HARNESSING THE SUN AND WIND FOR ECONOMIC DEVELOPMENT? AN ECONOMY-WIDE ASSESSMENT FOR EGYPT

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Abstract

While the recent political transition in Egypt has put much-needed policy reforms on hold, our paper suggests that under certain conditions, fostering the national renewable energy strategy may be a promising way of giving an ailing economy an urgently needed impetus. Based on the literature and results of a renewable-energy focused computable general equilibrium model, we recommend that Egypt focus on the generation of wind power. At least part of the newly produced energy should be for the domestic market to ease the existing supply constraints and to avoid Dutch disease effects. In addition, to maximize the benefits of renewable energy sources, the renewable energy strategy should be accompanied by a reduction of energy subsidies. Finally, lessons from other countries suggest that sound institutions; appropriate, clear and lasting regulations; careful technology transfer; and cross-ministerial coordination are important for success.

JEL Classification: O11, D3, 0530, D58

Keywords: renewable energy, economic development, income distribution, CGE analysis, Egypt

ملخص

تقترح الورقة أنه في ظل ظروف معينة، وبتعزيز استراتيجية وطنية للطاقة المتجددة فى مصر قد تكون هذه هى الوسيلة الواعدة لإعطاء قوة دفع للاقتصاد المتعثر وذلك بالرغم من التحولات السياسية في مصر التى وضعت الإصلاحات التي تحتاجها مصر بشدة فى قائمة الانتظار. استنادا إلى الأدبيات ونتائج نموذج التوازن العام المحسوب للطاقة المتجددة، نوصى فى هذه الورقة بأن تقوم مصر بالتركيز على توليد الطاقة من الرياح. وعلى أقل تقدير ينبغي أن يكون جزءا من الطاقة المنتجة حديثا متاحة للسوق المحلية لتخفيف القيود على العرض الحالي وتجنب آثار Dutch disease. بالإضافة إلى ذلك، ولتعظيم الفوائد من مصادر الطاقة المتجددة، ينبغي أن تقترن استراتيجية الطاقة المتجددة بخفض دعم الطاقة. وأخيرا، الدروس المستفادة من البلدان الأخرى تشير إلى أن المؤسسات السليمة؛ واللوائح المناسبة، ونقل التكنولوجيا الدقيق؛ والتنسيق عبر الوزارات عوامل هامة للنجاح.

1. Introduction

The global debate on renewable energies often revolves around carbon dioxide (CO_2) emissions as one option to mitigate climate change. The power sector constitutes 41 percent of global CO_2 emissions (IEA 2012a), and the world is not on track to realize the 2020 interim CO_2 emission reduction targets (IEA 2012b). The energy-related global carbon emissions are largely driven by the increasing volume derived from within developing countries, including many Arab countries (IEA 2012a).[1] Limiting the increase of carbon emissions from energy generation in these countries is therefore indispensable for achieving challenging targets (IPCC 2011).[2] However, because economic development requires energy, especially at earlier stages of growth, balancing the rising demand for energy with a need to limit CO_2 emissions is one of the key climate change mitigation challenges (Chow et al. 2003; Jakob et al. 2012). Together with the increase of energy efficiency, which has huge potential to mitigate carbon emissions, the rapid diffusion of renewable energy technologies (RET) is thus considered the second most important mitigation option (GEA 2012).

The development of renewable energies may also have positive strategic and economic effects. The early and broad diffusion of RET would not only slow down the increase of global carbon emission but also allow economies to "leapfrog" over the use of conventional energy resources like oil, coal, or gas toward production technologies reliant on more climate-friendly power (Popp 2011; Watson and Sauter 2011). Diversifying electricity generation through RET may be particularly important in light of potentially rising future energy costs and geopolitical risks related to mineral resources (energy security). In addition, renewable energies may create jobs and thus foster economic development. Several studies to date have been comparing job creation effects of RET deployment with conventional power generation (see Rutovitz and Atherton 2009). The general picture shows that on a per-megawatt basis there are more jobs being created in solar and wind technology deployment than in conventional power technology. Finally, there may be other associated socioeconomic benefits, including the protection of resources, the reduction of air pollution, and improved health outcomes.

One of the main criticisms of renewable energies is that they are often not competitive and have to be subsidized. However, production costs for windmills and solar panels have decreased (in part because of subsidies) and—depending on location and the relevant opportunity costs for conventional energy—energy production from renewables can be profitable (REN21 2013). As a result, several emerging economies are stepping up efforts in RET deployment (IEA 2013). China, one such example, has been strengthening its renewables policies and targets since 2012; other countries, including several Arab countries, have developed renewable energy strategies and show considerable potential toward achieving them (OECD 2012). Economic challenges across the Arab world, such as the lack of transparency, political uncertainty, and regional economic disparities, need to be resolved in order to attract and retain investors (OECD 2012).

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[1] This led to the occurrence, for the first time in history, of developing countries surpassing transition and industrialized countries in aggregate CO_2 emissions from the energy sector (IEA 2012a). The net installations (that is, annual new power capacity installations without repowering) have been slightly larger for RET compared to conventional technology at the end of 2012 (REN21 2013, p. 23).

[2] The global energy supply has not become significantly cleaner in the last two decades, as evidenced by the fact that the amount of CO_2 emitted for each unit of energy supplied has decreased by less than 1 percent since 1990 (IEA 2013). Coal-fired power generation rose by nearly 6 percent between 2010 and 2012 globally and continues to grow faster than nonfossil energy sources on an absolute basis.

Egypt is one of the countries that laid out ambitious plans for developing RET. In fact, one of the reasons for developing RET is the hope that it will help promote economic growth and job creation. This is particularly important since recent political events have slowed down economic growth prospects and increased unemployment and poverty (AfDB 2013; Breisinger et al. 2013). Poverty has increased by nearly 50 percent in the past 15 years from a low of 16.7 percent (9.9 million people) in 1996 to 21.6 percent in 2009 and 25.2 percent (21 million) in 2011.[3] Moreover, although poverty remained highest in rural areas, the period 2009–2011 saw the fastest rate of increase in urban areas, where poverty grew by nearly 40 percent.

The objective of this paper is to assess how exactly RET can support economic development in Egypt and thus also provide lessons for other countries. In order to provide answers to these key related questions, the remainder of the paper is structured as follows. Section 2 examines the status quo of energy in Egypt as well as the potential and plans for renewables. Section 3 discusses the data and model. Section 4 presents the key results and section 5 concludes.

2. Energy in Egypt: Status Quo, Potential and Plans for Renewables

2.1 Status Quo

Energy production and use has been growing rapidly in Egypt over the past years. Oil and natural gas are the most important natural resources in Egypt´s natural assets (AfDB 2013). Gas production reached 2.17 trillion cubic feet (tcf) in 2011. Despite this strong growth in gas production, the existing capacity is still insufficient to meet export and domestic demand.

