity undertaken by the Fraunhofer-Gesellschaft encompasses far more than just fulfilling contractual obligations: basic and project-related funding by the German Federal Ministry of Education and Research enables the Fraunhofer-Gesellschaft to conduct non-contract advanced research into technological fields with great promise for the future, paving the way for entering new markets.

A key feature of the Fraunhofer-Gesellschaft is its role in stimulating entrepreneurship. At present, about 400 spin-offs have been created that have registered thousands of patents from their research results. Technology transfer at the institutes also occurs through graduate students' on-the-job training (Abramson 1997).

The Fraunhofer-Gesellschaft acts as an umbrella institution that links research institutes with each other as well as with the private sector, and supports technology transfer as a core element of its innovation system. The main principles behind the success of the Fraunhofer model in Germany are: the focus on national economic strengths, the networking of its institutes, excellent reputation and name recognition, commercial focus and autonomy (Reid et al. 2010) and

especially, its positioning between basic and applied research. A final attribute is the proximity to universities that is institutionalized through Fraunhofer directors' appointments as university professors (Abramson 1997).
Source: http://www.fraunhofer.de/ (accessed on 12 February 2012)

Box 3-8: The National Renewable Energy Laboratory (NREL)
U.S.-based national research also supports close collaboration between research and business organizations. The federal research laboratories that operate in various technical areas are the channels for organizing such research activities. The National Renewable Energy Laboratory (NREL) is the only national laboratory (government-owned, contractor-operated) that is solely dedicated to advancing renewable energy and energy efficiency technologies from concept to commercial application. The NREL's collaboration with industry and other organizations is governed by various partnership mechanisms that facilitate commercialization and technology transfer, such as cooperative and research and development agreements.
Source: http://www.nrel.gov/; http://en.wikipedia.org/wiki/National_Renewable_Energy_Laboratory (accessed on 12 February 2012)

In Egypt, as in most developing countries, there are no institutes like these outlined above.[65] While several initiatives do exist for supporting scientific research, technology development and innovation,[66] their effectiveness is questionable in light of the low level of R&D in the country.[67] Nevertheless, despite the political upheaval and economic hardships brought about by the Arab Spring, scientific research in Egypt increased by 35 percent in 2011,

65 Several research institutes have been established that are affiliated with the Ministry of Higher Education and Scientific Research (Source: http://www.uis.unesco.org/ StatisticalCapacityBuilding/Workshop%20Documents/ST%20Workshop%20dox/Mombasa%202009/Egypt-Policy%20of%20Scientific%20Research%20and%20Technology.pdf (accessed on 31 January 2012). However, as our interviews with different stakeholders in Egypt suggest, these institutes play only limited roles in advancing knowledge about clean energy (Interview with Dr. Adel Khalil; Cairo, November 2011).

66 One such initiative was the 2007 establishment of the Higher Council for Science and Technology (HCST), along with a Science and Technology Development Fund (STDF), which coordinates programs for the scientific community, mainly through the Academy of Scientific Research and Technology (ASRT) (Source: http://news.egypt.com/en/20070724298/news/-science-nature/future-of-the-science-and-technology-in-egypt.html – accessed on 31 January 2012)

67 In 2007, Egypt spent only 0.23 percent of GDP on R&D while Germany spent about 2.5 percent of GDP on R&D (Source: The World Bank, World Development Indicators; http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS (accessed on 31 January 2012)

as part of the MHESR goal of reaching a 1 percent of GDP spending on science (Badr 2012).

The National Research Centre (NRC) is the main research organization (a centre of excellence) for various fields. But it appears that at least in the field of renewable energy, the private sector has not yet benefited much from collaborations with the NRC (Interviews with representatives of MEET, SWEG, OCI and Sphinx Glass; Cairo, October–November 2011). According to the interviewees, despite the high level of expertise among NRC researchers, their focus is more theoretical than applied, which is why most local companies do not find much value in forging collaborations with the institution.[68] As Khein-El-Din (2005) argues, since most research institutes and academic organizations set their research agendas without consultation with "prospective users of their output", the return on scientific research is low – as is investor and business confidence regarding the necessity and relevance of research.[69] For example, while the Fraunhofer-Gesellschaft is interested in developing research activities on renewable energy in Egypt, few companies in Egypt have expressed interest in collaborating, mostly because of a lack of a *"collaborative research culture"* (Interview with Fraunhofer Cairo, October 2011). Pilot projects in the private sector – as well as in the academic and research community – could help raise awareness and demonstrate the benefits of such an approach to research and innovation.

Previous efforts towards achieving closer collaboration between research institutes and the private sector were initiated through the CMRDI (discussed in section 2.1), which has acted as a national research laboratory in the field of metal casting. Assessing how this initiative could be applied to the energy sector might produce some insights into how to improve the research environment in Egypt. More recently, the Egyptian Cabinet unanimously approved USD 2 billion for the Zewail City of Science and Technology (the brainchild of Egyptian-born Nobel laureate Ahmed Zewail, pro-

---

68 Another problem that plagues Egypt's emerging scientific sector, especially during this period of political and economic uncertainty, is the great brain drain. In 2011 alone, about 400 researchers left the NRC for other countries, in particular, Qatar and Saudi Arabia (Badr 2012).

69 As the author further argues, this problem does not apply to research institutes and centres directly related to some ministries such as the Agricultural Research Centre and its affiliated institutes, the National Centre for Water Research, the Centre for Housing and Building Research and the Centre for Research and Development of Metals.

fessor at the California Institute of Technology, US). This project is aimed at fostering innovative research, building networks of collaboration with national and international institutions and improving collaborations with the private sector (Almohsen 2011).[70] However, renewable energy has not yet been explicitly integrated into the Zewail project's focus areas. It would be very worthwhile to explore the possibility of also founding a centre of R&D expertise in fields related to solar and wind technology.

So far we have mainly discussed Egypt's education and research environment, which are critical for advancing local knowledge and strengthening the absorptive capacity of know-how. However, developing countries cannot catch up without the transfer of technology across national borders. The experience of China and India in developing local wind energy sectors shows the importance of the spillovers that can result from technology transfer: Suzlon (India) has acquired R&D facilities in Germany and the Netherlands, and Goldwind (China) has sent employees abroad for training; both India and China use licensing agreements with European firms to gain access to technology (Lewis 2007; Popp 2011). Nevertheless, as mentioned earlier, in both cases, it was necessary to have stable and large local markets for these technologies. Egypt could further capitalize on the steps it has already taken to foster international collaborations for acquiring know-how (e.g. OCI with Flagsol, and SWEG with SIAG and MTorres). Strengthening local absorption capabilities (by strategically investing in education and research) should accompany identifying the channels for technology transfer that are suitable to local conditions as defined by the available technological capabilities and industrial development.

3.2.2 The internationalization of innovation activities and orgnizational decomposition of innovation activities: opportunities for Egypt?

The globalization of innovation activities is not a new phenomenon: extensive literature documents the process, especially since the mid-1990s. Yet the topic has gained more prominence with the growing evidence that emerging

70 Zewail City will include a university (starting with a capacity of 1,000 students and aiming to grow to a maximum capacity of 5,000), a graduate research institution, a technology park for students' innovations and an industrial institution to link science with industry (Almohsen 2011).

economies, such as China and India, having become major global producers of products and services, are also making advances in building up innovation capabilities (Altenburg et al. 2008b). Table 3-5 is a taxonomy of global sources of innovation, and the related actors and mechanisms. In China and India, multinational enterprises (MNEs) and large national firms (such as Goldwind and Suzlon) have been crucial for the development of renewable energy sectors (both in terms of production and innovation capabilities).

Further research is needed to assess the conditions necessary for less industrialized developing countries to engage in international innovation activities; this remains uncharted territory. In Egypt, R&D activities, while limited, have been mostly concentrated within a few large national firms, so it would be reasonable to hypothesize that the globalization of innovation activities (in any of the forms presented in Table 3-5) has had limited impact on Egypt. Yet as discussed in previous sections, especially regarding the wind-power sector, a few large companies such as SWEG and OCI have expanded internationally, establishing joint ventures and acquiring foreign firms to facilitate technology transfer for specific innovation projects. As long as the local market is expanding and an integrated strategy for the sector is being pursued, positive developments appear to be underway.

The decomposition of innovation activities observed in developed countries (Schmitz / Strambach (2009), as shown through the decentralization of R&D and the engagement of independent suppliers of knowledge-intensive products and services, is likely to change the geography of innovation by enabling developing countries to participate in innovative activities. Table 3-6 describes different types of organizational decomposition of innovation activities along two main dimensions. (The focus of this study prevents us from discussing these processes in detail.)

Egypt could benefit from the organizational decomposition of innovation and global distribution through several processes, such as branches opened by foreign firms that establish partnerships with local firms, closer collaborations between universities and other research organizations, and the development of a network of local suppliers of related products and services. Pederson (2009) discusses how, in this globally dynamic innovation environment, Vestas, the leading Danish wind turbine manufacturer, has pursued a strategy of internationalizing its technology R&D activities both in emerging economies and developed countries (see Table 3–7). Egypt's current players with capacity to invest in R&D have only recently begun to pursue international cooperation and technology transfer activities, while

Table 3–5: A taxonomy of the globalization of innovation

Categories	Actors	Forms
International exploitation of nationally (domestically) produced innovations	Profit-seeking (national and multinational) firms and individuals	Exports of innovative goods; licences and patents; foreign production of innovative goods internally designed and developed
Global generation of innovations	Multinational enterprises (MNEs)	R&D and innovative activities both in the home and the host countries; Acquisitions of existing R&D laboratories or green-field R&D investment in host countries
Global techno-scientific collaborations	Universities and public research centres	Joint scientific projects; scientific exchanges, sabbatical years; international flows of students
	National and multinational firms	Joint ventures for specific innovative projects; productive agreements with exchange of technical information and/or equipment

Source: Narula / Zanfei (2005)

their R&D activities remain limited. By acquiring MTorres in Spain, SWEG has taken the first steps to engaging in the cross-border, global generation of innovations. However, much remains to be done to expand their innovation capabilities at the firm level and create networks of collaboration with local actors in the arena of research and industry. Similarly, OCI has engaged in joint ventures with key players in service-related activities in the solar and wind sectors, in order to develop manufacturing capabilities. It could be beneficial to open 'Centres of Excellence' or 'Competence Centres' for specific technical aspects in the value chain of renewable energy, in close cooperation with national and international players.

Evidence from emerging countries suggests that while core R&D capabilities have tended to be retained in the MNEs' home countries, countries such

Table 3–6: Types of organizational decomposition of innovation activities

		Intra- and Inter-organizational	
		Internal	External
Connection between innovation and production	Loosely connected	*Type 1* Decentralizing the R&D department; Setting up internal knowledge communities	*Type 3* Commissioning research from universities or other organizations
	Tightly connected	*Type 2* Delegating the development of new products to subsidiaries; Founding internal centres of excellence	*Type 4* Engaging suppliers of products and services in developing new products or processes

Source: Schmitz / Strambach (2009, 234)

Table 3–7: Vesta's technology R&D global operation model

Category	Competence	Sites: Aarhus > 2008	Aarhus > 2009	Aarhus > 2012	Isle of Wight > 2008	Isle of Wight > 2009	Isle of Wight > 2012	Singa-pore > 2008	Singa-pore > 2009	Singa-pore > 2012	Chennai > 2008	Chennai > 2009	Chennai > 2012	US > 2008	US > 2009	US > 2012
Aeromechanical	*Aerodynamics*		▒	▒											▒	■
	Material science		▒	▒				▒	■	■						
	Composites				■	■	■					▒	▒		▒	■
	Advanced loads modeling		■	■								▒	▒			
	Structural design & analysis	▒	■	■	▒	▒	▒				▒	▒	■		▒	■
	Gear and drive train		■	■								▒	▒			
Electrical	*Power electronics*	■	■	■					▒	■			▒		▒	▒
	Electromagnetic design		■	■											▒	▒
	Power control	■	■	■				▒	▒	■			▒			
Control and System Architect	*Technology platforms*															
	Control algorithmus															
Power Plant	*Power systems engineering*	■	■	■					▒	■					▒	▒
	Control systems engineering	■	■	■					▒	■						
	Integrated park control															

■ Center of Excellence
▒ Competence Center

Source: Pederson (2009)

as China and India are moving up the value chain not only by providing R&D services to MNEs, but also by contributing domestically developed core competences (Lema / Lema 2012; Pederson 2009). However, given the large inflow of international financial resources, the potential of the renewable energy sector (both domestically and for energy exports), and the presence of large firms with strong investment capacity, Egypt could begin to nurture its innovation capabilities.

3.2.3 Key challenges for acquiring innovation capabilities and potential solutions

The above analysis can help us to identify several barriers that preclude the acquisition of innovation capabilities. We focus primarily on challenges to expanding the role of educational and research organizations in the renewable energy sector in Egypt. To conclude, we discuss Egypt's options for expanding its innovation capabilities in the new configuration of the organizational decomposition of innovation and global distribution of innovation activities.

First, the absence of an Egyptian national strategy for the renewable-energy industry has prevented the drafting of a technology research road-map to highlight strategic areas for research in the technical and non-technical domains. Second, universities and research organizations are rarely included as stakeholders in national strategic discussions on economic and industrial development, which leads to a mismatch between the graduates' skills and industry needs. Third, collaborations between universities and the private sector are limited. There are several reasons for these shortcomings: the lack of long-term vision of the role that renewables can play in Egypt; limited incentives for academics to engage in commercialization and collaboration with the private sector; the private sector's perception that universities cannot add value to their activities; and a lack of entrepreneurship and industrial liaison programs at universities to support effective networks of collaboration.

The issue of incentives in academia is not unique to Egypt; it is wide-spread in the developing world and is even found in some developed countries. With regard to innovative start-ups from university research programs or collaborations with industrial partners, since it is the number of publications and not patents that are key to promotion, university professors are not specially motivated to engage in research activities of a commercial nature (Interviews with professors at Ain Shams University, Dr. Adel Khalil at Cairo University, German Technology Solar Systems; Cairo, October–November 2012). This is not just a problem for university professors, but also for researchers at public research institutions such as the ASRT, who are also promoted based on their publications track record (Interview with Fraunhofer Cairo; Cairo, October 2011). A second issue is that employment in the educational system has been an important aspect of the social contract: teachers have been the fastest growing occupational group in government employment in Egypt, accounting for more than a third of all government employment (World Bank 2004, 101). Dr. Heba Handoussa, former Director of the Economic Research Forum in Cairo, considers that the third issue concerns the lack of a knowledge platform, as well as researchers' reluctance to share information, and difficulties regarding the dissemination and application of scientific research (Interview with Dr. Handoussa; Cairo, November 2011). Lam (2011) argues that academic commercial engagement could be encouraged by policies not based on financial motivations, but rather on reputation and intrinsic motivations. Creating a culture of academic entrepreneurship that builds on stronger university-industry ties calls for a change in work norms among university scientists.

In the USA, recognition of this problem resulted in the Bayh–Dole Act of 1980, which aimed to transfer the intellectual ownership that resulted from government research funding from governments to universities, who could then license the intellectual property to firms (see Box 3-9). Although various studies dispute the legislation's impact on commercializing academic research, it is acknowledged to have played an important role. Later federal initiatives included the National Science Foundation's Science and Technology Centres and Engineering Research Centres, which allocated government research funding for universities contingent on industry participation (Lester 2005).

However, institutional ownership of intellectual property is not sufficient. The recognition of patent activity in the evaluation and recruitment of faculty, as well as royalty-sharing agreements or equity participation in academic startups, could also provide incentives for researchers.[71] In the Egyptian university system, there is limited mobility of the academic staff between industry and academia, which is important for developing new industries and fostering innovation (Vidican 2009). In particular, work

Box 3–9: The Bayh–Dole Act
The Bayh–Dole Act or Patent and the Trademark Law Amendments Act are pieces of legislation in the United States that deal with intellectual property created as a result of federally-funded research. The Act, supported by two senators, Birch Bayh and Bob Dole, and enacted on 12 December 1980, gave US universities, small businesses and non-profits intellectual property control of their inventions and other intellectual property that resulted from federal funding, for the purpose of further commercialization (http://en.wikipedia.org/wiki/Bayh%E2%80%93Dole_Act –accessed on 12 February 2012). The contracting universities and businesses were thereby allowed to exclusively license the inventions to other parties. Since enactment, more than 5,000 companies have been formed based on university research, leading to technology transfer creating billions of dollars of direct benefits to the US economy every year (http://www.b-d30.org/ – accessed on 12 February 2012). Empirical evidence suggests, however, that the effects of the legislation on the degree of commercialization should be cautiously interpreted, because other factors have also contributed to the level of commercial activities in universities (Mowery et al. 2001; Sampat / Mowery / Ziedonis 2003). In particular, the increased influence of biomedical and pharmaceutical research during the 1970s has often been used to explain subsequent changes in the patenting and R&D behaviour of universities and colleges (Rafferty 2008). Nevertheless, the Bayh–Dole Act's positive impact on increasing entrepreneurship within universities and national research laboratories has been indicated in several studies (Mowery 2004; Link / Siegel / v. Fleet 2011). But as Link et al. (2011) argue, regarding national research laboratories (which would also hold for universities), a key factor in the success of such legislation is the recognition that technology commercialization is a strategic priority, as shown in patterns of resource allocation, the employment of individuals with strong technical and commercial backgrounds, and other related measures.

experience in the private sector is a disincentive for those that seek academic employment (Interview with CMRDI; Cairo, November 2011).

In the literature, university entrepreneurship has been widely recognized as an important contributor to a region's innovation potential (Clark 1998; Etzkowitz 1998). With reference to Germany and the USA, Colatat / Vidi-

71 For example, Tsinghua University in China offers its young researchers prizes for inventions that are commercialized (Cenvantes 2011).

can / Lester (2009) find that research universities (i. e. universities that go beyond their traditional role of teaching to actively pursue a diversified research agenda) have played a critical role in the development of the solar-PV energy sector – by pursuing new knowledge, pushing the technological frontier, setting the research agenda for future research, and fostering strong collaborative networks between academics, the business community and governmental agencies and officials.

Hence, a change of outlook regarding the role of universities in the larger economy could help bring industry and academia closer and enhance local innovation capabilities. Of course, these aspects are not only important for the emerging renewable energy sector, but also for the larger industry. Since renewable energy technology is a relatively new domain of knowledge and industrial activity with a value chain that spans a range of sectors, such changes are likely to result in wide spillover effects. Drawing on the experience of the American University of Cairo's (AUC) Desert Development Centre,[72] Dr. Handoussa argues that universities can better "showcase" their potential for adding value to the industry and society by developing successful demonstration projects that involve various stakeholders and create a living laboratory (Interview with Dr. Heba Handoussa; Cairo, November 2011).

It is important, however, to point that significant research outcomes require at least 10 years of uninterrupted work as well as a critical mass of dedicated researchers and equipment (Marinova / Balaguer 2009; Al-Saleh / Vidican 2011). Support for sustained research is crucial for establishing energy industries (Al-Saleh / Vidican 2011) as well as strong links between research-driven universities and the private sector (Vidican 2009).[73]

72 The Desert Development Centre (DDC) is a non-profit, applied research institution that was established by the American University in Cairo in 1979. Since its inception, the DDC has focused on the ecological, social and economic sustainability of communities in Egypt's arid lands.