The oil sector presents a similar picture. Even though Egypt continuously discovers more reserves—which increased from 3.7 billion barrels in 2010 to 4.4 billion barrels in 2012—it produced only 815,000 barrels per day (2011), which shows decline. At the same time, domestic oil consumption has grown to about the same amount as oil production in 2011 (EIA 2013).

Egypt’s current installed capacity for electricity generation consists of 88 percent fossil-fuel-based technologies and 12 percent renewable energy technologies, of which 83 percent is hydropower (RCREEE 2012). Since all major hydropower sites have been developed there is little potential to expand electricity production from hydropower (AfDB 2012). In places where 99 percent of households have access to the electricity system, the peak load growth rate averaged 7.5 percent per year from 2005 to 2010 (AfDB 2012; Ibrahim 2012). In order to satisfy demand increase, the power sector expanded its installed capacity to roughly 25,000 megawatts by the end of 2010. Those efforts were insufficient to fully meet high and rising demand, however, and have led to widespread electricity shortages across the country (AfDB 2012). Natural gas has traditionally comprised nearly 100 percent of conventional supply but dropped to roughly 80 percent in 2010 because of the insufficient supply of gas (AfDB 2012). Heavy fuel oil has been burned to compensate for the gas shortage in the power sector.

2.2 Potential for renewables

Due to the limited availability of fossil fuels in the power sector and the increasing cost of electricity supply, the government´s interest in the diversification of the energy mix has been evolving rapidly in the past few years. Egypt is not only endowed with fossil fuel as a natural resource, however, but rather it also has solar irradiation and appropriate wind conditions—the prerequisites to producing electricity from renewable sources. The country has large deserts that

[3] A large share of poor and nonpoor people clusters around the poverty line, which can partially explain the rapid rate of increase of people moving into poverty in recent years.

are sparsely populated and thus, in principle, both solar and wind technologies have potential for widespread application. The annual direct normal solar irradiance ranges from 2,000 kilowatt hours per square meter (kWh/m2) to 3,200 kWh/m2 across the country, with a steady daily profile of approximately 9–11 hours of sunlight (AfDB 2012). Wind conditions are also favorable in the Gulf of Suez reaching wind speeds of 7–8 meters per second. The lower cost of wind technologies combined with the higher potential of wind power particularly in the western part of the Gulf of Suez (Ibrahim 2012) favor the adoption and proliferation of wind technologies in Egypt's energy mix.

Renewable technologies in Egypt are competitive with renewable technologies in both the MENA region and Europe (see Figure 1).

The estimated average costs of Egyptian power generation from existing power plants (including hydro, natural gas, and fuel oil) is at US$0.05/kWh. Those of onshore wind energy generation are at US$0.04–0.16/kWh, utility scale solar photovoltaic (PV) at US$0.9–0.40/kWh, and concentrated solar power (CSP) costs US$0.17–0.38/kWh (JCEE 2012; REN21 2013). This illustrates that wind technology specifically is competitive with conventional power generation technologies in Egypt. The figures we use (Dii 2013) are in that range and also confirm that wind technology is competitive with conventional power unlike PV and CSP.

2.3 Egypt´s renewable energy strategy

In response to these acknowledged challenges in the energy sector, the Egyptian Supreme Council of Energy has approved a strategy that aims to increase the share of renewable energy to 20 percent of electricity overall by 2020, with 12 percent coming from solar and wind technologies and 8 percent from hydropower (REN21 2013).[4] Specifically, Egypt's wind target is set at roughly 7,200 megawatts until 2020 and is clearly prioritized due to its lower cost compared to solar technologies (REN21 2013). Solar development targets are less pronounced and not as ambitious with a solar PV target at 220 megawatts by 2020 and 1,100 megawatts of CSP. Egypt announced further a 2027 target of 2,800 MW of CSP and 700 MW of PV (REN21 2013). The lower solar PV target is also due to the fact that solar technology is more expensive relative to wind technology.

Achieving these targets will require swift mid-term development of solar and wind power plants. In order to meet this requirement, the current installed capacity of wind electricity generation needs to grow by 13 times, PV by 15 times, and CSP by 55 times (RCREEE 2012).

The process by which to achieve these targets is in two parts (Vidican 2012; Amer 2009). First, a competitive bidding process for projects will be organized, leading to long-term power purchase agreements (PPA) of 20 to 25 years. Second, there will be feed-in tariffs (FiT) determined based on the results of the bidding process. The FiT intend to support small and medium developers with capacities up to 50 MW. The NREA has also increased efforts to incentivize private sector engagement in the emerging renewable energy sector. Proposed measures include favorable permits and land-use agreements for renewable energy project developers, custom-duty exemptions, local content awards in tendering processes, and power generation licenses from the national utility company.

[4] The development of wind technology was initiated in 1996 when the New & Renewable Energy Authority (NREA) was formed. A series of large-scale grid-connected wind projects have been implemented with a total installed capacity of about 550 megawatts in 2010 (AfDB 2012).

Solar and wind technologies in Egypt are not only expected to contribute to fuel savings and CO_2 reductions but also to meet the increasing electricity demand in the country (annual growth rate of peak load averaged between 2005 and 2010 at 7.5 percent per annum; AfDB 2012) and may cover part of the electricity demand in Europe, as proposed, for example, by the Desertec vision.[5]

In the following sections, we will investigate how these proposed renewable energy plans and the Egyptian power sector's shift toward renewable energy technologies will impact the country's overall economic development and welfare situation.

3. Modeling the Economy-Wide Effects of Investing in Renewable Energy

3.1 The database: a renewable-energy-focused social accounting matrix

The basis for our assessment of renewable energy investments in Egypt is a social accounting matrix (SAM) we developed. The SAM represents the structure of the Egyptian economy and importantly describes the linkages between various renewable energy sectors, other sectors of the economy, institutions, and other countries (through trade).[6] The SAM is based on the latest published supply and use tables compiled by the Central Agency for Public Mobilization and Statistics (CAPMAS) for 2008/09 and is complemented with data from the Household Income, Expenditure, and Consumption Survey for the same year (CAPMAS 2008/2009) as well as data on the economically active population in 2007 (ILO 2013). The SAM includes production, intermediate use, final demands, sectoral capital earnings, and sectoral expenditures on wages and salaries, as well as the distribution of factor income to households and the redistribution of income between the private and public sector. Key aspects of the Egyptian economy in 2008 will be discussed below.

The input-output data compiled by CAPMAS (2013) do not include statistics on renewable electricity supply technologies; rather the electricity sector in the benchmark data is an aggregate of existing renewable and conventional technologies. We therefore calculated the input requirements for the renewable electricity technologies based on additional data sources, allowing us to disaggregate the aggregate electricity sector into renewable and conventional subcomponents, as in Desertec Industrial Initiative (Dii 2013) and Calzadilla et al. (2013). We conduct our disaggregation using data from an industry survey conducted by Dii that describes cost and technological characteristics of PV, CSP, and wind electricity generation technologies (see Tables 1 and 2).