73 Quite often, universities need brokers to create windows of opportunities for strategic partnerships with the private sector. For example, the Stanford Photonics Centre was established at Stanford University in order to facilitate communications with the private sector and leverage cross-disciplinary knowledge. More specifically, a former entrepreneur was brought in to identify interesting ideas and research projects, and then link researchers across different departments with potential collaborators from the solar-PV industry (Vidican 2009).

Another aspect concerns the meagre financial incentives for university professors, who are forced to seek additional sources of income and can only focus on the bare minimum of on-campus activities. This has also become evident in interviews with faculty at Ain Shams University: “One can rarely find professors on campus, with the exception of the times when they are teaching” (Interview with faculty at Ain Shams University; Cairo, October 2011). This claim cannot be generalized, yet it does suggest the various challenges and constraints in the academic and research environment. While some studies find that financial incentives matter less than intrinsic motivations (Lam 2011), in developing countries this factor may play a significant role in behavioural changes in academia.

Furthermore, despite the fact that there are some educational and research initiatives for renewables, most are focused on aspects of engineering and not on socioeconomic and political issues. For example, the economics department at the Cairo University is 51 years old but was only accredited in 2011 (Interview with Dr. Heba Handoussa; Cairo, November 2011). The social sciences, and in particular, political sciences, are taught more extensively at the private AUC that is generally attended by the privileged classes (Interview with Dr. Heba Handoussa; Cairo, November 2011). At the AUC, a new initiative, the Egyptian Accelerator Flat6Labs, that focuses on stimulating start-ups in various sectors, is likely to set the stage for future developments combining technical skills with managerial, marketing, economics and sociological knowledge (Curley 2012). Given the socioeconomic developmental challenges facing the MENA region, we advocate placing equal emphasis on improving education and research in these fields at local universities and research institutes. Platforms for international research collaborations on related aspects should also be further developed, possibly in the form of ‘centres of excellence’.

Although knowledge and expertise are being deepened at universities, awareness and capacity building should start much earlier and also continue beyond the university level. Regional initiatives in science education, technology and innovation are found under the umbrella of United Nations Educational, Scientific and Cultural Organization (UNESCO), and that of InWent (now part of the GIZ) in renewable energy and energy efficiency for managers and senior staff of government energy agencies, as well as in various areas of vocational education and training across the MENA region.

In closing, in order for academic and research institutes to make a real difference in supporting the development of the renewable energy sector, these organizations should be recognized as stakeholders in strategic discussions and policy decisions. More importantly, technology development and innovation policies should be elaborated in close alignment with the private sector development roadmap. The decomposition of innovation and global distribution of innovation activities can reveal new innovation niches in collaboration with leading foreign firms, or as participants in a global supply chain. Steps in this direction exist in the wind power sector, but are unlikely to have much impact without a strong local market and a national strategy for the development of renewable industry in Egypt. Such a strategy could assist Egyptian private sector investors to further capitalize on early steps in technology transfer by acquiring international firms (technology providers) and starting joint ventures. Forging strong links of cooperation with national and international stakeholders requires a strategic approach.

This interactive and dynamic process of innovation has been widely documented in the literature on innovation systems. The innovation systems literature (Freeman 1987; Lundvall 1992; Nelson 1993) emphasizes that innovation results not only from large investments in R&D, but also from intense and continuous interaction with different groups/stakeholders, such as users (Fagerberg / Srholec 2005), universities and research organizations (Mowery / Sampat 2005), and other competing or collaborating firms. From this perspective, the institutional set-up and the relationships with other organizations are critical determinants of the firms' ability to innovate (Chaminade 2009). This suggests that in order to build innovation capabilities, the Egyptian government cannot just invest in education and R&D but needs a comprehensive strategy for building up an innovation system with strong and multiple organizations, institutions and relationships.

4 Political economy perspectives on the expansion of technological capabilities

In previous chapters, we have examined the potential for developing domestic technological capabilities (in terms of production and project execution, as well as innovation capabilities) in Egypt's wind power and CSP sectors. We have also assessed potential channels for Egypt to enhance these capabilities and build competitive advantage in niche areas. However, the process of acquiring and expanding technological capabilities does not happen in a vacuum, but is greatly influenced by the institutional structure and dynamics that shape the local development process. In this chapter, we use the political economy lens to examine the underlying interests, incentives and institutions that enable or prevent change in Egypt with respect to the renewable energy sector. We focus on the evolving dynamics between those alliances of stakeholders that favour and those that are against the development of the renewable energy sector. We discuss these dynamics in terms of the social contract, as reflected by the redistribution of rents through widespread energy subsidies that aim to legitimize elite social groups, as well as by the high employment in the public sector, constrained decision-making in the energy sector, and the nature of state–business-sector alliances.

These defining characteristics of the social contract perpetuated an economic model that has become unsustainable (Ferro 2011) due to high unemployment, energy insecurity, budgetary pressures created by an increasing subsidies, and low competitiveness in the private sector. Examining the process of building technological capabilities through the political economy lens is especially important for the MENA countries, with their patrimonial capitalism systems and rentier states (Schlumberger 2004), where concerns for cronyism/favouritism, rent-seeking, inapt institutions and legal settings dominate discussions of development policy.

Enhancing local technological capabilities for solar and wind power requires concerted efforts to create coalitions of interest across a variety of stakeholders and to overcome vested interests in the status quo. We argue that the social contract needs to aim at a more sustainable allocation of energy subsidies, less constrained decision-making with respect to renewable energy, less reliance on public-sector employment, and a transition to developmental relations between the state and private sector.

The core argument is that finding channels to change the social contract can unlock barriers to developing renewable energy in Egypt, thereby creating opportunities for sustainable development and private-sector competitiveness. Below we discuss the core characteristics of the social contract briefly, then in greater detail, and highlight possibilities for reform.

4.1 The social contract and the need to change it

The social contract is generally defined as *"an agreement between the members of a society—or between the governed and the government—defining and limiting the rights and duties of each. … It defines the boundaries of acceptable policy choice, and it affects the organization of interests in society by helping to determine who wins and who loses in a given political economy"* (World Bank 2004). For Egypt and other countries in the MENA region, the social contract translates into the unwritten expectation that the government will continue to provide a generous welfare system and cheap energy, keep unemployment rates in check by providing well-remunerated positions in the public sector and at the same time, diversify and advance its economy (Samulewicz / Vidican / Aswad 2012).

In the MENA countries, which have been characterized by neo-patrimonial governance systems and strong states of a rentier and clientelistic nature (see Box 4-1), the social contract is deeply rooted in the political apparatus and the alliances between various stakeholders. The state's rentier nature is evident: most of the Egyptian state's revenues do not derive from taxes,[74] but rather from rents such as oil and natural gas exploitation, Suez Canal duties, tourism and foreign currency remittances from Egyptians working in the oil-rich Arab countries. The state redistributes these rents from 'non-productive' activities to various groups in order to maintain its legitimacy. In neo-patrimonial governance systems, rents can create incentives for political capture. The challenge to development is managing rent creation in a way that does not undermine social welfare, while at the same time reducing clientelistic relationships and keeping political capture to a minimum (Altenburg 2011).

Box 4–1: The governance system in MENA
Among the extensive research on the political economy of the MENA region, Schlumberger's (2004) assessment of the political systems in various countries captures key differences in light of the socioeconomic framework conditions, and grounds the analysis in theoretical debates. In MENA, at least prior to the Arab Spring, the dominating governance system met the characteristics of 'neo-patrimonialism'.

74 As Zaki (1999, 119) argues, despite the fact that the Egyptian state has exhibited highly coercive powers, it has also exhibited weaknesses in its difficulties in taxing its constituency.

According to Schlumberger (2004), neo-patrimonialism is invariably built on (equally informal) patron–client relations that shape social relations not only at the state's helm, but also throughout the society at large. They shape the very social fabric. Relations between ruler and the elite are strictly hierarchical, that is, they represent relations of loyalty, dependence and power. Moreover, social relations are highly personalistic at all levels, meaning that the strength or weakness of an individual's personal ties to the rulers determine their influence on decision-making. Another frequent characteristic of the patrimonial state is its strong paternalistic traits. Not only repression, but also elaborate legitimating mechanisms help patrimonial systems survive. The allocations of favours, material benefits and chances effectively compensates for the lack of formal participation in political decision-making. It is precisely the rent-influenced nature of state revenues that provides patrimonial leaders with the material resources needed to build up and maintain circles of loyal clients, which constitutes the "rentier-state" aspect of neo-patrimonialism.

The social contract that became established over the years gave rise to enduring institutions, interests, norms and practices that structure the constraints and incentives governments face under pressure for reform (World Bank 2004). It is crucial to first understand what the social contract in Egypt (and in other MENA countries) embodies – its origins, consequences for development and effect on the energy system – in order to make any assessment of regional prospects for renewable energy and the potential for building domestic capabilities in this industry. We will not expand much about the origins of the social contract in Egypt since several studies have already highlighted the main driving factors (World Bank 2004;Victor 2009; Ragab 2010). However, we will focus on the core elements of the social contract as they relate to the emergence of the renewable energy sector.

The Egyptian social contract manifests itself in specific ways. First, universal subsidies on key items, including fuel, were *"a visible and easy way to deliver benefits in exchange for supporting autocratic regimes"* (Victor 2009; Ragab 2010). A key challenge to the deployment of renewable energy (and to developing a local industry) results from the fact that it is less competitive than conventional energy in terms of price. In Egypt, conventional energy prices are heavily subsidized, creating a price disadvantage for renewables, overburdening state budgets and maintaining vested interests in the current system. We argue that in order to build local capabilities in renewable energy by creating economic incentives to integrate renewables into the energy system, it is crucial not only to tackle the irrationality of energy subsidies, but also to encourage private sector development.

A second dimension of the social contract relates to specific characteristics of the public sector, that is, over-employment and constrained decision-making, which tend to complicate the negotiation of different interests and create a clear strategy for renewable energy. Public sector employment is at the core of the social contract, whereby guarantees of job security, social security programs, relatively high wages with generous nonwage compensation benefits and sharp restrictions on the dismissal of workers are all used to legitimize the political regime (World Bank 2004). These aspects reflect a preference for the redistribution of rents as the corner-stone of the social contract. As a result, across MENA, the public sector is the preferred employer. In Egypt, for example, 29 percent of the labour force is employed in the public sector (World Bank 2010) where, despite the contraction of the public-enterprise sector, civil service employment actually increased (World Bank 2004, 96).[75] Such government hiring practices trap human capital in unproductive public sector jobs, constraining the development of a vibrant private sector, and simultaneously draining already limited budgets. This is problematic for the emerging renewable energy sector because of the need for job creation in entrepreneurial, productive fields in the private sector.[76] While we do not yet have sufficient evidence about the extent of public employment in Egypt's energy sector, we can discuss this issue within the context of the national decision-making process for the renewable energy sector.

In addition to over-employment, another characteristic of Egypt's public sector is what we call "constrained decision-making" – how the two core organizations – the MoEE and the NREA – operationalize decision-making. Reassessment of responsibilities and decision-making in these organizations could help strategize the development of the renewable energy sector. We discuss this aspect at greater length in the following sections.

A third element of the social contract emerges from the strong state, which enjoys close links to powerful actors in the dominant class and has relatively

75 A similar trend occurred in the oil-exporting countries in the region.

76 The World Bank (2004, 117) argues, *"[B]y rewarding educational credentials in public employment with higher wages, governments have encouraged investment in types of human capital that are not necessarily valued in the private sector."*

unconstrained capacity to extract resources from society for the benefit of the patrimonial leadership. Such state–business relations generally prevailed in the 'pre-Arab-Spring Egypt', but some elements are likely to carry over into the new regime as well. When seeking not only to develop a new industry, but also to reform an existing energy system that affects the economy and thereby the society at large, it is crucial to pay attention to the dynamics between alliances for and against such change. Changing on the way such alliances and networks are formed and finding channels to shift them towards renewable energy serves to catalyze change in the social contract.

In the following sections we examine how these three defining characteristics of the social contract play out in the development of the renewable energy sector in Egypt, and also the potential ways to reform it.

4.2 The irrationality of the energy subsidies regime and opportunities for reform

As emphasized repeatedly during our interviews with different stakeholders in Cairo in 2011, energy subsidies[77] are the main stumbling block to integrating renewables into the energy system and Egypt's large economy. The principle obstacle for renewable energy is the energy subsidies system that creates a cost disadvantage for renewables relative to conventional fuels.

Extensive subsidization is one of the most salient features of the governance system in the MENA region, and is therefore a politically sensitive issue to reform. The vast majority of these subsidies go towards energy (mainly in the form of price supports for electricity and fossil-fuel products). Policymakers tend to justify energy subsidies by arguing that they contribute to poverty reduction, enhance security of supply and contribute to economic growth (IEA et al. 2010). But the high cost of the subsidies and inefficient allocation has overburdened state budgets, giving rise to the recognition that the current system must be changed.

77 *"In the Egyptian context, subsidies on energy products (excluding electricity) are defined as subsidies given to the Egyptian General Petroleum Corporation that keep prices of energy prices below international prices (prices paid to foreign partners), i. e. the difference between the price paid to the foreign partner and that paid by consumers whether households, businesses or the government sector, in addition to other costs"* (Khattab 2007, 9).

In Egypt, and across the region, energy subsidies are the 'Achilles' heel' of the energy sector. Through their impact on energy prices, subsidies distort incentives for consumers (by reducing demand for clean energy, which costs more for individuals and commercial consumers) and for the private sector (by increasing investment costs for manufacturers of renewable energy parts and components, as well as for service providers, because of the limited and unpredictable market). Energy subsidies have also been shown to limit technology transfer of more than intellectual property rights such as patents for renewables (Copenhagen Economics / IPR Company 2009). Energy subsidies can thereby "lock-in" some technologies to the exclusion of others that are more promising, such as renewables (IEA et al. 2010, 9). Faced with an already overburdened budget, the financial incentives required for renewable energy deployment are perceived as unaffordable, thus preventing the formation of coalitions for change.

4.2.1 High, overburdening and politically important

Official Egyptian statistics vary regarding the current level of subsidies expended from the national budget.[78] However, more recent studies estimate that approximately 25 percent of total government expenditures go for subsidies (including food and energy subsidies, grants and social benefits), representing between 8 and 10 percent of GDP (Abouleinein / El-Laithy / Kheir-El-Din 2009). Of this sum, energy subsidies represent about EUR 12 billion (EGP 68 billion), accounting for approximately 27 percent of total revenues, the highest among the MENA countries (Albers / Peeters 2011), and 6 percent of Egypt's GDP in 2009 (World Bank 2011).[79] However, as Castel (2012) argues, since this estimate is based only on financial subsi-

---

78 Energy subsidies were not recorded in the budget until 2005 (Castel 2012). *"Since then the government's budget reports subsidies given to the Egyptian General Petroleum Corporation (EGPC) that keeps prices of oil and gas below the price that the Government pays to the foreign partners involved in the production of oil and gas in Egypt. This is a partial measure since it does not cover electricity and since it is calculated on the basis of benchmarks which do not necessarily reflect the cost of energy supply."*

79 Accurate data on energy subsidies is limited because of a lack of transparency in reporting the actual cost of electricity generation. However, various estimates can be found. At the roundtable on the Mediterranean Solar Plan held by the BMU (the German Ministry for Environment and Natural Conservation) on 24 January 2012 in Berlin, the GIZ representative to Egypt put energy subsidies at approximately10 percent of GDP – higher than other estimates.

dies, it underestimates the real economic cost of energy subsidies: if energy subsidies were calculated on the basis of full economic cost, their level would be as high as 11.9 percent of GDP (EGP 140 billion). More than half of all energy subsidies go to petroleum products, with one third going to electricity and about 15 percent to natural gas (Castel 2012) (see Annex 3 for the approximate amount of energy subsidies in Egypt by categories).

Energy subsidies (especially for petroleum products such as liquefied petroleum gas (LPG), diesel and gasoline) are highly regressive and crowd out other social and infrastructure spending that would have greater impact on poverty reduction (ENCC 2010, 86). To get a sense of the spending on energy subsidies relative to other social goals, the 2007 energy subsidy bill represented about 146 percent of the spending on education and 440 percent of the spending on health, progressively higher than in earlier years (Khattab 2007). This suggests large trade-offs with respect to welfare-spending items. This level of subsidization in Egypt is the second highest in the MENA region, following Yemen which spends about 10 percent of its GDP on energy subsidies (World Bank 2011). From another perspective, in 2009, the Egypt's subsidy rate for fuel consumption (a proportion of the full cost of supply) was 56.3 percent, with only the rich oil-based economies of Qatar and Saudi Arabia subsidizing more (Abaza / Saab / Zeitoon 2011).

Given that Egypt is not an oil exporter and that its natural gas exports have declined throughout the past decade, it is obvious that it has become financially unsound to maintain this social contract. With increases in population and unemployment, as well as the rise in global energy prices, the high level of subsidization increases the pressure on an already stressed budget.[80] In recognition of these problems, in 2007 the Egyptian government agreed to annual increases of national gas and electricity prices and sought to adjust the prices of most petroleum products (Suding 2011, 4437). But in 2009, the price adjustments for electricity and gas were stopped *"when industry, in particular energy intensive industry, agreed that, together with the global financial crisis, their competitiveness would suffer and layoffs would be*

80 In 2011, the balance of payments had a deficit of USD 2.36 billion compared to the 2010 surplus of USD 14.7 million. In the fourth quarter of 2011, foreign direct investment fell from USD 1.60 billion to USD 440.1 million, and in late November 2011, the Central Bank of Egypt announced that foreign reserves had dropped to USD 20 billion, about USD 1.4 billion less than in October, barely enough to cover four months of imports (Abdellatif 2011).

inevitable when prices increased" (Suding 2011, 4438). As a result, the government postponed streamlining energy subsidies until 2014 (ENCC 2010, 86). The protests that swept through most of MENA countries in 2010 did even more to reverse the process.

Subsidies are recognized as to be instruments for social policy (ENCC 2010), yet 'uniform' subsidization (irrespective of income or consumption levels)[81] has led to major inefficiencies in the allocation of subsidies. Specifically, the poorest 20 percent of Egypt's urban population benefits from only 3.8 percent of the total energy subsidies, whilst the richest 20 percent receive 33 percent of total energy subsidies (Abouleinein / El-Laithy / Kheir-El-Din 2009). Inequitable distribution of subsidies is the direct result of a misalignment between energy subsidies for different types of fuel and consumption patterns.[82] As Coady et al. (2006, 18) argue, *"[T]he very poor targeting performance of universal fuel subsidies means that it should be possible to identify more effective social protection mechanisms that shield the poorest households from increases in fuel prices and still have substantial savings left to allocate for higher priority expenditures or tax cuts that benefit the population more broadly".* Energy subsidies are also likely to have encouraged overconsumption (the so-called "rebound effect"), as electricity consumption per capita has annually increased by an average 5 percent since 2000 (IEA 2011). Persuading the population that budgetary savings will actually be used to provide a social safety net is a crucial component of the political economy of the reform process (Coady et al. 2010, 18).

As Loewe (2011b, 2) argues, *"[S]ocial policies in Arab countries were and still are used by most political leaders for their own goals rather than the well-being of the population."* The fact that energy subsidies disproportion-

---

81 This is especially true for the subsidization of petroleum/fossil-fuel prices (Suding 2011; Abouleinein / El-Laithy / Kheir-El-Din 2009). The Egyptian Electric Utility and Consumer Protection Regulatory Authority (EEUCPRA) publishes the electricity tariffs for non-industry customers, but is less forthcoming with respect to the prices for petroleum products.