To generate cost shares for renewable equipment manufacturing, we calculated the weighted cost for each technology from the input-output data using the components in Table 1 as weights. This allows us to compile input cost shares for each technology and to separate the aggregate electricity generation sector into conventional and renewable subsectors. The input cost shares for all electricity-generating technologies are given in Table 3.

Overall, the key differences between renewable and conventional electricity technologies is that the renewable energy technologies are more capital intensive and less energy intensive than the conventional electricity generating technology. Renewable energy technologies are also somewhat less labor intensive and require significantly less intermediate inputs. Moreover, our data suggest that the renewable equipment manufacturing sectors, especially CSP, have a higher

[5] The Desertec vision aims to generate sustainable power from the sites where renewable sources of energy are most abundant and export it to regions like Europe with high electricity demand. This also contributes to combatting climate change, ensuring a reliable energy supply, and promoting security and development. (See www.desertec.org for online resources.)

[6] An aggregated macro-SAM can be found in Appendix A. For the detailed SAM, please contact the authors.

proportion of value added compared to the broader manufacturing sector. Yet, most of the value added that will be generated in the renewable sectors is capital income on foreign direct investment that will be repatriated to foreign owners of the capital stock.

3.2 The model: a dynamic computable general equilibrium model

To assess the potential impacts of alternative renewable investment schemes for Egypt, we build a multi-sector dynamic computable general equilibrium (DCGE) model. The Egyptian economy is modelled as a competitive economy with flexible prices and market conditions. Agents represented in the model are consumers, who maximize utility; producers, who maximize profits; and the government. Egypt is connected with the rest of the world via bilateral trade flows, remittances, and other transfers.

To reflect the fact that investments in windmills and solar panels take place over a longer period of time, the analytical framework is recursively dynamic—which means that the evolution of the economy over time is described by a sequence of single-period static equilibria connected through capital accumulation, changes in factor supply, and sector specific technical progress. The economic structure, including energy production from renewables, is fully specified and covers production, investment, and final consumption by consumers and the government. Policy instruments are taxes, subsidies, or quantity constraints in factor markets, product markets, and international trade. The model results show relative changes to a reference scenario that also needs to be defined.

Producers of renewable energy and those of other goods and services (including 1 agricultural sector, 23 industrial sectors, and 2 service sectors) are assumed to operate at constant returns to scale in a perfect competitive environment, and so make zero profits (see Table 4). For all sectors, except renewable energy producers, the production function consists of a constant-elasticity-of-substitution (CES) aggregate of capital and labor (and land in agriculture and renewables) nested within a Leontief aggregate of all other inputs (that is, intermediate demand is determined by fixed technology coefficients, or Leontief demand). For renewable energy producers, we support the entire capital-labor-land nest within the fixed factor foreign direct investment (FDI), which is determined exogenously by foreign investors.

We model separate domestic manufacturing sectors that produce capital equipment for renewable energy generation (for example, wind turbine blades, nacelles, solar panel and inverter manufacturers). Producers of renewable energy will choose to purchase outputs from these manufacturing sectors, rather than purchasing imported renewable energy capital goods. Profit maximization implies that factor payments equal average production revenues. Labor, capital, and land are fixed, implying full employment and intersectoral mobility, except for capital and land, which are assumed to be immobile across sectors. New capital from past investment is allocated to sectors according to profit rate differentials under a "putty-clay" specification. This means that once capital stocks have been invested it is difficult to transfer them to other uses. The same holds true for land in agriculture and in renewable electricity sectors. This means that as renewable electricity sectors expand, they generate additional demand for labor, which then affects economy-wide wages and production in other sectors by increasing labor competition. Based on the 2008/09 Household Income, Expenditure and Consumption Survey (HIECS), labor markets are segmented across three skill groups: (1) low-skilled workers with primary education, (2) semi-skilled workers with secondary education, and (3) skilled workers who have completed tertiary schooling.

Factor incomes are distributed to households using fixed income shares on households' initial factor endowments. Incomes are then saved (based on marginal propensities to save) or spent on consumption (according to marginal budget shares). Household savings and foreign capital inflows are collected in a national savings pool and used to finance investment demand (meaning a savings-driven investment closure). Finally, prices equilibrate product markets so that demand for each commodity equals supply. The model therefore links production patterns to household factor incomes through changes in factor employment and returns.

Households maximize a Cobb-Douglas utility function so that budget shares are constant. Households are disaggregated across rural/urban and by per capita expenditure quintiles, giving a total of 10 representative households in the full DCGE model. Households pay taxes to the government based on fixed direct and indirect tax rates. Tax revenues finance exogenous recurrent spending and transfers to households, resulting in an endogenous fiscal deficit. Finally, the model includes a simple consumption-side microsimulation module where each respondent in HIECS is linked to their corresponding representative household in the DCGE model. Changes in commodity prices and each household group's consumption spending are passed down from the DCGE model to the survey respondents, where their total per capita consumption and poverty measures are recalculated.

International trade is captured by allowing production and consumption to shift imperfectly between domestic and foreign markets, depending on the relative prices of imports, exports, and domestic goods (inclusive of relevant sales, trade taxes, and subsidies). This specification captures differences in domestic and foreign products and allows for observed two-way trade. However, Egypt is still considered a small economy, such that world prices are fixed and the real exchange rate (that is, price index of tradable to nontradable goods) adjusts to maintain a fixed current account balance.

Renewable electricity expansion is assumed to be driven entirely by foreign direct investment, and all profits generated in the renewable sectors are remitted abroad. The decision to invest is thus resolved exogenously by foreign investors, and we assume that the level of investment remains consistent with necessary profitability. Renewable energy producers must, however, compete with other sectors for intermediate inputs and labor resources. In the DCGE model, we assume full employment, which means that total labor supplies are fixed and increasing labor demand raises workers' wages. Moreover, we assume that all renewable electricity is exported.

We initially create the renewable electricity and renewable equipment manufacturing sectors representing their current capacities (see next section) then smoothly increase renewable energy production over the period 2008–2020, reflecting the likely gradual expansion of the industry. The wind target in Egypt is set to 7,200 megawatts by 2020 and is clearly prioritized for its lower cost compared to solar technologies (REN21 2013). Solar development targets are less pronounced and not that ambitious with a solar PV target at 220 megawatts by 2020 and 1,100 megawatts of concentrated solar power.

The Egypt DCGE model is first run forward using the 2008–2020 period, assuming no expansion in renewable electricity production. This produces a reference scenario against which to assess Egypt's renewables strategy. For this, we first calibrate the Egypt DCGE model to track observed trends in key demographic and macroeconomic indicators. Population growth and growth of unskilled, medium-skilled, and high-skilled labor are all set at 2 percent per year during 2008–2020. We exclude an expansion of agricultural land to capture rising population density in rural areas. In order to achieve recently observed growth rates in GDP, total factor productivity growth is set to 0.5 percent for agriculture and 1.6 percent for industry per year during the simulation period. Thus, the baseline scenario also captures the recent poor performance of the Egyptian economy. Then in the renewables simulations we expand the size of the renewable electricity and renewable equipment subsectors to produce the above mentioned target values.