82 For instance, Abouleinein / El-Laithy / Kheir-El-Din (2009) find that in Egypt, diesel oil gets the highest share of subsidies (39.1 percent), although it account for only 19.2 percent of total consumption. At 42.6 percent, natural gas has the highest share of consumption, yet receives only 20 percent of the subsidies. LPG is heavily subsidized (21.8 percent), but represents only 8.1 percent in terms of consumption. Fuel oil accounts for 24% of consumption and 10% of subsidies. Gasoline receives the smallest share of subsidies (9%), as the least consumed petroleum product with 6% of total consumption.

ately benefit the middle-class (rather than the poor and workers in the informal sector) supports this argument. Hence, the challenge for reform is political rather than technical or economic (Loewe 2011b). The regime's stability is the main policy-making rationale. Coady et al. (2010) also refer to several obstacles to subsidy reform that are related to the governance of the process.[83] Moreover, subsidies become entrenched in the social system and in the absence of viable alternatives, recipients feel entitled to these benefits, and the state depends on the legitimacy it gets from distributing these resources. In addition, because of the nature of energy subsidies, coordination with multiple ministries is also an issue; the management of energy subsidies should be of interest to several governmental bodies: the Ministry of Finance (who allocates resources), the Ministry of Petroleum (who sets petroleum prices), the MoEE (who plans the energy sector and strategizes the energy mix), the MIFT (who devises and carries out industrial policy), and the Ministry of Social Affairs (who sets and implements welfare policy). Nevertheless, these ministries have acted separately because they each have their own political constituents (Interview with Dr. Mohamed El Sobki; Cairo, November 2011). Since the ministries that set the subsidy policy do not coordinate extensively with the other ministries, the process needs a new institutional approach, based on horizontal policy coordination to ensure the most efficient use of resources to implement social policies.

4.2.2 Political obstacles to reform in Egypt

Previous reforms of the welfare system have been slow and limited in scope – even in the early 1990s, when liberalization programs were adopted. The approach under Mubarak was to gradually introduce reform measures in a manner that would not alienate the existing coalitions and provoke upheaval that could threaten the regime's survival (Zaki 1999, 108). The 1977 riots, and later attempts to reduce subsidies in the 1980s and 1990s, paralyzed any changes to energy pricing and resource allocation, reflecting how these policies can lead to "lock-in".

In 2004, the government launched an energy subsidy reform, which included an increase in the price of gasoline and diesel oil, and a gradual annual rate increase of 5 percent in the price of electricity from 2005 to

83 These factors are: (1) a weak capacity for targeting mitigating measures for the poor; a lack of transparency in reporting subsidies; (3) opposition by vested interests; (4) cross-border spillover effects; and (5) ad hoc price-setting mechanisms (Coady et al. 2010).

2008; in 2008, the price of natural gas and electricity for energy intensive industries was increased (Castel 2012) (see Box 4–2). Then, in 2009, political and economic concerns led to the suspension of the program that had aimed to reach full cost recovery by 2012.

Box 4–2: Recent attempts to reform energy subsidies in Egypt
The price of gasoline was increased in 2004 from EGP 1 to 1.4 per litre and the price of diesel from EGP 0.4 to 0.6 per litre. Further increases in fuel prices took place until 2008, when the price of fuel oil reached EGP 1,000/tonne compared to the 2004 price of EGP 180/tonne. Electricity tariffs were increased by 8 percent in 2004, with annual increases of 5 percent in the following years. The last adjustment was made in October 2008; no adjustment was made in 2009 because of high inflation and a potential economic slowdown. Presently the average electricity tariff is about US cents 3.5/kWh compared to US cents 2.2/kWh in 2004. Industrial consumers have been subject to sharper tariff adjustments and now pay up to US cents 6.3/kWh for medium voltage. The price of natural gas was increased in 2007 for energy intensive industries from USD 1.26/mmbtu to USD 3/mmbtu. The original plan had been to phase out subsidies for electricity and gasoline by 2014, with only LPG continuing to receive a substantial subsidy. However, the cost recovery benchmarks were based on the financial (rather than economic) costs, and would not have resulted in the complete removal of subsidies.
Source: Castel (2012)

A cautious strategic approach is needed to prevent political and social backlash. Without adequate social safety nets into which a policy response could be embedded, the population at large will not believe that such a major policy change will spare them. Egyptian society's lack of trust in what it regards as an illegitimate government is likely to lead to the view that any change in the subsidy regime is at the behest of outside interests and organizations, and that only a small minority of citizens benefit from economic growth (Yemtsov 2010).[84] This problem also transpired in January 2012, when *"rumours about an impending hike in fuel prices […] sparked a public panic"* among Egypt's population, reflecting not only "government's problems in communicating policy objectives" but also deep distrust in government officials (Washington Post 2012).

84 Earlier attempts to eliminate subsidies – made under pressure from the World Bank and IMF (in the 1970s and 1990s) – led to large protests. Since then, subsidies have been reduced only marginally.

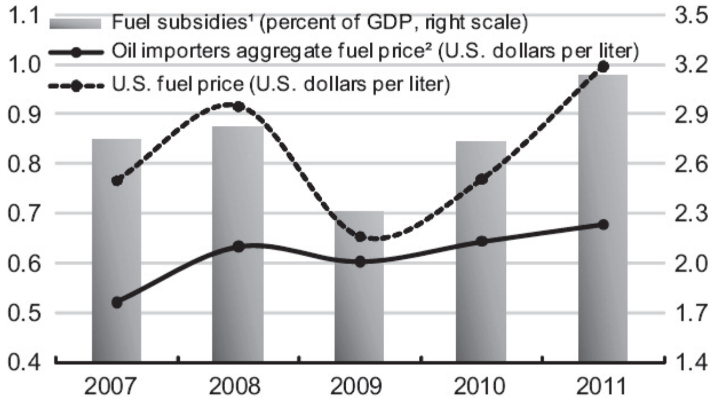
4.2.3 Difficult but not impossible to reform

Reluctance to change and fears of political and social backlash are other factors that prevent reform of the subsidies system despite its widespread inefficiencies and the overburdened state budget. Nevertheless, examples of proposals and initial attempts to phase out energy subsidies in countries such as Jordan, Iran, Morocco and Indonesia could provide some guidelines for how to reform Egypt's subsidy scheme without disproportionately hurting the lower-income groups.

As Figure 4-1 shows that despite efforts to reform energy subsidies schemes (in various countries in the region) that started around 2005, the trend in subsidies (as a share of GDP) has closely followed fuel prices. This suggests that that the 'culture' of neo-patrimonial governments legitimizing themselves through such measures as energy subsidies is at the core of the reform process. Nevertheless, as various studies on Egypt also show, there is a clear need to change the energy subsidies regime (World Bank 2005; Abouleinein / El-Laithy / Kheir-El-Din 2009; ENCC 2010).

Figure 4–1: Fuel prices and subsidies

(Period average prices of regular unleaded gasoline and diesel; PPP GDP weighted for aggregation)



Notes: [1] includes Egypt, Jordan, Lebanon, Mauritania, Morocco, and Tunisia
[2] includes Egypt, Jordan, Lebanon, Mauritania, Morocco, Pakistan, and Syria

Source: IMF (2011)

Boxes 4–2, 4–3 and 4–4 show how these countries began to initiate reforms. Cases from other parts of the world (specifically Asia and Latin America) are discussed in other studies (IMF 2011). Countries in the MENA region have only recently begun to consider reforming their decades-old subsidies schemes. The examples we provide below show positive steps in this direction, but it is still too early to know if their implementation was successful. As discussed above, the slowdown in implementation (and in some cases the reversal of reform, as in Jordan) suggests that the political class is not yet committed to changing the social contract.

Box 4–3: Reforming energy subsidies schemes – Jordan

Prior to 2005, Jordan spent 6 percent of its GDP on fuel subsidies.[85] Then, in 2005, faced with greater budgetary pressures and concerns for energy security, a plan to gradually eliminate fuel subsidies was developed with the aim of fully liberalizing prices by February 2008 (Coady et al. 2010). A major price increase took effect in 2006, followed by a price adjustment in 2008, which resulted in fuel subsidies declining to 1.4 percent of GDP (World Bank 2010). The reform was triggered by the loss of Jordan's preferential fuel supply from Iraq (World Bank 2010).

Following the elimination of energy subsidies, a system of monthly automatic price changes[86] was put in place (Ragab 2010). Although a relatively low proportion of fuel subsidies reaches the low-income population, it is this population group that suffers the most substantial decrease in real income as a result of their elimination (Coady et al. 2006). To mitigate this burden, a social safety-net program was developed which included compensations through increases in wages, pensions and social assistance payments. At the same time, as another mitigation measure, food subsidies were increased from 0.6 percent to 1.8 percent (World Bank 2010).

According to Coady et al. (2010: 14), the following specific measures were taken in order to mitigate the negative impact on the population groups most likely to be affected by the elimination of subsidies:

- The minimum wage was increased;
- A one-off bonus was given to low-income government employees and pensioners;
- The electricity lifeline tariff was maintained at low levels;

85 Information about Jordan's experience reforming the subsidy scheme primarily comes from Yemtsov (2010).

86 In 2009 Tunisia also adopted a system according to which, if the price of a barrel of oil on the world market exceeds USD 52 prices increase by a fixed amount (Ragab 2010).

– Cash transfers were provided to low-income households whose heads were non-governmental workers or pensioners;

– The government announced a plan to increase funding for a new program, the National Aid Fund, as part of a mechanism to improve the design and implementation of this national safety-net program with World Bank assistance.

The cost of the compensation measures was just one-third to one-half of the annual cost of fuel subsidies, but the effectiveness of this approach has not yet been established (Yemtsov 2010).

Nevertheless, although the pace of reform in Jordan seemed very promising, after 2009, with the worldwide increase in energy and food prices, in the face of popular discontent, Jordan, along with other oil-importing countries, chose to increase subsidies (IMF 2011). This ultimately resulted in a reversal of the commodity-pricing reforms. In Jordan, the automatic fuel-pricing mechanism that had been put in place is now largely inoperative (IMF). In 2011 fuel subsidies increased to nearly 2 percent of GDP.

Box 4–4: Reforming energy subsidies schemes – Iran

On 19 December 2010, the Iranian Government ended the decades-old subsidy programs for bread and energy products like gasoline, and replaced them with direct payments of about USD 45 per month per person. Today, Iran's subsidies are estimated at about USD 70 billion, nearly 20 percent of GDP, mostly for energy products. President Ahmadinejad had decided to launch the subsidy reform program, grandly named the "Economic Transformation Program", in the wake of popular uprisings. Despite having the backing of Supreme Leader Ali Khamenei and the Parliament, his program was attacked as reckless and a grave danger to the economy. Key to the reform were price increases of bread and all energy products to market levels – while at the same time, money was deposited in peoples' bank accounts.

In order to forestall angry reactions to the sudden price hikes and to overcome deep cynicism, the government used an innovative plan: The government opened bank accounts in the names of heads of households and deposited the first tranche of the cash subsidy, about USD 90 per person for two months.[87] The money in these accounts could be seen but not immediately withdrawn. Then, on 18 December 18 the President appeared on television to announce that prices

87 Jensen / Tarr (2002) also found that if subsidy money is equally redistributed among all households, it amounts to increasing the welfare of poor households by 200%. This suggests that *"programs to retarget subsidy money may not have to be perfect to increase the welfare of the poor"* (Ellis 2010).

would increase at midnight and the recently deposited cash subsidies would be available the next day. Predictions of Iranians rushing to their banks in the morning to collect the money did not come true. Despite the sudden price hikes – bread prices doubled and gasoline quadrupled; natural gas increased as much as eightfold, and diesel fuel nine-fold – there were no public disturbances. For Iran's poorest (living below the poverty line of USD 2 per day) – who made up about 10 percent of the population in 2010, a cash payment of USD 1.50 per person per day was not negligible. Nor was it insignificant for those with median daily incomes of USD 4.50.

Nevertheless, it is too early to call this program a success: First of all, the full impact of the removal of the subsidies has only begun to be felt. Second, the middle classes might be hit stronger than the poor population, which might translate into political protests that could reverse the program. Finally, it is not yet clear what impact the reform will have on industry and employment.

Source: Salehi-Isfahani (2012)

Box 4–5: Reforming energy subsidies schemes – Morocco

Morocco's energy subsidies' reform, which is in the planning phase, aims at a more gradual approach. Initially, it has focused on developing a thorough campaign to inform, followed by a scale-up and the institution of new social programs – in education and health – targeting the rural areas (Yemtsov 2010). At the same time, the government has been carefully consulting with industrial groups and retailers who would be influenced by a fuel price hike. Unlike Jordan, Morocco does not plan to eliminate all subsidies, but rather to cap them at a certain share of GDP to help make the system more able to absorb price shocks (Yemtsov 2010).

Some of these reform approaches seem as if they could succeed if they are pursued consistently. Complete transparency, with full explanations to the public about the policy plans, including the rationale for removing subsidies, are necessary for building public confidence in the policy process and countering speculations that it will benefit only a select group of the population. A carefully designed safety net to shield the poor from price increases is also essential. According to a recent IMF study (2011), *"[K]eeping prices liberalized has been the most robust pricing mechanism for preventing resurgence of subsidies, while well targeted safety nets continue to be the best means of providing for the needy."* This aspect was crucial to the reform programs pursued in Jordan and Iran. Instruments for compensating lower income groups include cash transfers, increases in minimum salaries and pensions, and payments for health and education.[88]

In light of the current political and social situation in Egypt, there appears to be consensus that energy subsidies will not be removed (for the bulk of the population) (ENCC 2010). Yet, because of great inefficiencies in distribution, the goal is to better target subsidies to those who need them the most, using the funds thus saved to support investments in renewables (Interview with Dr. Adel Khalil and Dr. Mohamed Elsobki; November 2011, Cairo). The problem with this policy is that accurate targeting (which requires compiling an accurate database of the population and their income levels) can be quite difficult. In Iran, this approach was cancelled after inconsistencies in reporting were identified, and a universal compensation package was used instead (Salehi-Isfahani 2012). An assessment of different policy alternatives is needed, as along with flexibility in policy implementation.[89]

These examples illustrate that solutions to the key challenge of changing the existing social contract, i.e. energy subsidies, can be found without generating massive resistance and backlash from the general population. Nevertheless, it is essential to maintain momentum and continuity in the implementation, despite external conditions, and to depoliticize the reform process. As Loewe (2011b) argues, the issue is not an inability to solve the problem but rather a "shortage of readiness" in the political class. This *"political dilemma of social policies" suggests that "even foreign donors cannot do much to support reforms, because they depend completely on the commitment of their partners (the national governments or other actors with the mandate to collaborate with foreign agencies)"* (Loewe 2011b).

In the face of political uncertainty in Egypt, three elements should be considered important in the policy-making process: commitment to reform; coordination at multiple levels; and consistent efforts to build legitimacy in the governance structure.

---

88 Nevertheless, as Loewe argues, there is currently a high level of fragmentation in the health and pension systems in Egypt (2009; 2011b). Therefore, a reassessment of these programs is needed when considering compensation schemes to offset higher energy prices.

89 For example, in Iran, after policy-makers realized that targeted compensation packages did not solve the issue of inefficiency in allocation (due to imperfect monitoring and identification of the poor), the policy was immediately changed (Salehi-Isfahani 2012).

4.3 Constrained decision-making with respect to renewable energy

Aside from energy subsidies, another defining characteristic of the Egypt's social contract is the strong state involvement in economic life that has led to over-regulation and the creation of a large public sector. This aspect has been reinforced through expectations of public sector employment, although significant changes took place after the 1990s following the privatization of state-owned enterprises.[90] Nevertheless, the declared aim of downsizing the public sector in Egypt has still remains to be achieved – while employment in state enterprises declined, in the administrative sector public employment has significantly increased (Schlumberger 2004, 125). In general, public-sector employment promises greater job security and better social benefits to individuals, while at the same time, it confers political legitimacy on the government.[91]

We hypothesize that there are two dimensions of public sector employment that constrain energy sector reforms. First, the MoEE (and its affiliated organizations) is one of the many Egyptian ministries that employs a large number of public servants. Second, restructuring the organizations would be politically risky, since it would result in a number of upper-level decision-makers losing their jobs. These dimensions require further investigation to assess how much they constrain the decision-making process regarding the development of Egypt's renewable energy sector.

The centralization of state power is very obvious in the energy sector. Despite earlier attempts to unbundle and privatize part of the activities (especially energy generation) (Eberhard / Gratwick 2005), the strategically important – for political and economic reasons – energy sector remains heavily state regulated. This affects the emerging renewable energy sector at different levels. First, the high degree of centralization within the MoEE constrains strategic decisions: approval is slow and the roles and responsi-

90 *As Schlumberger (2004, 99) claims, "[A]s of 2001, official figures put informal employment at around 10 million or 54 % of the total labour force, compared to five million civil servants and public sector employees (27 % of the total), and only 3.5 million or 19% of the official private sector"*. In contrast, with less than 10% in 1999, Morocco had the lowest share of public-sector employment as compared to other countries in the region (Yousef 2004, 45).

91 Schlumberger (2004, 126) argues that reforming the public sector would pose a threat to the regime's political survival. First, *"political delegitimation would most probably follow the large-scale layoffs that by necessity were a component of any effective reform of the public sector and the bureaucracy.…Second, by reducing the bureaucracy, the state would deprive itself of the stall needed to exert control over the overall economic process."*

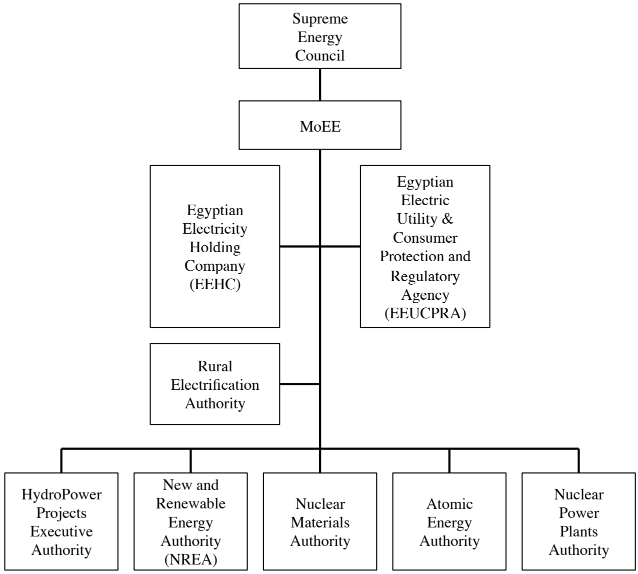
bilities of the various subdivisions are not clear (Interviews with NREA, Dr. Adel Khalil, Dr. Mohamed El Sobki, New Nile Co.; October–November 2011, Cairo). Besides the energy subsidies, the MoEE's organization and functioning impedes its ability to develop a strategic long-term vision for the energy sector. The MoEE's limited experience with, and reservations towards, private players in the energy sector further slows development of a local market for renewable energy in which independent power producers (IPPs) play an important role (Eberhard and Gratwick 2005). Finally, the centralized administration reduces flexibility and the capability to adapt to new demands posed by changes in the energy sector, as we discuss below (Interviews with Kreditanstalt für Wiederaufbau [KfW] Cairo, Dr. Adel Khalil, Dr. Mohamed El Sobki, and others; October-November 2011, Cairo). These aspects combine to create poor policy incentives for potential market entrants. In the next sections, we will discuss the roles of two major state organizations that oversee the development of the renewable energy sector: the MoEE and the NREA.