4. Potential Impacts of Investing in Renewable Energy Projects

4.1 Renewables in the economy-wide context

Table 4 shows the structure of the Egyptian economy in 2008, which is the initial starting point for the model. Given our focus on renewable energy, employment generation, and poverty reduction, we are interested in how Egypt's renewable energy strategy affects the amount of income earned by each household and how it is earned. The SAM provides the information needed to answer both questions. The former is what is referred to as the *functional* distribution of income—the returns to factors—and the latter is the *size* distribution of income—how the factor returns are distributed (and redistributed) among households (and the government and the rest of the world).

Agriculture generates only 13 percent of Egypt's gross domestic product but more than 30 percent of total employment. Most farmers are smallholders with low education levels; more than 17 percent of total low-skilled labor income is generated in agriculture. However, Egypt as a whole relies on imported food, which accounts for 14 percent of total imports and 18 percent of all processed food in the country.

The Egyptian economy is dominated by mining (including oil, petroleum, and petroleum processing) and private services (including tourism and Suez Canal services). Mining does not, however, generate much employment, and most nonfarm workers in the country are employed in private and public services and construction. Incomes in many of these nonfarm sectors are only slightly higher than those in agriculture, due in part to low education levels and shortage of skilled labor in the country. Indeed, 85 percent of skilled-labor income is generated in the public sector. Energy is a small sector and renewable energy is still in its infancy, making up only a tiny share of total value added and employment in 2008.

4.2 Renewable energy scenarios

We assess the Egyptian renewable energy strategy in several scenarios (Table 5). All scenarios incorporate Egypt's investment and production plans for renewable electricity production by 2020, both for specific technologies (labelled "PV," "CSP," and "WIND") or for the combined investment into all technologies (labelled "COMB"). For combined scenarios, this involves a permanent 34 percent increase in FDI inflow to the renewable energy sector. This increase is equivalent to just under 1 percent of baseline GDP and 5 percent of baseline investment but total investment in renewables reaches 10 percent of total investment in 2020.

In all scenarios we assume that all renewable electricity is exported while additional domestic demand for electricity is satisfied by domestic and import supply of conventional electricity, which is a perfect substitute to renewable sources. COMB1 (and PV, CSP, and WIND) examines a scenario without climate policy, where renewable electricity can only be exported at prices of conventional electricity. Given low fossil fuels prices, this requires substantial subsidies to CSP technology and to a less extent to PV technology (Table 5). COMB2 assumes that climate change mitigation policies raise conventional electricity prices to a level that covers CSP production costs. Finally COMB3 assumes that, additionally, the Egyptian government reduces fuel subsidies by 10 percent as a complimentary measure to renewables policy. Consequent changes in the domestic budget balance, which follows from climate change mitigation policy and fuel policy balance, are accommodated through adjustments in investment, thus implying a redistribution of income from fuel consumers to investors.

4.3 Impacts on economic growth and employment

The renewables simulations reflect the case, where FDI and land are allocated to the renewables sectors according to Egypt's renewable energy strategy. This implies that the electricity generating capacity of PV will increase from 15 megawatts in 2008 to 220 megawatts in 2020 and that of CSP and WIND from 20 to 1,100 megawatts and from 550 to 7,200 megawatts, respectively. We assume that the solar and wind parks will be located on brown field sites or other sites, where there is no other valuable land use—meaning that renewable energy parks will not displace any agricultural land being cultivated.

In the scenario without climate policy (COMB1), the Egyptian economy adopts low fossil fuel prices that require substantial subsidies to the renewable electricity sector, especially CSP electricity production, in order for them to be competitive with conventional energy. Our results show that these subsidies increase gradually to up to 2.5 percent of GDP. Compared to the baseline scenario without renewable investment, the transition to a decarbonized power sector in Egypt leads to real income gains in the renewable energy sector (Table 7) as a result of FDI inflow to the renewable energy sector. However, these real income gains are dampened by a decrease in domestic investment and real income in other sectors and the overall impact of the renewable energy strategy on growth across the Egyptian economy for that scenario would be quite low; overall growth would be just 0.01 percentage points above baseline growth (Table 6). The reduction of domestic investment is mostly felt in the construction sector, where the growth rate is one percentage point lower than in the baseline and largely results from the subsidies to CSP technology (see column 4 in Table 7), while the impact of subsidies to PV technology (column 5) is quite low, given their small share in the renewable energy investment plan.

Our findings suggest that, in the case of Egypt, the massive scaling up of renewable energy may negatively affect other sectors in two key ways. First, the expansion of PV and especially CSP technologies and the accompanying rise in subsidy payments to these sectors imply that an increasing amount of investment is drawn from the overall macroeconomic investment budget. Thus demand for investment goods is reduced, and this is mostly felt in the construction sector. Second, export sectors are negatively affected through Dutch disease effects, if all renewable energy is exported (see Table 7). This is because in our simulations the renewable energy sector eventually accounts for almost 25 percent of total merchandise export earnings by 2020. Since we assume that the current account balance is fixed in foreign currency, the increase in exports causes the real exchange rate to appreciate relative to the baseline scenario (see Table 6). This reduces the competitiveness of traditional export sectors, such as textiles, chemicals, electrical and nonelectrical machinery, and private services (tourism and Suez Canal services); these exports therefore decline.

In the isolated PV and CSP scenarios, the demand effects clearly dominate. For example, the number of workers employed in construction falls to 438,000 and 6,000 workers in the CSP and PV scenarios, respectively (Table 8). By contrast, the number of workers used in construction increases by 21,000 in the WIND scenario, because rising incomes lead to increases in total domestic savings and investment demand but also decreases in export-oriented sectors as a result of the real appreciation. In this case, workers are reallocated from trade-oriented agriculture and private services to the renewable energy sectors. In the COMB1 scenario, which replicates Egypt's renewable energy strategy, both effects are at work and lead to a restructuring of the economy toward manufacturing services while the construction sector contracts.

Scenarios **COMB2** and **COMB3** assume that prices for fossil fuels rise swiftly and steadily because of limits on CO_2 emissions, thereby leading to a convergence of renewable and conventional electricity production costs. The reduced need to subsidize solar power implies that the Dutch disease effect dominates, reducing the competitiveness of traditional export sectors, such as textiles, chemicals, electrical and non-electrical machinery, and private services (tourism and Suez Canal services), and these sectors decline. Agricultural production and food processing decrease despite rising domestic income since the appreciation of the real exchange rate also reduces the competitiveness of domestic import-competing sectors. Ultimately, the trade-offs from renewable energy production are smaller than the gains from new investments in the renewable energy sector. As a result, national GDP growth rates increase in all renewable energy scenarios, though these increases vary depending on the volume of investment and whether the renewable energy strategy is somehow flanked by additional measures.