4.3.1 The Ministry of Electricity and Energy (MoEE)

The MoEE manages several affiliated companies that represent the various energy-related activities in Egypt (see Figure 4-2). The MoEE is directly responsible to the Supreme Energy Council (SEC), a ministerial committee that was established in 1979 to oversee Egypt's energy sector.[92] The SEC's mandate includes developing energy strategies to support Egypt's economic and social development policies, as well as energy efficiency objectives, and providing guidance for energy reform. To demonstrate its commitment to integrating renewables into the energy mix, the SEC approved a plan to supply 20 percent of the total electricity generated from renewables by the year 2020, including 12 percent from wind energy (a total capacity of 7,200 MW), solar energy (4 percent) and hydro power (4 percent). But without a national strategy for renewable energy and energy efficiency (to set quantifiable goals, propose policy tools and legislation, monitor and follow up achievements, as well as assess impacts, accumulated experiences and lessons learned), the decision-making process is perceived as slow and tedious (Interviews with Dr. Adel Khalil, Dr. Mohamed El-Sobki, Fraunhofer Cairo, KfW Cairo, GIZ Cairo; October¬–November 2011).

92 Headed by the Prime Minister, the Council consists of twelve ministers: defence, finance, petroleum, electricity, economic development, environment, investment, housing, trade and industry, transport, intelligence and foreign affairs.

Figure 4–2: The MoEE organizational chart



Source: Based on information from the MoEE Website

The Egyptian Electric Utility and Consumer Protection and Regulatory Agency (EEUCPRA), which reports directly to the MoEE, regulates, supervises and controls electric power generation, transmission, distribution and consumption so as to ensure the availability and continuity of supply. EEUCPRA is also responsible for setting the electricity tariffs for different types of customers, although they are subject to approval by the SEC. However, EEUCPRA cannot set tariffs for renewable energy; that is the NREA's responsibility (also subject to SEC approval). This poses some regulatory difficulties that the New Electricity Law (now being discussed in Parliament) is meant to address (i.e. by shifting this NREA role to EEUCPRA).

Interviews with Government and stakeholders in the private sector reveal that one main regulatory challenge to integrating renewables into Egypt's energy mix is the *"culture of central electricity generation"* present in state utilities (Interviews with Dr. Adel Khalil, Dr. Mohamed El-Sobki, TAQA Arabia, Calensia; October–November 2011, Cairo). Egypt does not have much experience with independent power producers (IPPs).There are only three IPPs now, and until just a couple of years ago, the "door [was] closed" to private sector involvement in the development of the energy infrastructure (Eberhard / Gratwick 2005). More recently, however, since the 2020 target for renewable energy, under pressure to speed up the deployment process, IPPs have been reconsidered – although few steps have been taken to facilitate their participation in the energy market (the New Electricity Law provides for this). IPP investors are currently required to supply their own customers for the electricity generated, as well as to secure foreign currency and substantial domestic financing (NREA 2011). While this is more difficult for private investors, interest does exist, especially for renewable energy. For instance, the Italian cement producer, Italcementi, is signing an IPP agreement to build a wind plant of 120 MW in the Gulf El Zait area that is to be expanded to 400 MW and includes investment in a water desalination facility for the local community that uses renewables. The wind plant would supply the energy needs for its cement making (De-Beni 2011). However, according to this investor and other stakeholders, negotiations about land use permits and connecting to transmission lines have been very slow (Interviews with KfW, SWEG, New Nile Co., TAQA Arabia; Cairo, October–November 2011).

A frequent explanation for the slow regulatory process has also been linked to the current leadership and changing political environment. The head of MoEE, Dr. Hassan Younes, one of the most senior government ministers, is known for being uncompromising and not corrupt (Interviews with SWEG, Dr. Adel Khalil, Dr. Mohamed El-Sobki, Sphinx Glass; Cairo, October–November 2011). Now that policy-makers of the old regime are being closely scrutinized, every decision requires that benefits and costs be proofed to assure that no single entity receives special favours (Ibid.).

4.3.2 The New and Renewable Energy Authority (NREA)

Inside the MoEE, it is the New and Renewable Energy Authority (NREA), established in 1985, that possesses the expertise in renewable energy. The NREA is coordinating Egypt's process to reaching its renewable energy target of 20 percent by the year 2020. But as interview partners have repeatedly mentioned, existing capabilities within the NREA and its organizational structure pose big challenges to developing the renewable energy sector (both the deployment and localization of production and services capabilities) (Interviews with KfW, Dr. Adel Khalil, Dr. Mohamed El-Sobki, Fraunhofer Cairo, SWEG, EGYTEC; Cairo, October-November 2011). The NREA has conflicts of interest regarding its planning, developing, operating and regulating roles. It is mandated to develop renewable energy projects on its own and also to "invite" the private sector to invest in renewables in Egypt and develop the corresponding regulatory frame-work. According to most interviewees, this is one of the strongest barriers to the development of renewables in Egypt; major organizational changes are needed to induce more clarity in the required procedures.[93] In particular, the NREA's role as a public and private developer needs to be articulated (Elsobki / Wooders / Sherif 2009) and, as mentioned earlier, it might be necessary to 'transfer' its regulatory responsibility to EEUCPRA. Another option might be to split the NREA into two separate agencies. Elsobki / Wooders / Sherif (2009) suggests, *"[A] compromise position could be with NREA acting as a standard partner within all renewable energy developments."* An organization like NREA would require increased independence and flexibility in decision-making (see Box 4–6 for a successful case from the Egyptian Communication and Information Technology sector).

Box 4–6: Organizational changes in the Communication and Information Technology (CIT) sector

The experience of Egypt's CIT sector shows that one factor in its success was the creation of a separate entity, outside the realm of the Ministry of Communication and Information Technology (the ITIDA) (Abdel-Latif / Schmitz 2009). The new organization was able to create a vibrant and exportoriented CIT industry, leverage public-private partnerships, support the development of skills, research and innovation, and promote organizational transparency (Ab-del-Latif and Schmitz 2009).

More research is needed to examine the specific circumstances that led to the development of the CIT industry and its lessons for the renewable energy sector, but authorities within the MoEE and NREA could benefit from revisiting the approach used to develop the CIT sector.

93 For example, interviewees frequently mentioned an administrative problem related to the allocation of land for renewable energy projects: The Ministry of Planning has allocated more than 6,000 km^2 of land for projects, but it is the Egyptian Electricity Holding Company (EEHC) that decides how this land should be allocated. No clear process for allocating land exists (Interview with Mohamed El Sobki; Cairo, November 2011).

Because until recently, Egypt's energy sector was focused on generating conventional energy and exploring the potential for nuclear energy, the NREA administrative and knowledge capabilities have not much supported renewables (Interview with Dr. Mohamed El-Sobki; Cairo, November 2011). Our fieldwork indicates that this aspect gives cause for concern since the organization is not very familiar with the different aspects of renewable energy and how to best integrate it into the existing energy system. For instance, next year the NREA will assume O&M activities at the ISCC plant in Kuraymat (now performed by OCI, the EPC contractor). Although NREA staff is now being trained, it's not clear how capable it will be to independently perform these activities (Dr. Adel Khalil, Fraunhofer Cairo, Dr. Mohamed El Sobki; Cairo, October–November 2011). These shortcomings indicate inadequate emphasis on renewable energy and sustainability at local universities (which should provide the necessary expertise) and the limited number of renewable energy projects in Egypt – that is, the general lack of experts in the field. Efforts to fill this knowledge gap are currently in place, via capacity building programs in collaboration with Germany and other European countries.

These organizational and capacity deficiencies – along with the unstable political environment – make investors not very keen on the slowly developing Egyptian market. Italcementi compares their wind energy project in Egypt with their similar project in Morocco that began at the same time. In Morocco, the company's wind park has been approved and is being constructed, whereas after a year and a half, the project in Egypt has not yet been approved (De-Beni 2011). Further research will be needed to identify the specific differences in the business environment for renewables in these two countries.

As indicated, the development of a renewable energy sector in Egypt would require drastic organizational changes within the relevant institutions, such as the NREA. The centralization of decision-making and pervasive energy subsidies severely hinder the creation of effective incentives to develop the local industry in this emerging sector.

4.4 Alliances for renewable energy?

For decades, decision-making in Egypt has been highly centralized; most decisions have been taken by the executive branch and in particular, the presidential office. Such a process leads to a loss of legitimacy in the governing mechanism – that is, in the various ministries and the legislature. It also creates the need for business elites (and other groups) to develop close ties and allegiances on multiple levels so as to influence policy decisions (Schlumberger 2004). The 'personalism' and 'informality' that characterize neo-patrimonial regimes also perpetuate 'favouritism' or *'wasta'* (in Arabic) – *"the tendency to provide preferential treatment to friends and relatives"* (Loewe et al. 2007). Favouritism has been widely identified as one of the main obstacles to good governance and economic development in the MENA region, as it makes state–business relations inefficient and unfair (Loewe et al. 2007).

4.4.1 The East Asian experience: change is possible – but it requires a strong state

The development experience of East Asian countries was also characterized by close state–business relations. There, however, the state's checks and balances regarding its relations to the private sector reduced the opportunities for corruption (Amsden 1989; Amsden 2001). Altenburg (2011) also argues that "strategic capabilities" (the ability to define a clear policy vision and strategy) and "implementing capabilities" (the ability to set up service agencies, devise schemes for incentives and verifiable performance measurement systems, as well as to adopt meritocratic recruitment and promotion systems) were critical to the success of Asian countries' industrialization, reducing incentives for clientelism and favouritism in state-business relations.

4.4.2 The Egyptian State is strong but not developmental

Given the prominent role of the state in the larger MENA region, the concept of "embedded autonomy" (Evans 1995) provides a useful conceptual lens for discussing the nature of state–business relations in the context of Egypt's challenges to development. Evans argues that developmental states are embedded in dense networks of social ties that enable political elites to negotiate goals, policies and implementation strategies with business actors. The developmental outcomes are assured by political elites (supported by bureaucratic institutions) being sufficiently independent to resist corruption and capture by actors whose rent-seeking behaviour would otherwise derail state efforts to promote development and formulate policy in the national interest. Combining these two dimensions, Evans maps four types of states: the developmental state, the bourgeois clientelist state, the over-developed state, and the predatory state (see Box 4–7). Based on this typology, Egypt is somewhere between the "bourgeois clientelist" and the "predatory" state. For Egypt and other MENA countries, where clientelism and favouritism prevail and relations between state and business are close, it is important to identify the conditions that shift state intervention from clientelistic and predatory behaviour towards developmental outcomes. As Evans argues, through the lens of the computer industry in different countries, comparative advantage is 'socially constructed', a result of the interaction between institutional settings and the strategic decision-making process in which the state bears considerable responsibility for the outcomes. Hence, it is critical to be able to understand the conditions that support the attainment of developmental outcomes.

Box 4–7: State typologies based on theoretical dimensions of "embedded autonomy"

According to Evans (1995), four types of states are identified along the dimensions of "embeddedness" and "autonomy":

(1) The *developmental state* is very embedded in networks with dominant classes and also organized as a highly rationalized bureaucracy (autonomy). Officials and business elites may have been educated at the same elite university, or worked together in the public or private sectors: working together creates networks for state and business to exchange ideas. But the state is nevertheless autonomous: state officials have a strong *esprit de corps,* and the state is not especially dependent on society (especially elites) for important political resources. Because the state does not need elite wealth, it can implement the policies it feels are necessary for development.

(2) The *bourgeois clientelist* state lacks the key institutional feature of Weber's rational–legal bureaucracy (autonomy), but is closely linked to powerful actors in the dominant class (embedded). Personalistic patron-client relations are intrinsic to state organization and are closely hooked into networks with the dominant class – which means that many agencies could be captured by elite groups and used for rent-seeking purposes. State leaders are closely networked with social elites and may be dependent on them for necessary political resources – or even be a part of them. The state is too embedded in society and lacks independence. State policies probably serve the interests of the elite, or of certain segments of them.

(3) The *overdeveloped* state has a relatively rationalized bureaucratic apparatus (well-developed autonomy), but only weak ties to the dominant classes of civil society (poor embeddedness). That means that the bureaucracy has considerable competence and autonomy, which is not tempered by embeddedness. State officials regard businessmen to be mere traders, while businessmen look at officials as petty bureaucrats. The state often lacks the fine-grained information required to act effectively and frequently fails to gain the cooperation needed from civil-society actors.

(4) The *predatory state* does not have a rational–legal bureaucracy nor is it embedded in social networks with a dominant class. The state thus has a fairly unconstrained capacity to extract resources from the society for the patrimonial leadership within the state. State power is wielded in an arbitrary manner, largely in the self-interest of state elites. Furthermore, the state has a weak *esprit de corps* and lacks professionalism, and state officials engage in corrupt activities rather than enforce policy and the rule of law.

Source: Evans (1995) and Hass (2007)

Various studies have also examined how close state–business relations could be leveraged towards growth-enhancing goals, especially in the context of Africa (Moore / Schmitz 2008; Kelsall et al. 2010; Abdel-Latif / Schmitz 2011; Kelsall 2011). Drawing on the example of Egypt's communication and information technology (CIT), Abdel-Latif and Schmitz (2011) argue that a common interest must exist for both the entrepreneur and the state for such relations to have positive outcomes (see Box 4–8).

Box 4–8: The development of the Communication and Information Technology (CIT) sector in Egypt

Drawing on Abdel-Latif and Schmitz (2010), we highlight the conditions that made it possible for Egypt to build an internationally competitive communications and information technology (CIT) sector. The change in private investors' perception that the government is not working against them and that some state agencies are open to di7alogue and cooperation facilitated the formation of growth alliances between policy-makers and business leaders. The formation of these alliances resulted from: (1) shared interests (among the political class and the private sector) in the sector's growth and the awareness that both sides would lose if there was no investment; (2) a common understanding of the existing challenges; and (3) translating willingness and expressed commitment into action. All these conditions were necessary.

Large companies were willing to make big investments because they were aware of the large gains they could reap by being first movers in the market. Policy-

makers also recognized the potential of these new technologies to help modernize the country and for their own career prospects. Moreover, policy-makers understood the sector-specific challenges and technicalities. In particular, the policy-makers connected to Egypt's CIT sector were native professionals (not ordinary politicians or businessmen) who understood the specific technical requirements and how to launch the industry. One special circumstance that marked these developments was the Cabinet shuffle in 2004 which put business leaders into public positions, thereby facilitating closer networks based on trust and public–private interactions at the sector level. Political changes and the CIT's novelty for the Egyptian economy also facilitated the creation of a new and autonomous organizational body. As Abdul-Latif and Schmitz wrote, "[T]he key point coming out of the Egyptian experience is that – in order to bring about change – the sectoral public–private alliance needs to extend deep into the centre of power." In the case of CIT, support for the sector first came from the President himself – and later, the Minister of CIT became the Prime Minister. Assessing the origins of the CIT-sector growth alliances revealed that most of the connections originated at the IDSC (Information and Decision Support Centre), a semi-public institute closely connected to the Cabinet, which had a team of young engineers with expertise in computers and communication – a very new field in Egypt at the time. Most of them became important players in the CIT industry and in governmental organizations, and helped convince the conservative government of the need for a new sector. Important informal relations also existed between the policy-makers.
Source: Abdel-Latif / Schmitz (2010)

It is important to reflect on the positive experience of the CIT development in terms of the challenges to creating a new industry, i.e. the renewable energy sector. However, several questions remain unanswered. While it is clear that the circumstances within which CIT emerged were quite unique, as were the actors involved, it is not clear if it would be possible to sustain neo-patrimonial relations characterized by rent-seeking and weak institutions over the long term. Although the Egyptian state is highly "embedded" in the society, there is not enough evidence to show that "autonomy" ensured through bureaucratic institutions assisted the development of the CIT sector. In East Asia and elsewhere, the bureaucratic institutions that have contributed to developmental outcomes are characterized by meritocratic recruitment, standards of performance, professionalism, corporate coherence and an *esprit de corps* (Evans 1995). The state's embedded autonomy ensures that state–business relations are not clientelistic, but rather serve to connect constituencies and the state as an organization (Evans 1995). This suggests that neither embeddedness nor autonomy suffice to ensure developmental outcomes (see Box 4–9 on South Korea's information technology sector).

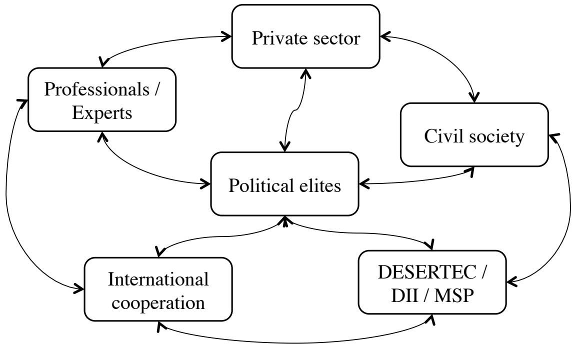
Box 4–9: Embedded autonomy through the lens of South Korea's information-technology sector
The South Korean state has been characterized as developmental in that elites within a mature state bureaucracy maintained close ties to conglomerate business groups *(chaebol)* that enabled them to devise and implement policies protecting local technology firms from international competition and providing incentives and resources to develop R&D facilities. The South Korean government provided substantial financial support and tax relief for R&D, grants for cooperative research projects and other inducements to stimulate the development of cutting-edge computer memory chips. South Korea "pushed the limit to which embeddedness could be concentrated in a few ties without degenerating into particularist predation" and South Korean firms eventually became strong enough to thrive on the international market for chips and other computer technologies.
Source: Evans (1995); Campbell (1998)

4.4.3 Challenges to building development alliances for renewable energy

Figure 4–3 illustrates various interest groups and the interconnected network of alliances needed to support the development of the renewable energy sector. It does not depict the type of relationships and alliances between the stakeholders and their role in the development process – which require more research. However, some preliminary assessments can be made in this first analysis of some of the stakeholders.

As shown in Box 4–8, close personal and professional relations among those pushing for its development were crucial to the development of the Egyptian CIT sector. In terms of the emerging renewable energy sector, most professionals advocating for renewables at different levels are very connected personally and professionally; these relationships were signifi-

Figure 4–3: Networks of alliances between different stakeholder groups



Source: The author's design

cant for persuading the government of the need to develop a new sector. For example, two of Egypt's experts in renewable energy who were colleagues at the AUC are now running the Energy Research Centre and teaching in the REMENA Masters program, while several family members are heading programs focused on the expansion of renewable energy development. The existence of this closely linked professional community increases opportunities for developing shared cognitive structures and opens up possibilities for creating epistemic communities[94] that could support renewable energy developments in Egypt. However, this core group of professionals does not belong to the political elite, which means that it might be difficult for the renewable energy sector to develop a common sense of purpose and direction with political elites.

94 An epistemic community is *"...a network of professionals with recognized expertise and competence in a particular domain and an authoritative claim to policy relevant knowledge within that domain or issue-area"* (Haas 1992).

Moreover, persuading the government to develop a new sector – the renewable energy sector – is more difficult than it was for CIT, because an energy sector already exists and renewables are perceived to be competing with other energy sources, i.e. fossil fuels. Also, decision-making with respect to renewable energy strategy and policy is centralized in the MoEE, so it is difficult to find space for solutions that can move the sector forward. Moreover, few policy-makers in the MoEE have experience in the field of renewable energy, and the NREA's president does not have a strong background in this area (Interviews with various stakeholders; Cairo, October–November 2011). These MoEE professionals come from a culture of governance that is less flexible in starting something new, especially in a volatile political environment in which forming support coalitions is difficult. The current leadership might not be in favour of bold moves, especially since it would be necessary to eliminate energy subsidies which could question the legitimacy of some of the politicians if such a decision were not fully supported from the centre of power (Interviews with various stakeholders; Cairo, October–November 2011).

Of general concern with respect to state–business relations in countries characterized by neo-patrimonialism is the danger of political capture by the business elite (Altenburg 2011). Corruption is rampant in Egyptian society, especially in business and political circles.[95] As Zaki (1999, 47) claims, *"[T]he tangled web of alliances between various competing investor groups and different elements within the top echelons of government placed a high premium on the ability to put together influential coalitions of businessmen and bureaucrats, and created a dense rent-seeking environment."*[96]

This broad network of *"favours and exchanges"* facilitated by top-ranking government officials ultimately led to the indictment of several politicians and magnates after the fall of Mubarak regime. The revelations of these large-scale illegalities have further eroded trust in the state apparatus, as representatives of the private sector expressed in Cairo in 2011.[97] Moreover,

95 The World Competitiveness Report (2010) also lists "corruption" and "red tape" as the greatest deterrents for foreign investors.

96 Schlumberger (2004, 107) argues, *"[A]ccess to powerful individuals has become the most potent means of resolving disputes in one's favour"*.

97 As one interviewee mentioned, because of limited trust in the Egyptian state apparatus, local companies prefer to partner with foreign companies so that if legal problems arise, they will have recourse to an international (foreign) justice system rather than be at the mercy of the Egyptian system of justice (Interview with Aecapromena; Cairo, November 2011).

Egyptian business culture generally displays limited trust outside of extended family circles. Zaki (1999, 151) argues that this is one of the major factors that has impeded the development of a business class: The general lack of trust prevented a rich and dynamic associational life, impeding formation of growth coalitions among unfamiliar stakeholders. Within this context, the slow process of impeaching key players of the previous regime, under the supervision and coordination of the military transitional government, challenges the direction of economic and political change. Recent protests have called for stronger involvement by other stakeholders, in particular the civil society, in setting up a system of accountability for the state.

In Egypt, successful business ventures have been limited to a few large, politically well-connected businessmen with *"timely access to relevant information about upcoming governmental policies"* (Schlumberger 2004). These same firms also benefited the most from neoliberal reforms aimed at private- sector development. Smaller businesses have had difficulty investing because access to credit for private- sector development remains restricted (Schlumberger 2004). While much emphasis has been placed on state structures (state agencies and political elites), less attention has been devoted to the institutional arrangements of firms and entrepreneurs. The South Korean economy is organized through well-established business groups (Campbell 1998) but Egypt lacks the well-organized business networks that Evans (1995) believes facilitate the sort of embeddedness that is critical for development (Campbell 1998). In addition, the small size of the local market for renewables and the lack of associative mechanisms among local firms in the sector (see Chapter 3), have prevented the formation of private sector alliances needed to lobby policy-makers for regulatory frameworks that support renewables.

Cross-regional initiatives such as DESERTEC Foundation, DII and MSP, as well as international cooperation stakeholders such as the KfW, the GIZ, and the German Ministries, are part of the alliance needed to development Egypt's renewable energy sector. These actors provide the necessary access to finance and know-how, while at the same time they open up new markets. Given the early stage of development of Egypt's renewable energy sector and the precarious economic situation, their role is critical.

When considering pathways for Egypt to change from being a clientelistic, predatory state to a developmental state where alliances between different interest groups enhance growth, it is important to introduce performance-based management in the public and private sectors, and develop well-organized business networks among firms that could become part of the renewable energy value chain. Economic structures are just as important as state structures for facilitating the sort of policies that scholars such as Evans deem so essential in developing countries. As the "embedded autonomy" concept argues, success heavily depends on entrepreneurs and firms having access to and working closely with political elites (rather than being cut off from them). For these reasons, bureaucratic institutions should be developed to ensure coherence and stability in policy-making. The constraints and incentives that political elites create for entrepreneurs and firms through a "delicate balance" of embeddedness and autonomy ultimately affect economic outcomes.

5 Policy recommendations

This study aimed to explore the possibilities for harnessing Egypt's untapped potential for development and overcoming barriers to this goal. Building on our analysis of the potential for expanding technological capabilities for renewable energy in Egypt, we identified several core areas that need to be improved. These targeted policy recommendations are addressed to Egyptian policy-makers, as well as to German international cooperation agencies (i. e. ministries involved in various programs in Egypt and the larger MENA region, and development cooperation organizations).

Since the political economy framework conditions permeate all levels of the development process, in light of Egypt's current socioeconomic challenges, we attempt to offer policy recommendations that are *"socially and economically desirable, technically and financially feasible and politically realistic"* (Loewe 2011b). Loewe points out that such measures should have two effects: they should serve the political interests of the regime and the socioeconomic interests of the population. Given the large share of development aid and investment targeted at sustainable development in the region, policy recommendations should also support the 'win-win' opportunities that could emerge from the deployment of large-scale renewable energy projects such as DESERTEC and MSP.

We first propose several dimensions of policy recommendations for Egyptian policy-makers, and then offer strategic advice for Germany's international cooperation with Egypt in the area of renewable energy.

5.1 Guidelines for Egyptian policy-makers

This report emphasises that although various challenges persist in the economy and the larger society, great potential exists for expanding the role of renewable energy. To this end, transparency should be increased in public decision-making and incentives offered to the private sector should be coupled with performance requirements.

5.1.1 Disseminating a new narrative

Narratives[98] are important. Policy narratives can effectively convey complex issues and solutions to a wider audience, especially when difficult decisions have to be made in conditions of great uncertainty and conflicts of interest – for example, reforming energy subsidies and abandoning a decades-old conventional energy system. Policy narratives can help make sense of an issue by reducing its conceptual complexity, providing frameworks for people to understand their experiences and observations, rationalizing public debate about possible courses of action and buttressing political actors' sense of identity (Hajer 1995; Boswell 2010).

Given the conditions present in Egypt and the need to enhance technological capabilities to support the development of a competitive renewable-energy sector, we argue that Egyptian policy-makers should promote a new narrative that addresses two main dimensions: (1) one which discredits the old conventional energy system and explains the irrationality of energy subsidies; and (2) one which emphasises how renewable energy 'can work' for Egypt.

First, a new narrative is needed to promote the shift away from irrational, unsustainable energy subsidies towards more targeted allocations. Essential for promoting a new narrative are well organized information campaigns geared to the population at large regarding the cost and main beneficiaries

98 Jones and McBeth (2010) define a narrative as "a story with a temporal sequence of events unfolding in a plot that is populated by dramatic moments, symbols, and archetypal characters that culminates in a moral to the story."

of the current subsidy regime and the rationale for reforming energy subsidies, the benefits expected and options for reform. This can be achieved two ways:

- *Organize media campaigns about the drawbacks of existing subsidies and the benefits of reform.* Earlier attempts in Egypt communicated very little about the reasons for such policies, and created the perception that only limited groups would reap the benefits (within the larger context of government favouritism and lack of transparency). In Jordan and Indonesia, such campaigns significantly contributed to public acceptance of these policies. They can also help defeat vested interests. Information channels used before fuel prices were raised have included: announcements in newspapers, TV talk-shows, notices on public announcement boards and the distribution of brochures answering frequently asked questions.
- *Promote cost transparency.* Petroleum subsidies should be transparently recorded in government accounts. Germany and Switzerland, for instance, have published reports with detailed information on the cost of subsidies (Coady et al. 2010).

The new narrative also explains how renewable energy can benefit Egypt in terms of energy security, jobs, private sector development, low carbon development, etc. To this end, it is critical to mobilize alliances between different interest groups and types of stakeholders – technical experts, financiers, academics, the private sector and civil society.

5.1.2 Targeted recommendations

The new narrative in support of expanding the renewable energy sector needs to be based on specific policy recommendations. The assessment of existing technological capabilities along the value chain of wind and solar power has allowed us to identify six areas that policy-makers should address:

- Developing a roadmap for renewable energy and the necessary technology
- Reforming the fossil-fuels subsidy regime
- Unbundling the NREA's services

- Developing the supply chain
- Expanding renewable energy education and training
- Expanding R&D for renewable energy

We discuss each of these aspects in greater detail below.

5.1.2.1 Developing a roadmap for renewable energy and the necessary technologies

The main barrier to developing the renewable energy sector in Egypt is the lack of a national strategy. Such a strategy would not only identify the renewable energy capacity targets to be achieved within a specific timeframe, but would also clearly articulate how this target would be achieved to maximize local benefits with respect to policies for market creation and industrial development (and employment generation), and the acquisition of technological capabilities. A comprehensive roadmap is necessary to create cohesion in the actions of various stakeholders and send the right signals to potential investors, thereby minimizing investment risks. A strategy for renewable energy technology in Egypt (technologies that are currently capable of providing a high local content and others that could only do so in the future) would help orient the strategic efforts of investors and companies (local and international). Such a strategic roadmap would also assist the rollout of a knowledge-development and R&D agenda to support the process. Clear policy incentives to encourage private sector investment are another important part of such a national roadmap for renewable energy. Developing a national strategy requires coordination between the various stakeholders. The study being conducted by Lahmeyer International with funding from KfW, *"A Combined Renewable Energy Road Map for Egypt", could eventually serve this purpose.*

To this end, we propose the following policy recommendations:

- Create medium and long-term roadmaps for the energy sector, with the goal of rapidly scaling up all forms of renewable energy in Egypt and developing local technological capabilities.
- Develop a technology roadmap, which will further guide efforts to strategize educational and R&D activities.
- Enhance institutional capacity by implementing long-term support policies such as FITs, which would reduce the risks of investment.

- Develop a coordinated and transparent approach between different stakeholders in the renewable- energy sector through multidisciplinary teams that bring together different types of expertise.

5.1.2.2 Reforming fossil-fuels subsidy regimes

As discussed in Chapter 4, in order for the renewable energy sector to take off in Egypt, it is necessary to reform the energy subsidy scheme for two main reasons: (1) it would remove price distortions from the energy system and (2) it would relieve the government budget and therefore reduce pressure on other social and infrastructure needs. While there is broad agreement at multiple levels that the current subsidization program needs to be changed, no commitment has been made to a strategy for reform. The experience of several countries in phasing out energy subsidies (including Jordan, Indonesia, Morocco and others) points to several key aspects that could be considered for reforming energy subsidy regimes in socially and politically acceptable ways. In addition to extensive media campaigns and the transparent communication of the costs of the current energy subsidy regime, targeted compensation mechanisms (social safety nets) should be designed to mitigate adverse effects on the social groups that would be most affected. In Jordan, for example, savings that result from increasing energy prices have been applied to compensation packages. Such packages have included: increases in state employees' salaries and food subsidies; reductions of certain import duties; introducing projects to combat unemployment and poverty; basic health care and health insurance for the poor; village improvement programs; and public-transport improvement programs (World Bank 2010).

The successful implementation of these measures requires thorough accounting of the costs involved and the financial gains to be made by gradual reductions of energy subsidies, as well as identifying the social groups that would be most affected by such a policy. Transparency and accountability are essential for building trust between the population and policymakers.

5.1.2.3 Unbundling the NREA services

If approved, Egypt's New Electricity Law would help solve some of the problems faced by the energy sector. In particular, there must be more private sector participation in the generation and transmission of electricity.

Currently, there is not enough capacity in the national utility to cover the increasing demand for energy. In addition, major organizational changes are required to facilitate decision-making, reduce delays in the project development stage and build stronger knowledge capabilities within the NREA. It is important to consider some aspects:

- Allowing IPPs and providing long-term PPAs would contribute to decentralizing the energy sector in Egypt, thereby creating incentives for private-sector involvement and the generation of renewable energy in particular.
- An entity should be created for planning and overseeing renewable energy developments that is not controlled by the MoEE, but instead coordinates with it (giving the NREA more autonomy).
- As an entity separate from the MoEE, the NREA should implement more flexible hiring and firing procedures and targeted training modules.
- The NREA's overlapping roles in project development and regulation should be separated, and EUCPPR should assume regulation of the renewable energy sector.

5.1.2.4 Developing the supply chain

While subsidies constitute the main hurdle to creating a market for renewable energy, low competitiveness, a lack of training programs, and the poor quality of local manufacturing and service provisions hinder the development of local industry. The quality and cost of a product or service offered on the market is not only a function of the capabilities of the operator of the power plant, but also those of the supplier network that provides inputs to the enterprise. It is crucial to improve supply chain development programs to create jobs, expand local industry and build catch-up capabilities.

The Industrial Modernization Centre (IMC) has successfully developed analogous programs for other sectors in Egypt. Therefore, rather than just creating new organizations and new programs, it would be wise to take stock of the specific needs of the solar and wind energy sector – in close consultation with local companies across the value chain. This process would enable IMC staff to identify the supplier development programs that should be developed and what internal capabilities need to be enhanced to support such programs. It could be beneficial to collaborate with international organizations, such as the United Nations Industrial Development

Organization (UNIDO), and German international cooperation agencies that have extensive experience in this area. More importantly, an agency like IMC should facilitate interaction between foreign private-sector investors and local suppliers.

The following measures could be considered:

- Giving tax credits for retooling manufacturing facilities to encourage local companies to become suppliers of parts and components[99]
- Creating a favourable policy environment to create incentives for private sector investment in renewable energy technologies
- Removing custom tariffs for products and components that cannot be produced locally, but building in flexibility to reapply them when local manufacturing capabilities emerge
- Building on training programs (i.e. for subcontractors), such as those offered by IMC, but increasing industry's share of funding to raise their interest in supporting such programs and make the investment more efficient
- Creating an agency that could act as a 'middle man', forging links between customers and suppliers, promoting industrial linkages and stimulating domestic subcontracting
- Improving information sharing and cooperation in order to align different actors according to the national strategy for renewable energy; without this, duplication and unproductive interagency rivalry could hamper achievement of strategic goals
- When tendering documents, clearly specify the requirements for local content and preferences for joint venture projects in order to enhance technology transfer
- Creating well-organized business networks to facilitate the type of embeddedness necessary to achieve developmental outcomes; forming industry associations, geared towards networking and lobbying. (Egypt

99 Becoming a supplier of parts and components for renewable energy systems is challenging due to the need to reinvest and retool plants, and to demonstrate the ability to expand as the demand grows. In the USA, for example, the American Recovery and Reinvestment Act (Stimulus Bill) attempts to make it easier for manufacturers to enter wind turbine and other renewable manufacturing industries by creating a 30% tax credit for retooling manufacturing facilities or exporting in new manufacturing plants (David 2009, 14).

already has an ineffective wind industry association; a solar industry association is also needed.)

- Developing expertise in metrology, quality and standards institutions through closer cooperation with German professional organizations such as the Physikalisch–Technischen Bundesanstalt (the Federal Physical–Technical Institute)
- Developing supplier certification procedures and incentives to motivate suppliers (e.g. acknowledging supplier improvements through awards, future business guarantees, and sharing achieved cost savings).

5.1.2.5 Expanding renewable energy education and training

One of the problems we have identified in this analysis is the lack of a broad range of educational and training programs and a mismatch between what the industry needs and what the labour market can offer. To this end, it would be worthwhile to pay attention to the experience of other countries that have developed renewable energy sectors that might be relevant to Egyptian policy-makers. Although job creation is one of the main challenges for Egypt and other countries in the region, there is no skills-development strategy for renewable (wind and solar energy) energy. In Denmark in the late 1990s, green employment became a key policy priority with the introduction of a law in 1997 about a new ‘green job pool’ that led to the allocation of some EUR 67 billion between 1997 and 2001 for stimulating employment growth and green occupations (ILO 2011, 263). Germany, too, can offer instructive policy recommendations with respect to educational and skills-development programs.

Education programs

- Integrate sustainability, renewable energy, climate change, and green-growth topics in the curricula from primary school through higher education. In Egypt, the Sekem Initiative is an example of such an approach for the agriculture sector that could be applied to other sectors, such as renewables.[100]
- Fund demonstration pilot projects at universities.
- Use existing solar and wind plants as educational platforms for schools.

100 For more details see: http://www.sekem.com/node/118.

- Organize prize-based competitions at local universities.
- Change the incentive structure in universities to encourage research and collaboration with the private sector.
- Allow for flexibility for personnel to shift between academia and industry.

Skills development

- Integrate a renewable energy component in vocational education and training programs to enable skills development on a larger scale. Involve companies at all levels of training– as they do in Germany.
- Include the Ministry of State for Environmental Affairs and the NREA in the coordination mechanisms for skills development that are currently shared between several ministries.[101]
- This will help prioritize an analysis of labour market requirements for green jobs.
- Designate an entity to systematically collect data on the skills and knowledge base of the workforce that are necessary to sustain development of a renewable energy sector (the Danish and the German experience would be instructive here).[102]
- Open communication and collaboration channels between various organizations concerned with the environment and renewable energy, as well as the various organizations and agencies active in education and training, to pave the way for a skills development strategy (ILO 2011, 277).

5.1.2.6 Expanding renewable energy R&D

To support the process of technological catch-up, emphasis should be placed on enhancing innovation and R&D capabilities.

---

101 See ILO (2011: 277) for a description of the current structures for skills development in Egypt.

102 The importance of measuring the necessary skills is highlighted in the following example from the ILO (2011) report. *"In Germany, according to the Vocational Training Act, a specific skill need has to be identified in the economy for a modernization or the establishment of a new training regulation to occur. In 2006, the Federal Environment Ministry started an educational initiative entitled 'Environment creates perspectives', in association with firms from the environmental technologies/renewable energy sectors. As a result, 6,000 additional apprenticeships were created in 2009. The initiative aims to identify the apprenticeship trades, skills and competencies required by the environmental sector."*

- Develop a national strategy for science and technology with a focus on renewable energy to support the technology strategy roadmap discussed above.
- Establish funding for clean energy R&D programs that emphasize collaborative research on the adaptation of technology to local environmental conditions (e.g. CSP water desalination or dry-cooling for solar thermal power plants).
- Support founding Centres of Excellence at local universities (in close collaboration with international research institutes) to focus on innovative technologies that will open up domestic niche markets.
- Encourage creation of a Fraunhofer Institute or the NREL in Egypt. For this, the Ministry of Education and Research could bring together different stakeholders (from the private sector and academia) to begin a dialogue about possible collaborations.
- Explore potential strategic long-term research collaborations with research communities abroad (in Germany, for example) in the field of renewable energy, similar to the integrated R&D collaboration of China and Denmark (see section 5.2).

5.2 German partnership in energy transition

Given its expertise in this field, Germany has a lot to offer to Egypt and the other MENA cooperation partners in terms of institutional expertise, capacity building, and technological know-how. Strengthening its cooperation in renewable energy in Egypt will help Germany enhance its competitive advantage in the sector.

However, for this Germany must speak with one voice through a 'whole-of-government' strategy of cooperation within the field of renewable energy – while at the same time aligning itself with European-level initiatives. Germany is already cooperating with Egypt in the field of renewable energy.