Scenario **COMB3** assumes that the renewable energy strategy is supported by a 10 percent reduction of fuel subsidies. Lower fuel subsidies have no direct impact on the renewable energy sectors, but exhibit significant indirect effects: by raising input costs to almost all sectors, they lead to a higher real appreciation. Moreover, lower government subsidies imply a reduction of the public deficit and an increase in investment, both of which lead to significantly higher growth in the COMB3 scenario compared to COMB 1 and COMB2.

Generally, the more profitable the renewable electricity production technology is, the larger its impact on national economic growth. Thus, the scenario with the largest positive gains in total GDP is WIND, which is the most profitable renewable electricity technology (see Table 2).

Table 8 reports impacts on employment. The number of jobs created in the renewable energy sector varies greatly across scenarios. The last three columns show the labor requirements to build up and operate a 100 megawatt solar or wind park. Generally, CSP is the most labor-intensive technology followed by PV and WIND. For all technologies, the number of workers used to produce renewable electricity is much smaller than the number of workers used to build up a renewable energy park. For example, one individual operation and maintenance worker in electricity production is needed for every 26 equipment manufacturing workers in the PV sector. The labor intensity of renewable electricity production is higher. Finally, CSP generation is also highly labor-intensive. In fact, the large amount of capital required to produce CSP equipment makes it the most labor-intensive option overall.

Low investments in PV and low labor-intensity mean that only 7,700 manufacturing jobs are created in the PV scenario. Conversely, CSP equipment manufacturing employs 74,000 additional workers to produce renewable equipment in the CSP scenario. Wind equipment manufacturing is less labor-intensive than CSP and PV, however; the significant investment pays off and generates the most jobs.

Renewable electricity generation creates very few jobs, with almost all employment effects from renewable investment coming from equipment manufacturing. Moreover, unlike those in equipment manufacturing, jobs in electricity plants are largely reserved for semi-skilled and skilled workers; most of these workers must be sourced from other manufacturing subsectors as the renewable electricity sector grows. Lower skilled laborers mainly come from agriculture and services. Enhancing a renewable electricity industry in Egypt will therefore create new job opportunities for some sectors but will also impose significant adjustment costs on others, especially those in export agriculture and services.

4.4 Impacts on household incomes and poverty

Investments in renewables increase national GDP and factor returns, causing household incomes to rise. Although this is true in all renewables scenarios, there are significant differences in the distributional impacts across household groups. Table 9 reports changes in households' equivalent variation, which is a welfare measure that controls for changes in prices. All rural quintiles benefit from the expansion of renewable energy production in Egypt. What's more, lower-income households actually see the most benefit because they receive a larger share of their income from labor, which has become relatively scarce as a result of the renewables expansion.

Urban households also benefit from an increase in the economy-wide returns to labor and capital and from the higher overall level of economic growth in the country. It is typically the middle of the urban income distribution that benefits the most, owing to the fact that these quintiles rely more heavily on labor wages for their incomes. Moreover, these households are typically endowed with semi-skilled and high-skilled labor, which is used fairly intensively in the renewable equipment manufacturing sectors (for example, as operators and technicians).

Figure 2 shows the national distributional effects of the renewables strategy on households' equivalent variation. PV receives only a tiny share of the total investment volume of Egypt's renewable strategy and therefore generates very little additional value added in the economy, so its effects on household welfare are small. CSP and WIND are far more beneficial for households. Moreover, the welfare gains are evenly distributed across lower expenditure quintiles. Clearly, only if the renewables strategy is combined with a reduction of fuel subsidies will the strategy lead to significant improvements in income distribution. Lower-income households benefit the most from the expansion of overall activity in COMB3.

Table 10 reports changes in national and regional poverty rates for the various renewable scenarios. The headcount rate—which measures the share of the population below the poverty line—declines most under the renewable energy cum fuel sector liberalization scenario (COMB3). There is almost no poverty reduction, however, in the unilateral Egyptian renewables strategy (COMB1). Yet, if undertaken within a global climate protection system (COMB2) and combined with a reduction of fuel subsidies (COMB3), prices for conventional electricity and higher public investment in Egypt will benefit poor households, which earn most of their income from the provision of low-skilled labor to construction and the production of consumer nondurables ,including food and agricultural products.

5. Summary and Policy Implications

Investments in renewable energy can be beneficial for economic growth, employment, and the poor. However, the quantity and quality of those benefits depend on the natural conditions, opportunity costs of conventional energy, structure of the economy, institutional capacity to implement energy sector reform, and other factors.

One of the countries that has significant potential for renewable energy production and ambitious plans for expansion is Egypt. While the recent political transition has put many initiatives on hold, the authors suggest that, under certain conditions, fostering the renewable energy strategy may be a promising way to provide an urgently needed impetus for the ailing economy. More specifically, the evidence-based results of our research lend themselves to the following recommendations.

- Egypt should focus on the generation of wind power. Not only is wind power the sole renewable energy source competitive without subsidies, but also it is among the most favorable for economic growth, employment, and poverty reduction.
- An export-led renewable energy strategy can offset some of the positive effects through Dutch disease. Results suggest that if all renewable energy planned under the Egyptian strategy is exported, these may compose up to 20 percent of all exports by 2020. Given the related appreciation of the real exchange rate and potential loss of jobs in other export sectors, it is advisable to consume a significant amount of additional energy domestically.
- The implementation of the renewables strategy should be accompanied by a reduction of energy subsidies. Energy subsidies distort markets and render most of the renewable energies uncompetitive; they also contribute to Egypt's high budget deficit. Reducing energy subsidies would not only lower the deficit but also support the development of renewable energies.
- While investments in renewable energy have positive growth and employment effects, their impact on the poor has been rather modest to date. Thus, if poverty reduction is the main policy goal, other policies that support broader-based growth and targeted social safety nets are more appropriate.

Finally, it is important to stress that the implementation of a renewable energy strategy can be very challenging and complex. For example, windmills and solar panels designed for a European climate may not function well in Egypt's desert region, where temperatures are higher and the volume of sand is a concern. If these potential caveats are carefully assessed, however, sun and wind have the potential to support economic development. Sound institutions, appropriate and lasting regulations, careful technology transfer, and cross-ministerial coordination are the keys to success.

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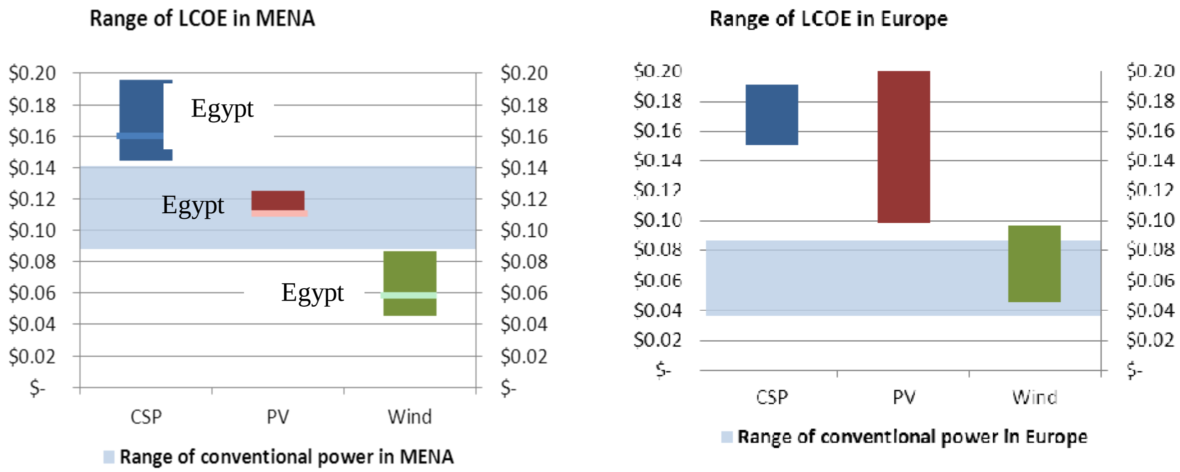
Box: Energy Subsidies in Egypt

The contradiction of high natural resource wealth on the one side and insufficient supply to domestic markets on the other can be explained by the highly distorting subsidy scheme. Egypt´s energy consumption has been growing faster than consumption rates in comparable economies. For example, Egypt's consumption of natural gas grew by more than 15 percent in 2011—even though the economy was in a contraction phase. This is due to the fact that oil producers are required to sell to national consumers at a price well below world market level. The results of providing this cheap oil and gas to domestic industries and households? Government losses in excess of US$1 billion per year in 2010.

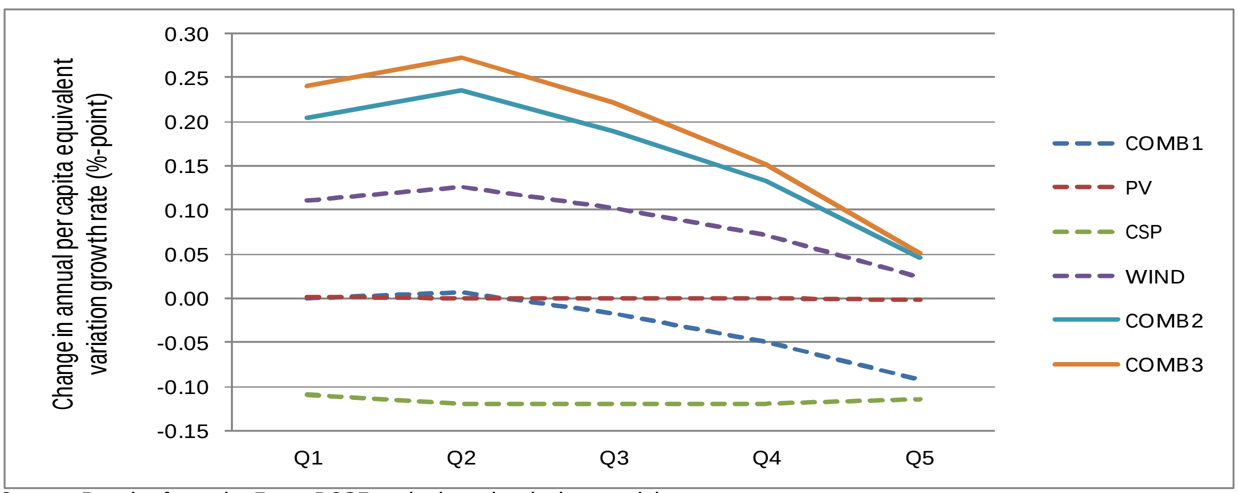
Simultaneously, it has become more difficult to maintain fossil-fuel-extraction margins since newly discovered reserves are increasingly expensive to access. Energy subsidies amounted to 11.9 percent of gross domestic (GDP)—one-third of which is spent for subsidies for electricity generation (EBRD 2012).

Figure 1: Range of Levelized Cost of Electricity for Different Technologies in MENA and Europe (€/kWh)



Note: LCOE = levelized cost of electricity; CSP = concentrating solar power; PV = photovoltaic
Source: Authors' calculations based on Desertec Industrial Initiative (Dii 2013).

Figure 2: Change in Per Capita Equivalent Variation from Baseline Scenario by Quintile, 2010–2020



Note: Equivalent variation is a measure of household welfare that controls for changes in commodity prices
Source: Results from Egypt DCGE and microsimulation model.

Table 1: Production Cost Estimates for Renewable Equipment Manufacturing (EUR/kW)

	PV	CSP	WIND
Minerals and mineral products		464	
Rubber, plastic products		579	
Metals and metal products	150	678	289
Electronic equipment	810	355	
Machinery and other equipment	260	919	459
Vehicles and transport equipment			224
Construction	90	583	79
Other transport		215	15
Business services	150	997	134
Total	1460	4790	1200

Source: Dii (2013).

Table 2: Production Cost Estimates for Renewable Electricity Generation (EUR/kW)

	PV	CSP	WIND
Electronic equipment	7.5		
Machinery and other equipment	4.2	21.7	10.8
Water		3.8	
Business services	0.7	8.1	3.2
Insurance	5.0	26.6	3.2
Labor remuneration	21.0	32.6	3.6
Capital rental	102.2	335.3	84.0
Land rental	1.60	0.20	3.20
Total	142.2	428.3	108.0

Source: Dii (2013).

Table 3: Benchmark Cost Shares for Renewable Equipment Manufacturing, All Other Manufacturing, and Electricity Generation

	Equipment manufacturing				Electricity generation			
	PV	CSP	WIND	Other manu.	PV	CSP	WIND	Conventional
Intermediates	0.65	0.56	0.65	0.69	0.12	0.14	0.16	0.55
Energy								0.10
primary education	0.05	0.06	0.05	0.03	0.09	0.05	0.02	0.09
secondary education	0.02	0.02	0.02	0.01	0.04	0.02	0.01	0.04
tertiary education	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01
Capital	0.28	0.35	0.27	0.25	0.72	0.78	0.78	0.21
Land	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.00
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Source: Dii (2013) and CAPMAS (2013).