The Energy Concept of the BMU/BMWi (the German Federal Ministries for Environment, Nature Conservation and Nuclear Safety, and for Economics and Technology) states that North Africa has an important role to play for Germany and Europe, and yet there is only limited collaboration between the ministries and no overall strategy of international cooperation with the MENA region. While Germany's competitive advantage in the renewable energy sector is well known, it is not yet established in the region as a preferred partner and role model, and its influence on 'green reforms' in emerging economies could still be considerably enhanced. So far, none of its organizations or bilateral cooperation platforms have developed into recognized centres of excellence or become influential stakeholders in the regional policy process.

More could be achieved if Germany would (a) *agree on a 'whole-of-government' approach and (b) define clear policy priorities* and bundle the efforts of various ministries, implementing agencies, industries and university initiatives in areas specifically related to renewable energy. The goal should be to establish an inter-ministerial process with the aim of agreeing on priorities for topics and partners, as well as bundling activities and sharing experiences. Such a process should create a joint vision for strengthening regional cooperation and achieve further integration in the European market. Successful examples of such coordination efforts at the federal level exist in the form of the Indo–German Policy Dialogue in Energy (see Box 5-1), the German Electric Mobility National Plan (see Box 5-2) and the German–South African Binational Commission (established in 1996), which has cooperated across a broad thematic spectrum.

Box 5–1: The Indo-German Policy Dialogue in Energy

In 2006, the Indian Prime Minister Manmohan Singh and German Chancellor Angela Merkel set up the Indo–German Energy Forum, a bilateral dialogue forum on energy. This Forum acknowledges energy's crucial role for both countries, as well as the potential for cooperation, whether in efficient thermal power generation or renewable energies.

The Forum meets yearly at the secretary level, led by India s Ministry of Power and Germany s Federal Ministry of Economics and Technology (BMWi). The most recent meeting took place in New Delhi in November 2010; the next meeting was planned for late 2011 in Germany.

The Forum has several working groups: thermal-power-station modernization, renewable energies, energy efficiency and carbon trading, and coal. In addition, other relevant ministries are involved, such as Germany s Federal Ministry of Environment (BMU) and India s Ministry of New and Renewable Energy. Industry participation is encouraged to include the views of the corporate sector in deliberations.

The Forum secretariat is organizing additional expert inputs and logistic support. An additional working group on energy research to be led by India s Department for Science and Technology and Germany s Federal Ministry for Education and Research (BMBF) was also planned for 2011.

Science and technology (S&T) cooperation is another major focus area of the strategic relationship between Germany and India. There are presently more than 150 joint S&T research projects and 70 direct university partnerships. In Gurgaon in September 2008, a jointly funded Indo–German Science & Technology Centre was inaugurated – funded annually with EUR 2 Million from each country – that serves as a model for public–private partnerships in science and industrial research. The first tranche of bilateral research projects in the fields of biotechnology and renewable energies started in 2010.

S&T partnerships focus on specific fields and are grounded in partnerships between universities in Germany and India. For example, the (IIT) in Chennai signed a Memorandum of Understanding with the German Academic Exchange Programme (DAAD) and a group of nine German Technical Universities to open a new Centre for Sustainability Research at IIT Chennai.

Source: http://www.india.diplo.de/Vertretung/indien/en/12__Climate__ Development__Cooperation/Energy/Bilateral.html and http://www.mea.gov.in/mystart.php?id=50044473 (accessed on 6 March 2012)

Box 5–2: The German Federal Government's National Electric Mobility Development Plan

On 18 August 2009, the German Cabinet adopted the National Electric Mobility Development Plan, with a budget of EUR 500 million. This development plan intends to make Germany the leader in electro-mobility and help maintain its cutting edge in science and in the automotive sector and related supplier industries. The entire value added chain is included – from materials, components, cells and batteries to the overall system and its application. The German Federal Government, which aims at having one million electric vehicles on German roads by 2020, created a National Platform on Electric Mobility that will coordinate all the players from the very beginning, ensuring consultations among representatives from politics, industry and science, municipalities and consumers, and facilitating working groups with various tasks.

The Ministries directly involved in coordinating this national plan are the Federal Ministry for Education and Research (BMBF), the Federal Ministry for Transport, Building and Urban Development (BMVBS), the Ministry of Economics and Technology (BMWi) and the Ministry of Environment and Nature Conservation and Nuclear Safety (BMU).

Source: http://www.germanenergyblog.de/?p=13(and) http://www.bmu.de/english/mobility/doc/44799.php (accessed on 6 March 2012)

To this end, and building on the strategic approach for other programs, we propose the establishment of a German–MENA Energy Partnership to be endorsed by the Chancellery, which would define the *cooperation corridor* (see Box 5–3) with the MENA region. With DESERTEC and DII taking the lead in pursuing energy collaborations between MENA and Germany/the EU, and the World Bank and other international agencies starting to play larger roles in the region, Germany needs to make a *strong political push* for a strategic energy dialogue with the MENA region. Given the region's changing socioeconomic and political conditions, a decision should be taken as to whether it would be better to establish bilateral partnerships or whether the focus of such an interministerial approach should be at the level of North Africa (and not of MENA) – given the strategic role of cross-Mediterranean energy market integration.

Box 5–3: Development cooperation 'corridors' and 'beacons'
Altenburg et al. (2008a) defined development cooperation 'corridors' and 'beacons' with respect to Germany's development cooperation with anchor countries. Inter-ministerial cooperation increases the visibility and attractiveness of German cooperation and is likely to generate spillover effects. There are various possible formats for departmental cooperation. The term *'cooperation corridors'* refers to the mechanism for cooperative design of jointly agreed thematic areas. For example, such corridors allow multiple ministries to cooperate on specific subject areas (such as democratization, renewable energy or tropical forest conservation) and facilitate possible coordination under the respective thematic umbrella. *'Beacon projects'* are clearly defined jointly funded individual projects with high visibility and spillover effects, such as the establishment of long-term partnerships with universities or training centres in Germany. Beacon projects can be part of a corridor, along with other measures or instruments.
Source: Altenburg et al. (2008a)

The process of organizing such a German 'whole-of-government' strategic-energy partnership with MENA could emerge from the following process:

- Organize a workshop with the Ministries to articulate Germany's interest in cooperating with the MENA region on renewable energy, and identify what needs to be done and how to do it. Such a workshop should address possible tensions between stakeholder interests, for example between 'German interests' in export promotion, foreign policy or strengthening

German S&T ties to the region, and 'public goods' interests in mitigating climate change or building local capability, with the aim of balancing these interests and exploiting synergies to the maximum.

- Plan a fact-finding mission to identify the MENA counterparts' areas of strategic interest. Germany could establish a 'committee' of experts from various stakeholders (e. g. industry,[103] education and research and policy think-tanks) to start consultations with Egyptian counterparts with the aim of coming to a common understanding of the need for a strategic approach to renewables.
- Coordinate a policy negotiation process backed by the Chancellor as a German energy initiative.
- Systematically link various elements of cooperation (policy dialogue, technical and financial cooperation, scholarship, staff exchange programs, etc.) to maximize synergies.

To implement this process, a jointly funded (by German Federal Ministries) Centre of Excellence for Green Transformation would further enhance the strategic character of the German–MENA energy partnership. Preferably, such a centre would be a physical entity, but it could also act as a virtual platform for coordination and action where regional initiatives could be spearheaded. This Centre of Excellence should be a beacon project (see Box 5–3) for German international cooperation in the field of renewable energy, and serve as a clearing-house and 'one-stop shop' for related initiatives, such as the Danish–Chinese Energy Partnership (see Box 5–4) and the National Platform for Electric Mobility (see Box 5–2).

The centre could provide a focal point for joint learning in policy making and technology know-how, project development and management. Instruments such as DAAD scholarship programmes, secondment of experts (CIM, GIZ), collaborative research (the EU Framework Paper 8 and German research foundations) or institutional twinning programmes could be employed to reinforce the centre as a knowledge hub. In addition to the centre, regional networks such as the Pan Arab University Research and Education Network (PAN), MSP and RCREEE should be supported, and an assessment should be made about how to better integrate these initiatives into international platforms for supporting developments in the field of renewable energy, such as the International Renewable Energy Agency (IRENA).

103 DII could act as a strategic representative for the region's renewable energy sector.

Box 5–4:	**Danish–Chinese partnership in the area of energy research and development**
In 2012, following years of extensive collaboration with China in the field of wind energy, the Danish Energy Agency launched a cooperation agreement with the China National Renewable Energy Centre that intends to help convert the Chinese energy supply to a climate friendly, 'low carbon' energy system. The two countries will cooperate on the development, distribution and use of renewable energy sources. The cooperation will increase the exchange of experiences and also pave the way for the increased application of Danish solutions in China. The Danish Energy Agency will assist the centre with Danish expertise on technology and the administration of development programs and advanced energy systems. Over the last two years, two Chinese wind turbine manufacturers have started R&D activities in Denmark. The cooperation agreement might result in more Chinese companies pursuing this strategy. The Danish Ministry for Climate, Energy and Building already has a number of cooperation agreements with Chinese authorities and partners that cover the integration of renewable energy into the power grid, groundwater mapping and geological surveys, meteorological research, including the mapping of wind resources and climate changes and CDM (Clean Development Model) projects.	
Source:	Danish Energy Agency at http://www.ens.dk/en-us/info/news/news_archives/2012/sider/20120224_denmarkandchinaintensifycooperationonre.aspx (accessed on 6 March 2012).

There are several options for creating such a Centre of Excellence, which should be further explored with respect to the institutional set-up:

- The centre could be linked to local initiatives such as Egypt's Zewail City for Science and Technology that is planned as the nucleus of research centres affiliated with the Ministry of Science and Higher Education, or other regional initiatives.

- Another channel could be the DESERTEC Foundation's initiative to create a research institute or platform for collaboration, between Germany/Europe and the MENA countries that would focus on inte-grating socioeconomic and technical aspects to assist the development of renewables and EU–MENA energy integration. An alternative approach, which we believe should be given serious consideration, is bilateral cooperation based on the model of Danish–Chinese partnership in the area of energy research and development, with specific emphasis on capacity building and technology transfer (see Box 5-4). To this end, the study by the Nordic Institute of Asian Studies is useful for showing how to structure such a collaboration and the benefits for both Denmark and China of such a partnership (Delman / Chen 2008). Different levels of cooperation/collaboration, ranging from small- to large-scale cooperation could be envisioned, that could be developed through a more sequential or cascading approach, as in the Nordic–China collaboration.

Bibliography

Abaza H. / N. Saab / S. Zeitoon (2011): Arab Environment: green economy: sustainable transition in a changing Arab world, Beirut: Arab Forum for Environment and Development

Abdel-Latif, A. / H. Schmitz (2009): State-business relations and investment in Egypt, Brighton: IDS (Research Report 61)

– (2010): Growth alliances: insights from Egypt, in: *Business and Politics* 12 (4), 4

– (2011): The politics of investment and growth in Egypt: experimenting with a new approach, in: *Development Policy Review* 29 (4), 433–458

Abdellatif, R. (2011): Egypt to implement maximum wage as it battles budget deficit, in: *The Daily News Egypt*; online: http://www.thedailynewsegypt.com /economy/egypt-to-implement-maximum-wage-as-it-battles-budget-deficit.html, December 20, 2011 (accessed 1 Feb. 2012]

Abouleinein, S. / H. El-Laithy / H. Kheir-El-Din (2009): The impact of phasing out subsidies of petroleum energy products in Egypt, Cairo: The Egyptian Center for Economic Studies (Working Paper 145)

Abramson, N. H. (1997): Technology transfer systems in the United States and Germany: lessons and perspectives, Washington, DC: National Academy Press

AEE (Asociación Empresarial Eólica) (2007): Eolica 07: todos los datos, analisis y estadisticas del sector eolico, Madrid

Al-Saleh, Y. / G. Vidican (2011): The role of research universities in creating a CleanTech industry: theory, international experience and implications for the United Arab Emirates, Cambridge, Mass.: Massachusetts Institute of Technology, Industrial Performance Center (MIT-IPC Working Paper 11–002)

Albers, R. / M. Peeters (2011): Food and energy prices, government subsidies and fiscal balances in South Mediterranean countries, Brussels: European Commission (Economic Papers 43)

Almohsen, R. A. (2011): Egypt announces US$2 billion science city, London: SciDevNet; online: http://www.scidev.net/en/news/egypt-announces-us-2-billion-science-city.html (accessed 31 Jan. 2012)

Altenburg, T. / J. Leininger / I. Scholz (2008a): Umwelt- und klimapolitische Zusammenarbeit mit Ankerländern: Vorschläge zur Koordinierung und Fokussierung der BMU- und BMZ-Angebote an Brasilien, China, Indien und Südafrika, Bonn: DIE (Manuskript)

Altenburg, T. / H. Schmitz / A. Stamm (2008b): Breakthrough? China's and India's transition from production to innovation, in: *World Development* 36 (2), 325–344

Altenburg, T. (2011): Can industrial policy work under neopatrimonial rule? Bonn: United National University (Working Paper 2011/41)

Amer, H. (2009): Renewable energy strategy for 2020 and regulatory framework: Egyptian Electric Regulatory and Consumer Protection Agency, Washington, DC: Global Workshop on Grid Connected Renewable Energy

Amsden, A. (1989): Asia's next giant: South Korea and late industrialization, New York: Oxford University Press

– (2001): The rise of "The Rest": challenges to the West from late-industrializing economies, New York, NY: Oxford University Press

Archibugi, D. / C. Pietrobelli (2003): The globalization of technology and its implications for developing countries – windows of opportunity or further burden, in: *Technological Forecasting and Social Change* 70 (9), 861–883

Badr, H. (2012): Egypt's scientists savour post-revolution year, SciDevNet: science and innovation policy: science in the Islamic world; online: http://www.scidev net/en/science-and-innovation-policy/science-in-the-islamic-world/newsegypt-s-scientists-savour-post-revolution-year.html (accessed 31 Jan. 2012)

Bashshur, M. (2004): Higher education in the Arab States, Beirut: UNESCO Regional Bureau for Education in the Arab States

Bell, M. (2007): Technological learning and the development of production and innovative capacities in the industry and infrastructure sectors of the least developed countries: what role for ODA?, Sussex: University of Sussex (UNCTAD – The Least Developed Countries Report 2007 Background Paper)

Bhagwati, J. H. (1982): Directly-unproductive profit-seeking activities, in: *Journal of Political Economy* 90 (5), 988–1002

Boswell, J. (2010): Policy narratives in a deliberative system: connected globe: conflicting worlds, Melbourne: University of Melbourne (Australian Political Studies Association)

Campbell, J. (1998): Book reviews: embedded autonomy – states and industrial transformation, in: *Theory and society* 27 (1), 103–108

Carter, N. T. / R. J. Campbell (2009): Water issues of Concentrating Solar Power (CSP) electricity in the U.S. Southwest, Washington, DC: Congressional Research Service (CRS Report for Congress)

Castel, V. (2012): Reforming energy subsidies in Egypt, African Development Bank, Chief Economist Complex

Cenvantes, M. (2011): Academic patenting: how universities and public research organizations are using their intellectual property to boost research and spur innovative start-ups, Geneva: World Intellectual Property Organization (WIPO); online: http://www.wipo.int/sme/en/documents/academic_patenting.html#P7_279 (accessed 22 Nov. 2011)

Chaminade, C. (2009): Understanding the changes in the global distribution of innovation activities: a challenge for innovation studies, in: W. Ostreng (ed.), Confluence: interdisciplinary communications, Oslo: Centre for Advanced Study

CIA World Factbook (2011): Egypt – economy; online: http://www.indexmundi.com/g/g.aspx?v=81000&c=mo&l=en (accessed 10 Jan. 2012)

Clark, B. R. (1998): Creating entrepreneurial universities, Oxford: Pergamon Press

Coady, D. et al. (2006): The magnitude and distribution of fuel subsidies: evidence from Bolivia, Ghana, Jordan, Mali, and Sri-Lanka, Washington, DC: International Monetary Fund (Working Paper WP/06/247)

– (2010): Petroleum product subsidies: costly, inequitable, and rising, Washington, DC: International Monetary Fund (IMF Staff Position Note, SPN/10/25)

Colatat, P. / G. Vidican / R. K. Lester (2009): Innovation systems in the solar photovoltaic industry: the role of public research institutions, Cambridge, Mass.: Massachusetts Institute of Technology, Industrial Performance Center (MIT-IPC Working Paper 09-007)

Copenhagen Economics / *IPR Company* (2009): Are IPR a barrier to the transfer of climate change technology? Copenhagen

Curley, N. (2012): Egyptian accelerator Flat6Labs graduates first cycle of tech start-ups, Wamda; online: http://www.wamda.com/2012/01/egyptian-accelerator-flat6labs-graduates-first-cycle-of-tech-startups, January 17

David, A. S. (2009): Wind turbines: industry and trade summary, Washington, DC: United States International Trade Commission, Office of Industries (Publication ITS-02)

De-Beni, G. (2011): The perspective of an international investor in the renewable energy sector, Bergamo, Italy: Italian Group (10th World Wind Energy Congress in Cairo 31 Oct.–2 Nov. 2011)

Delman, J. / Y. Chen (2008): Nordic collaboration with China in energy research and development: a study commissioned by Nordic Energy Research, Copenhagen: Nordic Institute of Asian Studies

Dersch, J. / C. Richter (2007): Water saving heat rejection for solar thermal power plants: NREL Trough Meeting, Stuttgart: Deutsches Zentrum für Luft- und Raumfahrt (DLR), Institute of Technical Thermodynamics

DESERTEC (2008): Clean power from deserts: the DESERTEC concept for energy, water and climate security, Hamburg: DESERTEC Foundation (White Book, 4th Edition)

DFID (*Department for International Development)* (2009): Political economy analysis: how to note: a DFID practice paper, London

*DLR (German Aerospace Center) (*2005): Concentrating solar power in the Mediterranean region, Stuttgart: Institute for Technical Thermodynamics, Department of Systems Analysis and Technology Assessment

Dutz, M. A. / S. Sharma (2012): Green growth, technology and innovation, Washington, DC: World Bank (Policy Research Working Paper 5932)

Eberhard, A. / K. Gratwick (2005): The Egyptian IPP experience, Stanford: Stanford University, Center for Environmental Science and Policy, Program on Energy and Sustainable Development (Working Paper 50)

Ellis, J. (2010): The effects of fossil-fuel subsidy reform: a review of modeling and empirical studies, Geneva: Global Studies Initiative (GSI) of the International Institute for Sustainable Development (IISD)

El Sewedy (2009): Local Manufacturing: Experiences from the MENA region: El Sewedy for wind energy generation – SWEG, Sharm El Sheikh, Egypt (RCREEE Conference: MENA Energized - Regional challenges to green the power sector)

Elsobki, M. / P. Wooders / Y. Sherif (2009): Clean energy investment in developing countries: wind power in Egypt: trade, investment and climate change series, Winnipeg: International Institute for Sustainable Development

ENCC (The Egyptian National Competitiveness Council) (2010): Green Egypt: a vision for tomorrow, Cairo (7th Egyptian Competitiveness Report)

Erdle. S. (2010): The DESERTEC Initiative: powering the development perspectives of Southern Mediterranean countries? Bonn: DIE (Discussion Paper 12/2010)

Etzkowitz, H. (1998): The norms of entrepreneurial science: Cognitive effects of the new university-industry linkages, in: *Research Policy* 27 (8), 823–833