Table 4: Structure of Egypt's Economy, 2008

		Share of total (%)				Export intensity (%)	Import penetration (%)
		GDP	Employment	Exports	Imports		
1-26	Total	100.00	100.00	100.00	100.00	16.59	20.14
1	**Agriculture**	**13.41**	**31.82**	**2.70**	**8.00**	**4.00**	**13.70**
2-24	**Industry**	**36.95**	**22.05**	**63.63**	**82.20**	**22.00**	**31.76**
2	Mining	15.83	0.16	19.40	6.40	31.90	16.00
3-18	Manufacturing	14.92	11.01	39.70	72.80	23.62	41.71
3	Food processing	3.61	2.07	4.10	6.00	10.30	18.00
4-18	Other manufacturing	11.31	8.94	35.60	66.80	27.62	47.37
4-6	**Renewable equipment manufacturing**	**0.18**	**0.05**	**0.70**	**0.60**		**36.21**
4	PV equipment	0.01	0.00	0.00	0.00		49.50
5	CSP equipment	0.03	0.01	0.10	0.10		30.30
6	Wind equipment	0.15	0.04	0.60	0.50		36.70
12	Petroleum and petroleum processing	2.05	0.79	14.90	4.40	45.70	24.40
19-23	Utilities	1.71	1.27	2.40	2.60	12.44	15.96
19-22	Electricity	1.33	0.94	2.30	0.60	15.10	5.29
19-21	**Renewable electricity**	**0.04**	**0.00**	**2.20**	**0.00**	**100.00**	
19	PV electricity	0.00	0.00	0.10	0.00	100.00	
20	CSP electricity	0.01	0.00	0.30	0.00	100.00	
21	Wind electricity	0.04	0.00	1.80	0.00	100.00	
22	Conventional electricity	1.29	0.93	0.10	0.60	0.80	5.30
23	Water	0.38	0.34	0.10	2.00	1.90	39.50
24	Construction	4.50	9.60	1.50	0.40	3.90	1.40
25-26	**Services**	**49.64**	**46.13**	**33.50**	**9.30**	**0.07**	**5.10**
25	Private services	18.35	22.07	31.10	2.20	29.40	3.40
26	Government services	31.29	24.07	2.40	7.10	1.70	6.00

Source: Results from the Egypt DCGE model

Table 5: Scenarios for Renewable Energy Development in Egypt by 2020

Scenario	Capacity buil-up, MW	Total FDI/baseline investment, %	Reference electricity price	Subsidy rate %
COMB1	585─8,420	4.80	fuel unit cost	PV: 18.8%; CSP 75.1%
PV	15─220	0.85	fuel unit cost	18.80%
CSP	20─1,100	2.22	fuel unit cost	75.10%
WIND	550─7,200	3.23	fuel unit cost	─
COMB2	585─8,420	4.80	converges to CSO unit cost	─
COMB3	585─8,420	4.80		fuel excise subsidy: -10%

Table 6: Core Macroeconomic Assumptions and Results, 2008–2020

	Initial, 2008	Baseline scenario	Investment in renewable energy sectors					
			COMB1	PV	CSP	WIND	COMB2	COMB3
			Average annual growth rate, 2008-20 (%)					
Population	80 millions	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Total GDP	100.00	4.15	4.16	4.15	3.96	4.34	4.48	4.55
Labor	24.93	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Primary	9.17	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Secondary	4.55	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Tertiary	11.21	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Domestic capital stock	73.79	2.95	2.87	2.95	2.87	2.96	2.96	3.03
Renewables FDI supply	0.20	0.00	34.21	3.35	23.86	27.18	34.21	34.21
Total land supply	1.08	0.00	0.15	0.00	0.00	0.14	0.15	0.15
			Final-year value, 2020					
Electricity generating capacity, MW								
PV	15	15	220	220			220	220
CSP	20	20	1,100		1,100		1,100	1,100
Wind	550	550	7,200			7,200	7,200	7,200
Real exchange rate	100.00	100.60	100.20	100.60	101.20	99.70	99.00	99.00
Nominal exchange rate	100.00	100.40	99.90	100.40	100.60	99.70	99.20	99.20
Domestic prices	100.00	99.80	99.60	99.80	99.40	100.00	100.10	100.10
Renewables FDI supply	244.1 millions EUR	244.13	4,627.47	102.22	1,864.26	2,660.99	4,627.47	4,627.47

Source: Results from the Egypt DCGE model

Table 7: Sector growth results, 2008–2020

	GDP share 2008 (%)	Baseline growth (%)	Deviation from baseline scenario growth rate (%-point)					
			Investment in renewable energy sectors					
			COMB1	PV	CSP	WIND	COMB2	COMB3
GDP	**100.00**	**4.18**	**0.25**	**0.00**	**0.07**	**0.17**	**0.31**	**0.36**
Agriculture	**13.41**	**2.87**	**-0.04**	**0.00**	**-0.02**	**-0.01**	**-0.02**	**0.04**
Industry	**36.95**	**4.62**	**0.69**	**0.02**	**0.20**	**0.48**	**0.84**	**0.88**
Mining	15.83	4.82	-0.09	0.00	-0.08	-0.01	-0.01	0.05
Manufacturing	14.92	4.51	1.61	0.03	0.70	0.92	1.62	1.59
Food processing	3.61	4.18	-0.04	0.00	-0.03	-0.02	-0.03	0.03
Non-food manufacturing	11.31	4.61	2.08	0.05	0.92	1.20	2.09	2.04
Renewable equipment manufacturing	0.18	1.54	34.92	3.39	24.85	27.40	34.85	34.82
PV manufacturing	0.01	1.54	31.26	31.28	0.06	-0.08	31.15	31.12
CSP manufacturing	0.03	1.53	50.05	0.00	50.15	-0.07	49.93	49.89
Wind manufacturing	0.15	1.54	29.76	0.00	0.07	29.68	29.72	29.70
Textiles	2.22	4.62	-0.05	0.00	-0.01	-0.04	-0.07	0.00
Wood	1.20	4.61	-0.07	0.00	-0.04	-0.03	-0.06	0.02
Paper and printing	0.41	4.62	0.02	0.00	0.03	0.00	-0.01	0.04
Chemicals	1.33	4.67	-0.03	0.00	0.02	-0.05	-0.07	-0.06
Rubber and plastics	0.22	4.70	0.17	0.01	0.06	0.11	0.16	0.23
Petroleum and petroleum processing	2.05	4.77	-0.11	0.00	-0.08	-0.03	-0.06	-0.57
Non-metallic products	0.86	4.63	0.02	0.00	-0.03	0.04	0.11	0.08
Basic metals	0.88	4.69	0.38	0.01	0.05	0.32	0.39	0.26
Fabricated metal products	0.86	4.48	0.17	0.00	-0.10	0.26	0.34	0.44
Non-electrical machinery	0.26	4.70	-0.22	0.00	-0.09	-0.13	-0.19	-0.12
Electrical machinery	0.55	4.67	-0.16	0.00	-0.06	-0.10	-0.15	-0.07
Transport equipment	0.30	4.59	-0.04	-0.01	-0.11	0.06	0.01	0.11
Utilities	1.71	4.19	3.30	0.09	1.39	2.05	3.24	3.08
Electricity	1.33	4.16	4.00	0.12	1.71	2.52	3.97	3.86
Renewable electricity	0.04	1.61	34.32	3.70	23.05	27.77	34.21	34.18
PV electricity	0.00	1.56	31.30	31.28	0.04	-0.03	31.15	31.12
CSP electricity	0.01	1.59	50.09	0.00	50.12	-0.02	49.93	49.89
Wind electricity	0.04	1.62	29.80	0.00	0.01	29.79	29.72	29.70
Conventional	1.29	4.24	0.22	0.00	0.08	0.14	0.23	0.08
Water	0.38	4.30	0.47	0.00	0.22	0.26	0.29	-0.11
Construction	4.50	4.45	-0.95	-0.02	-1.02	0.06	0.10	0.39
Services	**49.64**	**4.18**	**-0.03**	**0.00**	**0.00**	**-0.02**	**-0.03**	**0.02**
Private services	18.35	4.41	-0.04	0.00	0.00	-0.04	-0.06	0.00
Public services	31.29	4.04	-0.01	0.00	0.00	-0.01	-0.01	0.03

Source: Results from the Egypt DCGE model.