Evans, P. (1995): Embedded autonomy: states and industrial transformation, Princeton, NJ: Princeton University Press

EWEA (*European Wind Energy Association)* (2006): Wind power technology: factsheet, Brussels

– (2009): Wind at work: wind energy and job creation in the EU, Brussels

Fagerberg, J. / M. Srholec (2005): Catching up: what are the critical factors for success?, Oslo: University, Centre for Technology, Innovation and Culture (Background paper for the UNIDO World Industrial Development Report 2005)

Ferro, M. V. (2011): A reform agenda for Arab economies, New York: Council on Foreign Relations; online: http://www.cfr.org/middle-east/reform-agenda-arab - economies/p26889 (accessed 10 May 2012)

Freeman, C. (1987): Technology policy and economic performance: lessons from Japan, London: Pinter

GAFI (The General Authority for Investment) (2010): Invest in Egypt: renewable energy; online: http://www.gafinet.org/English/Pages/PotentialInvestmentSectors.aspx#29 (accessed 24 Nov. 2011)

Gereffi, G. / K. Dubay (2008): Concentrating solar power: clean energy for the electric grid, Durham, UK: Duke University, Social Science Research Institute, Center on Globalization, Governance & Competitiveness

Global Investment House (2009): Egypt cement sector: against all odds..., Safat, Kuwait

Goldemberg, J. (2008): Leapfrog energy technologies, in *Energy Policy,* 26 (10), 729–741

GTM (Green Technology Media) (2011): Concentrating Solar Power 2011: technology, costs and markets; online: http://www.greentechmedia.com/research/report/concentrating-photovoltaics-2011 (accessed 10 May 2012)

Haas, P. (1992): Introduction: Epistemic communities and international policy coordination, in: *International Organization* 46 (1), 1–35

Hajer, M. A. (1995): The politics of environmental discourse: ecological modernization and the policy process, Oxford: Clarendon Press

Hamilton, J. (2011): Careers in solar power: green jobs: solar power, Washington, DC: U.S. Bureau of Labor Statistics

Hass, J. K. (2007): Economic sociology, New York: Routledge Press

Hauptstock, D. (2010): Concentrating solar power technology in selected Middle Eastern and North African countries, Heidelberg: University, Alfred Weber Institute for Economics (Diploma Thesis)

Hernandez-Moro, J. / J. M. Martinez-Duart (2012): CSP electricity cost evolution and grid parities based on the IEA roadmaps, in: *Energy Policy* 41, 184–192

IEA (*International Energy Agency)* (2008): Renewable energy essentials: wind; online: http://www.iea.org/Papers/2008/Wind_Brochure.pdf (accessed 23 Nov. 2011)

– (2010): World Energy Outlook 2010, Paris

– (2011): Electric power consumption (kWh per capita): energy statistics and balances of non-OECD countries and energy statistics of OECD countries; online: http://www.iea.org/stats/index.asp (accessed 1 Feb. 2012)

IEA (*International Energy Agency)* et al. (2010): Analysis of the scope of energy subsidies and suggestions for the G-20 initiative, Toronto: Joint report prepared for submission to the G-20 Summit meeting, 26–27 Jun. 2012

ILO (International Labour Organization) (2011): Skills for green jobs: a global view, Geneva: Synthesis report based on 21 country studies

IMC (Industrial Modernisation Center) (2006): Renewable energy sector in Egypt, Cairo: Energy Research Center, Faculty of Engineering, Cairo University

– (2011): Energy efficiency, renewable energy and environmental protection; online: http://www.imc-egypt.org/pgmenergy.asp (accessed 23 Nov. 2011)

IMF (International Monetary Fund) (2011): Regional economic outlook: Middle East and Central Asia: world economic and financial surveys, Washington, DC

IRENA (International Renewable Energy Agency) (2011): Renewable energy jobs: status, prospects & policies, Abu Dhabi (Working Paper)

Jaramillo, A. / T. Melonio (2011): Breaking even or breaking through: reaching financial sustainability while providing high quality standards in higher education in the Middle East and North Africa, Washington, DC: World Bank

JCEE (Joint Committee for Renewable Energy and Energy Efficiency) (2012): Renewable energy and energy efficiency in Egypt, Cairo; online: http://www.jcee-eg.net/reee.asp?sublinkID=30 (accessed 22 Mar. 2012)

Jensen, J. / D. Tarr (2002): Trade, foreign exchange, and energy policies in the Islamic Republic of Iran: reform agenda, economic implications, and impact on the poor, Washington, DC: World Bank (Research Working Papers 1–32)

Jones, M. D. / M. K. McBeth (2010): A narrative policy framework: clear enough to be wrong?, in: *Policy Studies Journal* 38 (2), 329–353

Kelsall, T. (2011): Developmental patrimonialism? Rethinking business and politics in Africa, London: ODI, African Power and Politics Programme (Policy Brief 02)

Kelsall, T. et al. (2010): Developmental patrimonialism?: questioning the orthodoxy on political governance and economic progress in Africa, London: ODI, Africa Power and Politics Programme (Working Paper 9)

Khan, S. (2010): Egypt you reap rewards as steel prices stiffen, in: *The National,* Abu Dhabi; online: http://issuu.com/thenation/docs/january_12_2012 (accessed 12 Jan. 2012)

Khattab A. S. (2007): The impact of reducing energy subsidies on energy intensive industries in Egypt, Cairo: Egyptian Center for Economic Studies (Working Paper 124)

Kheir-El-Din, H. (2005): Productivity performance in developing countries: country case studies: Egypt (mimeo)

Knies, G. (2011): DESERTEC, Institute for Studies on Socio-economic Development and Employment (DISEM) (Draft), Hamburg

Komendantova, A. et al. (2012): Perceptions of risks in renewable energy projects: the case of concentrated solar power in North Africa, in: *Energy Policy* 40, 103–109

Kraemer-Mbula, E. / W. Wamae (eds.) (2010): Innovation and the development agenda, Paris: OECD and International Development Research Centre (IDRC)

Krueger, A. O. (1974): The political economy of the rent-seeking society, in: *The American Economy Review* 64 (3), 291–303

Lam, A. (2011): What motivates academic scientists to engage in research commercialization: 'gold', 'ribbon' or 'puzzle'?, in: *Research Policy* 40 (10), 1354–1368

Lema, R. et al. (2011): Competition and cooperation between Europe and China in the wind power sector, Brighton: IDS (Working Paper 2011, 377)

Lema, R. / A. Lema (2012): Technology transfer? The rise of China and India in green technology sectors, in: *Innovation and Development* 2 (1), 23–44

Lanjouw, J. O. / A. Mody (1996): Innovation and the international diffusion of environmentally responsive technology, in: *Research Policy* 25 (4), 549–571

Lester, R. (2005): Universities, innovation, and the competitiveness of local economies: a summary report from the Local Innovation Systems Project – Phase I, Working Paper 05-010, Cambridge, Mass.: Industrial Performance Center, Massachusetts Institute of Technology

Lewis, J. (2007): Technology acquisition and innovation in the developing world: wind turbine development in India and China, in *Studies in Comparative International Development* 42, 208–232

Link, A. N. / D. S. Siegel / D. D. v. Fleet (2011): Public science and public innovation: assessing the relationship between patenting at U.S. National Laboratories and the Bayh-Dole Act, in: *Research Policy* 40 (8), 1094–1099

Loewe, M. et al. (2007): The impact of favoritism on the business climate: a study of wasta in Jordan, Bonn: DIE (Studies 30)

Loewe, M. (2011a): Industrial policy in Egypt: 2004–2011, Bonn: DIE (Draft)

– (2011b): Reforming social policies in the Arab world: how much contribution to social justice can be achieved?: social justice in Egypt: theory, research, and practice, Cairo: Annual Research Conference of the American University

Lundvall, B.-A. et al. (2009): Innovation system research and developing countries: handbook of innovation systems and developing countries: building domestic capabilities in a global setting, Cheltenham: Edward Elgar, 1–32

Lundvall, B. A. (1992): National systems of innovation: towards a theory of innovation and interactive learning, London: Pinter Publishers

Mani, M. / R. Pillai (2010): Impact of dust on solar photovoltaic (PV) performance: research status, challenges and recommendations, in: *Renewable and Sustainable Energy Reviews* 14 (9), 3124–3131

Marinova, D. / A. Balaguer (2009): Transformation in the photovoltaic industry in Australia, Germany and Japan: comparison of actors, knowledge, institutions and markets, in: *Renewable Energy* 34 (2), 461–464

Maxfield, S. / B. R. Schneider (eds.) (1997): Business and the state in developing countries, Ithaca, NY: Cornell University Press

Moore, M. / H. Schmitz (2008): Idealism, realism and the investment climate in developing countries, Brighton: IDS

Mowery, D. C. (2004): Ivory tower and industrial innovation: university-industry technology transfer before and after the Bayh-Dole Act, Stanford: Stanford University Press

Mowery, D. C. et al. (2001): The growth of patenting and licensing by U.S. universities: an assessment of the effects of the Bayh-Dole act of 1980, in: *Research Policy* 30 (1), 99–119

Mowery, D. C. / B. N. Sampat (2005): Universities in national innovation systems, in: J. Fagerberg, / D. C. Mowery / R. R. Nelson (eds.), The Oxford handbook of innovation, Oxford: Oxford University Press, 209–239

Müller, S. / A. Marmion / M. Beerepoot (2011): Renewable energy: markets and prospects by region, Paris: IEA

Narula, R. / A. Zanfei (2005): Globalisation of innovation: the role of multinational enterprises, in: J. Fagerberg / D. Mowery / R. R. Nelson (eds.), The Oxford handbook of innovation, Oxford: Oxford University Press, 318–345

Nash, R. / A. Hudson / C. Luttrell (2006): Mapping political context: a toolkit for civil society organizations, London: ODI (Research and Policy in Development Programme)

Nasr, S. (2007): More steel duties: steps are being taken to help the steel market in Egypt adjust, online: http://weekly.ahram.org.eg/2007/838/ec1.htm (accessed 10 May 2012)

Nelson, R. (1993): National innovation systems: a comparative analysis, Oxford: Oxford University Press

– (2007): The changing institutional requirements for technological and institutional catch up, in: *International Journal of Technological Learning and Development* 1 (1), 4–12

– (2011): Economic development as an evolutionary process, in: *Innovation and Development* 1 (1), 39–49

NREA (National Rural Education Association) (2011): Wind energy in Egypt: a success story: 10th World Wind Energy Congress October 31st to November 2nd, Cairo

OECD (Organisation for Economic Co-operation and Development) (2010): Innovation and the development agenda, in: E. Kramer-Mdula / W. Wamae (eds.), OECD innovation strategy, Paris: OECD International Development Research Centre

Pederson, T. (2009): Vestas wind systems A/S: exploiting global R&D synergies, Copenhagen: Copenhagen Business School, Center for Strategic Management and Globalization

Popp, D. (2011): The role of technological change in green growth: draft report prepared for the World Bank, Syracuse, NY: Syracuse University, Center for Policy Research, The Maxwell School

Rafferty, M. (2008): The Bayh-Dole Act and university research and development, in: *Research Policy* 37 (1), 29–40

Ragab, A. (2010): Fossil fuel in the Arab world and the fear of reform: challenges facing reform attempts and the way forward, Eschborn: GTZ

– (2010): Fossil fuel prices in the Arab world and the fear of reform: challenges facing reform attempts and the way forward: increasing the momentum for fossil-fuel subsidy reform: developments and opportunities, Geneva: WTO

Reid, B. et al. (2010): Technology Innovation Centers: applying the Fraunhofer model to create an effective innovation ecosystem in the UK, London: The Work Foundation (Submission to the UK Science and Technology Committee)

REN21 (Renewable Energy Policy Network for the 21st Century) (2011): Renewables 2011: global status report, Paris

Richard, B. (2011): Saint-Gobain solar: job creation and industry development, Cairo: Presentation at the 2nd DII Conference – Desert Energy

Salehi-Isfahani, D. (2012): Iran: subsidy reform amid regional turmoil, Washington, DC: The Brookings Institution; online: http://www.brookings.edu/opinions/2011/0303_iran_salehi_isfahani.aspx?p=1 (accessed 2 Feb. 2012)

Sampat, B. / D. Mowery / A. Ziedonis (2003): Changes in university patent quality after the Bayh-Dole Act: a re-examination, in: *International Journal of Industrial Organization* 21 (9), 1371–1390

Samulewicz, D. / G. Vidican / N. G. Aswad (2012): Barriers to pursuing careers in science, technology and engineering for women in the United Arab Emirates: gender, technology and development, mimeo

Sawin, J. L. / L. Mastny (2010): Prospects of the renewable energy sector in Egypt: focus on photovoltaics and wind energy, Cairo: Environics, GIZ

Schlumberger, O. (2004): Patrimonian capitalism: economic reform and economic order in the Arab World, Tübingen: University (Ph.D)

OECD (Organisation for Economic Co-operation and Development) (2010): Innovation and the development agenda, in: E. Kramer-Mdula / W. Wamae (eds.), OECD innovation strategy, Paris: OECD International Development Research Centre

Pederson, T. (2009): Vestas wind systems A/S: exploiting global R&D synergies, Copenhagen: Copenhagen Business School, Center for Strategic Management and Globalization

Popp, D. (2011): The role of technological change in green growth: draft report prepared for the World Bank, Syracuse, NY: Syracuse University, Center for Policy Research, The Maxwell School

Rafferty, M. (2008): The Bayh-Dole Act and university research and development, in: *Research Policy* 37 (1), 29–40

Ragab, A. (2010): Fossil fuel in the Arab world and the fear of reform: challenges facing reform attempts and the way forward, Eschborn: GTZ

– (2010): Fossil fuel prices in the Arab world and the fear of reform: challenges facing reform attempts and the way forward: increasing the momentum for fossil-fuel subsidy reform: developments and opportunities, Geneva: WTO

Reid, B. et al. (2010): Technology Innovation Centers: applying the Fraunhofer model to create an effective innovation ecosystem in the UK, London: The Work Foundation (Submission to the UK Science and Technology Committee)

REN21 (Renewable Energy Policy Network for the 21st Century) (2011): Renewables 2011: global status report, Paris

Richard, B. (2011): Saint-Gobain solar: job creation and industry development, Cairo: Presentation at the 2nd DII Conference – Desert Energy

Salehi-Isfahani, D. (2012): Iran: subsidy reform amid regional turmoil, Washington, DC: The Brookings Institution; online: http://www.brookings.edu/opinions/2011/0303_iran_salehi_isfahani.aspx?p=1 (accessed 2 Feb. 2012)

Sampat, B. / D. Mowery / A. Ziedonis (2003): Changes in university patent quality after the Bayh-Dole Act: a re-examination, in: *International Journal of Industrial Organization* 21 (9), 1371–1390

Samulewicz, D. / G. Vidican / N. G. Aswad (2012): Barriers to pursuing careers in science, technology and engineering for women in the United Arab Emirates: gender, technology and development, mimeo

Sawin, J. L. / L. Mastny (2010): Prospects of the renewable energy sector in Egypt: focus on photovoltaics and wind energy, Cairo: Environics, GIZ

Schlumberger, O. (2004): Patrimonian capitalism: economic reform and economic order in the Arab World, Tübingen: University (Ph.D)

Schmitz, H. / S. Strambach (2009): The organisational decomposition of innovation and global distribution of innovative activities: insights and research agenda, in: *International Journal of Technological Learning, Innovation and Development* 2 (4), 231–249

SIAG Schaaf Industrie AG (2011): The SIAG Group is on the rise; online: http://www.siag.de/mod/Company-GB.htm?id=53&do=one&NewsArtikelID=1789 (accessed 19 Jan. 2012)

Suding, P. H. (2011): Struggling between resource-based and sustainable development schemes: an analysis of Egypt's recent energy policy, in: *Energy Po*licy 39 (8), 4431–4444

Sulaiman, S. A. et al. (2011): Effects of dust on the performance of PV panels, in: W*orld Academy of Sciences, Engineering and Technology* 58, 588–593

Trieb, F. / H. Müller-Steinhagen (2007): The DESERTEC concept: sustainable electricity and water for Europe, Middle East and North Africa, in: Trans-Mediterranean Renewable Energy Cooperation (TREC): clean power from deserts, Hamburg: TREC

Trieb, F. et al. (2012): Solar electricity imports from the Middle East and North Africa to Europe, in: *Energy Policy* 42, 341–353

UNCTAD (*United Nations Conference on Trade and Development)* (2011): Technology and innovation report 2011: powering development with renewable energy technologies, Geneva

UNDP (United Nations Development Programme) (2010): Egypt Human Development Report 2010: youth in Egypt: building our future, Cairo: Institute of National Planning (Project document EGY/01/006)

UNESCO (United Nations Educational, Scientific and Cultural Organization) (2004): Higher education in the Arab states, Beirut: UNESCO Regional Bureau for Education in the Arab States

Victor, D. (2009): The politics of fossil-fuel subsidies: the global subsidies initiative – untold billions: fossil-fuel subsidies, their impacts and the path to reform, Geneva: International Institute for Sustainable Development (IISD)

Vidican, G. (2009): The role of universities in innovation and sustainable development, in: C. Brebbia (ed.), Sustainable development and planning IV, Southampton: Wessex Institute of Technology

Walz, R. / J. N. Delgado (2012): Different routes to technology acquisition and innovation system building? China's and India's wind turbine industries, London: Taylor and Francis (Innovation and Development 2, 1)

Washington Post (2012): Rumors over gasoline shortages spotlight Egypt's problem with credibility after Mubarak; online: http://www.washingtonpost.com/world/middle-east/imf-team-arrives-in-egypt-for-talks-on-possible-32-billion-support-package/2012/01/16/, January 16, 2012 (accessed 18 Jan. 2012)

World Bank (2004): Unlocking the employment potential in the Middle East and North Africa: toward a new social contract, Washington, DC

– (2005): Egypt – toward a more effective social policy: subsidies and social safety net, Washington, DC (World Bank Document 33550-EG)

– (2010): Subsidies in the energy sector: an overview, Washington, DC (Background paper for the World Bank Group Energy Sector Strategy)

– (2011): MENA facing challenges and opportunities – regional economic update, Washington, DC

– (2011): Middle East and North Africa region assessment of the local manufacturing potential for concentrated solar power (CSP) projects: report conducted for the World Bank by Ernst & Young et Associés, Fraunhofer Institute for Solar Energy Systems / Fraunhofer Institute for Systems and Innovation Research, Washington, DC

Yemtsov, R. (2010): Developing effective reform strategies: safety needs to protect poor and vulnerable groups from the negative impacts of reform: increasing the momentum for fossil-fuel subsidy reform: developments and opportunities, Geneva: WTO

Yousef, T. M. (2004): Employment, development and the social contract in the Middle East and North Africa, Washington, DC: World Bank

Zaki, M. (1999): Egyptian business elites: their visions and investment behavior, Cairo: Arab Center for Development and Future Research and Konrad Adenauer Stiftung

Annex

Annex 1: List of interviews in Egypt

	Agency/Company	Interviewee	Position
Government - Energy	New and Renewable Energy Authority	Dr. Mohammed Mostafa El-Khayat	General Manager of Planning & Follow-up
		Eng. Ashour Abdel Salam Moussa	General Manager of Wind Energy Dpt.
		Ehab Farouk Abd El-Aziz	Manager of Technical Affairs for Solar Energy
Government - Industry	Industrial Modernization Centre	Dr. Mohamed Salah Elsobki	Energy Efficiency & Renewable Energy Manager
	The Executive Organization for Industrial and Mining Projects (Ministry of Industry and Foreign Trade)	Dr. Mahmoud Elgarf	President
		Raouf Hassan Farag	Vice President
	Central Metallurgical Research and Development Institute	Dr. Eng. Adel Nofal / Prof. Dr. Bahaa Zaghloul	Former President / Prof. of Metal Casting
	Egypt National Cleaner Production Centre	Ahmed Tawfik	Economist
		Ahmed Youssef	Energy Efficiency Specialist
Government - Research	Ministry of Higher Education and State for Scientific Research (MHESR)	Prof. Magued El-Sherbiny	Assistant Minister for Scientific Research / President Academy of Scientific Research & Technology

Annex 1 (cont.): List of interviews in Egypt

	Agency/Company	Interviewee	Position
Government - Research (cont.)	Research, Development & Innovation Program (MHESR)	Dr. A. Hamid El-Zoheiry	Coordinator of EU Cooperation & RDI Program
	Technical and Technological Consulting Studies and Research Fund (MHESR)	Prof. Dr. Bahaa Zaghloul	Managing Director
Private sector	Sewedy Wind Energy Group (SWEG)	Dr. Yehia Shankir	Sales Director
		Karim Donato	Business Development Manager
		Arne Wilhelm	Marketing Manager
	SIAG	Christian Adamczyk	Marketing Manager
	Calensia	Dr. Wahid Tawfik	Chief Executive Manager
	Sphinx Glass	Ayman Elkady	Sales & Marketing Manager
	New Nile Co.	Tamer M. Nasser	Managing Director
		Karim Wanis	Associate Project Manager
	AECAPROMENA	Rafi Kourouian	Managing Director
	MEET	Mohamed Abdel Hai	General Manager
		Wael El-Nashar	President & CEO
	SEKEM	Helmy Abouleish	Managing Director

Annex 1 (cont.): List of interviews in Egypt

	Agency/Company	Interviewee	Position
Private sector (cont.)	TAQA Arabia	Eng. Khaled AbuBakr	Chief Executive Officer
		Akmal Zaghloul	Business Development General Manager
	Orascom Construction Industries	Sherif Sharobeem	Deputy Manager
	German Technology Solar Systems	Mohamed Hassan	General Manager
	The Egyptian Society for Endogenous Development of Local Communities (NGO)	Prof. Dr. Hamed El Mously	Chairman
Consulting	EGYTEC	Amr G. Shawki	Chairman
	CiviTeck	Dr. Monir R. Kamel	Managing Director
Universities and Research Organizations	Cairo University	Prof. Dr. Mohamed Salah Elsobki	Director of Energy Research Centre
	REMENA / Cairo University	Prof. Dr. Adel Khalil	Program Director at REMENA, Professor in the Faculty of Mechanical Engineering at Cairo University
	Independent researcher	Eng. Mohamed Shalaby	Researcher in RE & EE

Annex 1 (cont.): List of interviews in Egypt

	Agency/Company	Interviewee	Position
Universities and Research Organizations (cont.)	Ain Shams University	Dr. Ahmed Reda El Baz	Dept. of Mechanical Power
		Prof. Dr. Sabry Abdel-Mottaleb	Department of Chemistry
		Dr. Mohamed Abdel-Mottaleb	Director of Nanotechnology Centre
		Dr. Ahmed Y. El-Assi	Professor, HVAC Consultant
	German University in Cairo	Prof. Dr. Heiko Fritz	Economics Department
	The Egyptian Centre for Economic Studies	Dr. Malak Reda	Senior Economist
		Dr. Iman Al-Ayouty	Senior Economist
		Dr. Omneia Helmy	Deputy Director
	Economic Research Forum for the Arab Countries	Dr. Heba Handoussa	Former Managing Director, Economics Professor at AUC, former Provost at AUC, Lead Author of Egypt Human Development Report 2010, former member of the Shura Council
Development Cooperation & International Agencies	KfW	Dr. Jens Mackensen	Director of Cairo Office
	DAAD	Dr. Michael Harms	Director Cairo Office
	UNIDO	Giovanna Ceglie	Director Regional Office

Annex 1 (cont.): List of interviews in Egypt

	Agency/Company	Interviewee	Position
Development Cooperation & International Agencies (cont.)	UNESCO	Nazar Hassan	Science & Technology Unit Chief
	Fraunhofer Egypt	Dr. Mona El Tobgui	Senior Advisor Egypt
	RCREEE	Prof. Dr. Adel Khalil	Chairman of the Executive Committee of RCREEE until end of February 2012
		Ludger Lorych	Team Leader
	GIZ – Egyptian-German Private Sector Development Program	Thomas Rolf	Program Coordinator
	GIZ – Human Capacity Development / Former InWent	Magued Youssef	Director
	DESERTEC Foundation	Dr. Hani El Nokraschy	Vice Chairman of the Supervisory Board
		Mohamed Aly El-Hamamsy	Resident Representative, Egypt
		Dr. Gerhard Knies	Chairman of the Board of Trustees
	DESERTEC University Network	Mouldi Miled	Executive Director

Annex 2: Electric energy prices in Egypt

	Prices
1. The energy usage on the super high voltage (piaster / kWh)	
– Kima	4.7
– The underground (Ramses)	6.8
– The Arab company of the oil tubes (Soumid)	27.3
a) Industries with intensive consumption (Iron-Cement-Fertilizers-Aluminium-Copper-petrochemicals)* * The prices of Electric Power Consumed is raising in these sectors by 50 % during the peak period (4 hours-the MoEE set the beginning)	21.7
b) Industries (flat glass-ceramics and porcelain)	15.9
c) The rest of industrial sector not included in the a, b	15.4
d) The rest of subscribers	12.9
2. The energy usage on the high voltage (piaster / kWh)	
The underground (Tora)	11.34
a) Industries with intensive consumption (Iron-Cement-Fertilizers-Copper-petrochemicals)* * The prices of Electric Power Consumed is raising in these sectors by 50% during the peak period (4 hours-the MoEE set the beginning)	26.3

Annex 2 (cont.): Electric Energy Prices in Egypt

	Prices
2. (cont.) The energy usage on the high voltage (piaster / kWh)	
b) Industries (flat glass-ceramics and porcelain)	19.2
c) The rest of industrial sector not included in the a, b	18.6
d) The rest of subscribers	15.7
3. The energy usage on the medium and low voltages (piaster / kWh)	
– greater than 500 kW	
a) Industries with intensive consumption (Iron-Cement-Fertilizers-Copper-petrochemicals)*	35.8
b) Industries (flat glass-ceramics and porcelain)**	26.3
c) The rest of industrial sector not included in the a, b**	25.5
d) The rest of subscribers	21.4
* Fixed monthly instalment for the actual recorded peak load (pound / kW)	12.1
** Fixed monthly instalment for the actual recorded peak load (pound / kW)	11.1
– until 500 kW	

Annex 2 (cont.): Electric Energy Prices in Egypt

	Prices
3. (cont.) The energy usage on the medium and low voltages (piaster / kWh)	
a) The agriculture and the land reclamation* * fees against the electricity consumption to the acre to the beneficiaries by the stations of the collective irrigation	11.2
b) The rest of subscribers	25.0
4. Residential users (on monthly basis)	
– 50 kWh the first	5.0
– 51 to 200 kWh the next	11.0
– 201 to 350 kWh the next	16.0
– 351 to 650 kWh the next	24.0
– 651 to 1,000 kWh the next	39.0
– more than 1,000 kWh	48.0
5. Commercial users (on monthly basis)	
– 100 kWh the first	24.0

Annex 2 (cont.): Electric Energy Prices in Egypt

	Prices
5. (cont.) Commercial users (on monthly basis)	
– 101 to 250 kWh the next	36.0
– 251 to 600 kWh the next	46.0
– 651 to 1,000 kWh the next	58.0
– more than 1,000 kWh	60.0
6. The public lighting and the traffic lights (piaster / kWh)	41.2

Source: http://www.egyptera.com/en/Bill_Tariffs.htm (accessed on March 22, 2012)

Annex 3: Approximate amount of Egypt's energy subsidies in FY 2009/2010

	Price (average)	Financial cost	Economic cost	Subsidy (Financial)	Subsidy (Economic)
Electricity	*EGP/MWh*	*EGP/MWh*	*EGP/MWh*	*EGP million*	*EGP million*
Industry	140–250	430–450	530–560	6,300	10,640
Agriculture	130–150	435–460	555–590	935	1,760
Commercial	240–300	435–460	555–590	720	1,450
Residential	157	480–520	575–625	10,350	16,650
Government	150–250	435–460	555–590	735	1,550
Other	100–350	440–520	530–625	2,880	4,800
Total				21,920	36,850
Natural Gas	*EGP/CM*	*EGP/CM*	*EGP/CM*	*EGP million*	*EGP million*
Power	0.25	0.45	0.55–0.85	5,860	13,360
Industry	0.3–0.6	0.45	0.60–0.90	1,150	2,820
Residential	0.25	0.50	0.65–0.95	754	1,315
Other	0.25–0.50	0.50	0.65–0.95	2,250	4,880
Total				10,014	22,375

Annex 3 (cont.) Approximate amount of Egypt's energy subsidies in FY 2009/2010

	Price (average)	Financial cost	Economic cost	Subsidy (Financial)	Subsidy (Economic)
Petroleum	*EGP/ton*	*EGP/ton*	*EGP/ton*	*EGP million*	*EGP million*
LPG	225	1,840	4,350	9,650	19,750
Gasoline	1,750	2,430	5,280	5,625	16,680
Kerosene	1,320	2,430	5,280	830	1,530
Gas Oil	1,320	2,210	4,920	12,870	26,775
Fuel Oil	995	1,975	2,980	6,750	16,380
Total				35,725	81,115

Source: Castel (2012)

Publications of the German Development Institute

Nomos Verlagsgesellschaft

Liebig, Klaus: Internationale Regulierung geistiger Eigentumsrechte und Wissenserwerb in Entwicklungsländern: Eine ökonomische Analyse, 233 p., Nomos, Baden-Baden 2007, ISBN 978-3-8329-2379-2 (Entwicklungstheorie und Entwicklungspolitik 1)

Schlumberger, Oliver: Autoritarismus in der arabischen Welt: Ursachen, Trends und internationale Demokratieförderung, 255 p., Nomos, Baden-Baden 2008, ISBN 978-3-8329-3114-8 (Entwicklungstheorie und Entwicklungspolitik 2)

Qualmann, Regine: South Africa's Reintegration into World and Regional Markets: Trade Liberalization and Emerging Patterns of Specialization in the Post-Apartheid Era, 206 p., Nomos, Baden-Baden 2008, ISBN 978-3-8329-2995-4 (Entwicklungstheorie und Entwicklungspolitik 3)

Loewe, Markus: Soziale Sicherung, informeller Sektor und das Potenzial von Kleinstversicherungen, 221 p., Nomos, Baden-Baden 2009, ISBN 978-3-8329-4017-1 (Entwicklungstheorie und Entwicklungspolitik 4)

Loewe, Markus: Soziale Sicherung in den arabischen Ländern: Determinanten, Defizite und Strategien für den informellen Sektor, 286 p., Nomos, Baden-Baden 2010, ISBN 978-3-8329-5586-1 (Entwicklungstheorie und Entwicklungspolitik 7)

Faust, Jörg / Susanne Neubert (eds.): Wirksamere Entwicklungspolitik: Befunde, Reformen, Instrumente, 432 p., Nomos, Baden-Baden 2010, ISBN 978-3-8329-5587-8 (Entwicklungstheorie und Entwicklungspolitik 8)

[Books may be ordered only through publishing house or bookshops.]

Book series with Routledge

Brandt, Hartmut and Uwe Otzen: Poverty Orientated Agricultural and Rural Development, 342 p., Routledge, London 2007, ISBN 978-0-415-36853-7 (Studies in Development and Society 12)

Krause, Matthias: The Political Economy of Water and Sanitation, 282 p., Routledge, London 2009, ISBN 978-0-415-99489-7 (Studies in Development and Society 20)

[Books may be ordered only through publishing house or bookshops.]

Springer Verlag

Scheumann, Waltina / Susanne Neubert / Martin Kipping (eds.)*:* Water Politics and Development Cooperation: Local Power Plays and Global Governance, 416 p., Springer, Berlin 2008, ISBN 978-3-540-76706-0

[Books may be ordered only through publishing house or bookshops.]

Berichte und Gutachten

[Price: 9,63 Euro; books may be ordered directly from the DIE or through bookshops. This publication series was terminated and superseded by the new publication series **"Studies"**, starting November 2004.]

Studies

64 *Ashoff, Guido et al.:* Evaluación del "Fondo de planificación estratégica e implementación de reformas autofinanciadas en Chile", 92 p., Bonn 2012, ISBN 978-3-88985-501-5

63 *Ashoff, Guido et al.:* Evaluierung des deutsch-chilenischen "Fonds zur strategischen Planung und Umsetzung eigenfinanzierter Reformen", 94 p., Bonn 2012, ISBN 978-3-88985-500-8

62 *Fues, Thomas / LIU Youfa:* Global Governance and Building a Harmonious World: A comparison of European and Chinese Concepts for international affairs, 215 p., Bonn 2011, ISBN 978-3-88985-499-5

61 *Weikert, Jochen:* Re-defining 'Good Business' in the Face of Asian Drivers of Global Change: China and the Global Corporate Social Responsibility Discussion, 378 p., Bonn 2011, ISBN 978-3-88985-497-1

60 *Hampel-Milagrosa, Aimée:* The Role of Regulation, Tradition and Gender in Doing Business: Case study and survey report on a two-year project in Ghana, 77 p., Bonn 2011, ISBN 978-3-88985-496-4

59 *Weinlich, Silke:* Reforming Development Cooperation at the United Nations: An analysis of policy position and actions of key states on reform options, 134 p., Bonn 2011, ISBN 978-3-88985-495-7

58 *Chahoud, Tatjana et al.:* Corporate Social Responsibility (CSR) and Black Economic Empowerment (BEE) in South Africa: A case study of German Transnational Corporations, 100 p., Bonn 2011, ISBN 978-3-88985-494-0

57 *Neubert, Susanne et al.:* Agricultural Development in a Changing Climate in Zambia: Increasing resilience to climate change and economic shocks in crop production, 244 p., Bonn 2011, ISBN 978-3-88985-493-3

56 *Grimm, Sven et al.:* Coordinating China and DAC Development Partners: Challenges to the aid architecture in Rwanda, 200 p., Bonn 2010, ISBN 978-3-88985-492-6

55 *Weinlich, Silke:* Die Reform der Entwicklungszusammenarbeit der Vereinten Nationen: Eine Analyse des Verhaltens und der Positionierung wichtiger Staaten gegenüber Reformoptionen, 121 p., Bonn 2010, ISBN 78-3-88985-491-9

54 *Ifejika Speranza, Chinwe:* Resilient Adaptation to Climate Change in African Agriculture, 311 p., Bonn 2010, ISBN 978-3-88985-489-6

[Price: 10.00 Euro; may be ordered directly from the Institute or through bookshops]

Discussion Paper

9/2012 *Becker, Bastian / Doris Fischer:* Promoting Renewable Electricity Generation in Emerging Economies, 19 p., Bonn 2012, ISBN 978-3-88985-552-7

8/2012 *Hoang, Ha:* How to Evaluate Budget Support Conditionality and Policy Dialogue: Using the qualitative approach to causality, 51 p., Bonn 2012, ISBN 978-3-88985-548-0

7/2012 *Faust, Jörg / Sebastian Ziaja:* German Aid Allocation and Partner Country Selection: Development-Orientation, Self-Interests and Path Dependency, 27 p., Bonn 2012, ISBN 978-3-88985-551-0

6/2012 *Hensengerth, Oliver / Ines Dombrowsky / Waltina Scheumann:* Benefit-Sharing in Dam Projects on Shared Rivers, 37 p., Bonn 2012, ISBN 978-3-88985-549-7

5/2012 *Faust, Jörg:* Poverty, Politics and Local Diffusion: Resource allocation in Bolivia's Decentralised Social Fund, 23 p., Bonn 2012, ISBN 978-3-88985-550-3

4/2012 *Marino, Robert / Ulrich Volz:* A Critical Review of the IMF's Tools for Crisis Prevention, 38 p., Bonn 2012, ISBN 978-3-88985-547-3

3/2012 *Grävingholt, Jörn / Sebastian Ziaja / Merle Kreibaum:* State Fragility: Towards a Multi-Dimensional Empirical Typology, 38 p., Bonn 2012, ISBN 978-3-88985-546-6

2/2012 *Dafe, Florence:* The Politics of Central banking and Implicatuions for Regulatory Reform in Sub-Saharan Africa: The cases of Kenya, Nigeria and Uganda, 38 p., Bonn 2012, ISBN 978-3-88985-545-9

1/2012 *Weimer, Bernhard:* Municipal Tax Base in Mozambique: High Potential – Low Degree of Utilisation, 48 p., Bonn 2012, ISBN 978-3-88985-544-2

13/2011 *Brandi, Clara / Matthias Helble:* The End of GATT-WTO History? – Reflections on the Future of the Post-Doha World Trade Organization, 22 p., Bonn 2011, ISBN 978-3-88985-542-8

[Price: 6.00 Euro; may be ordered directly from the Institute or through bookshops]

Analysen und Stellungnahmen (ISSN 1434-8934)

8/2012 *Mahn, Timo:* Finanzierung der Entwicklungszusammenarbeit der Vereinten Nationen: Steigende Beiträge, aber weniger Multilateralismus

7/2012 *Loewe, Markus / Nicole Rippin:* Globale Armutsstrukturen im Wandel

6/2012 *Vollmer, Frank*: Die „neue Sichtbarkeit“: Zur Auflösung des Zielkonfliktes zwischen der Wirksamkeit und Sichtbarkeit der Entwicklungszusammenarbeit

5/2012 *Bauer, Steffen / Silke Weinlich:* Die Zukunft der UN Nachhaltigkeits-Architektur – Erwartungen an den „Rio+20-Gipfel

4/2012 *Houdret, Annabelle et al.:* Nachhaltiges Wassermanagement durch Green Economy?

3/2012 *Klingebiel, Stephan:* Entwicklungszusammenarbeit – Auslaufmodell oder Entwicklungsmotor für Subsahara-Afrika?

[Analysen und Stellungnahmen free of charge available from the DIE.]

Briefing Paper (ISSN 1615-5483)

6/2012 *Bauer, Steffen / Silke Weinlich:* Rio+20 and the Future oft the UN Sustainability Architecture – What Can we Expect?

5/2012 Houdret, Annabelle et al.: Sustainable Water Management through Green Economy?

4/2012 *Vollmer, Frank:* Visibility Vis-á-Vis Effectiveness of Aid: Looking for the Third Way

3/2012 *Loewe, Markus / Nicole Rippin:* Changing Global Patterns of Poverty

2/2012 *Herrfahrdt-Pähle, Elke / Birte Rodenberg:* The World Development Report 2012 “Gender Equality and Development”: Conceptual Turning Point – But no Change in Practice?

1/2012 *Klingebiel, Stephan:* Aid – Dinosaur or Development Engine for Sub-Saharan Africa?

[Briefing Paper free of charge available from the DIE.]

A complete list of publications available from DIE can be found at:

http://www.die-gdi.de