Table 8: Employment results, 2008–2020

	Employment, 2008	Baseline employment, 2020	Deviation from baseline scenario, final employment						Employment generation/additional 100MW electricity		
			Investment in renewable energy sectors								
			COMB1	**PV**	**CSP**	**WIND**	**COMB2**	**COMB3**	**PV**	**CSP**	**WIND**
Total workers	21,677	26,422	0	0	0	0	0	0			
Agriculture	**6,897**	**8,145**	**53**	**-1**	**115**	**-58**	**-103**	**-117**	**-452**	**10,615**	**-878**
Industry	**4,780**	**6,013**	**-159**	**3**	**-304**	**135**	**226**	**260**	**1,238**	**-28,150**	**2,030**
Mining	**35**	46	0	0	1	-1	-1	-1	-10	48	-9
Manufacturing	2,387	2,998	233	8	122	103	172	141	3,845	11,297	1,547
Food processing	449	517	4	0	10	-5	-8	-10	-49	900	-74
Other manufacturing	1,939	2,481	229	8	112	108	181	151	3,893	10,396	1,621
Renewable equipment manufacturing	**11**	**11**	**185**	**8**	**74**	**103**	**183**	**182**	3,767	6,814	1,549
PV manufacturing	1	1	8	8	0	0	7	7	3,771	1	0
CSP manufacturing	1	1	71	0	73	0	70	69	0	6,793	-1
Wind manufacturing	9	9	106	0	0	103	106	105	-3	20	1,550
Textiles	430	550	3	0	10	-7	-13	-13	-80	971	-109
Wood	232	296	0	0	4	-3	-6	-6	-49	341	-50
Paper and printing	79	101	2	0	3	-1	-1	-1	3	264	-8
Chemicals	257	331	4	0	9	-5	-7	-10	-25	840	-75
Rubber and plastics	43	55	3	0	2	1	2	2	51	196	17
Petroleum and petroleum processing	170	222	-4	0	0	-4	-6	-23	-71	-26	-54
Non-metallic products	166	212	5	0	3	1	4	1	11	311	21
Basic metals	171	221	24	1	8	15	19	12	285	771	233
Fabricated metal products	166	206	11	0	-1	11	15	16	111	-105	172
Non-electrical machinery	50	65	-2	0	0	-2	-3	-3	-38	-14	-31
Electrical machinery	107	137	-3	0	1	-4	-6	-5	-29	83	-54
Transport equipment	58	74	0	0	-1	1	0	0	-43	-50	12
Utilities	276	342	24	1	12	12	18	6	269	1,103	178
Electricity	203	250	17	0	8	8	14	7	225	741	124
Renewable energy production	**0**	**0**	**5**	**0**	**2**	**3**	**4**	**4**	143	184	39
PV electricity	0	0	0	0	0	0	0	0	143	0	0
CSP electricity	0	0	2	0	2	0	2	2	0	184	0
Wind electricity	0	0	3	0	0	3	2	2	0	1	39
Conventional energy	203	250	12	0	6	6	10	3	82	556	85
Water	73	92	8	0	4	4	4	-1	44	362	54
Construction	2,081	2,627	-417	-6	-438	21	37	114	-2,867	-40,598	314
Services	**10,000**	**12,263**	**97**	**-2**	**187**	**-82**	**-132**	**-152**	**-994**	**17,269**	**-1,240**
Private services	4,783	5,986	41	-1	112	-65	-107	-115	-727	10,363	-984
Government services	5,217	6,277	56	-1	75	-17	-25	-37	-267	6,907	-256

Source: Results from the Egypt DCGE model

Table 9: Household Per Capita Equivalent Variation Results, 2008–2020

	Per-capita consumption, 2008 (LE)	Baseline growth (%)	Deviation from baseline scenario growth rate (%-point)					
			COMB1	PV	CSP	WIND	COMB2	COMB3
Rural	2,879.2							
Quintile 1	2,207.5	2.02	0.03	0.00	-0.11	0.14	0.27	0.32
Quintile 2	2,443.1	2.51	0.06	0.00	-0.12	0.18	0.33	0.39
Quintile 3	2,648.4	2.53	0.00	0.00	-0.12	0.12	0.23	0.27
Quintile 4	2,925.3	2.73	-0.03	0.00	-0.13	0.10	0.18	0.21
Quintile 5	3,591.0	2.77	-0.04	0.00	-0.12	0.08	0.14	0.17
Urban	4,715.3							
Quintile 1	2,778.9	2.13	-0.04	0.00	-0.12	0.08	0.14	0.17
Quintile 2	3,144.2	2.47	-0.04	0.00	-0.11	0.07	0.12	0.14
Quintile 3	3,701.6	2.59	-0.05	0.00	-0.12	0.07	0.14	0.16
Quintile 4	4,496.1	2.69	-0.04	0.00	-0.12	0.08	0.14	0.16
Quintile 5	8,356.4	2.76	-0.06	0.00	-0.11	0.05	0.10	0.11

Source: Results from the Egypt DCGE model

Table 10: Poverty Results, 2008–2020

	Poverty rate, 2008(%)	Baseline poverty, 2020 (%)	Deviation from final baseline scenario poverty rate (%age point)					
			COMB1	PV	CSP	WIND	COMB2	COMB3
Headcount (P0)	21.8	12.2	0.0	0.0	0.3	-0.3	-0.5	-0.7
RURAL	29.9	17.1	-0.1	0.0	0.3	-0.5	-0.9	-1.1
URBAN	10.4	5.3	0.1	0.0	0.2	-0.1	-0.1	-0.2
Gap (P1)	4.5	2.3	0.0	0.0	0.1	-0.1	-0.2	-0.2
RURAL	6.2	3.2	0.0	0.0	0.1	-0.1	-0.3	-0.3
URBAN	2.0	1.0	0.0	0.0	0.0	0.0	-0.1	-0.1
Squared gap (P2)	1.4	0.7	0.0	0.0	0.0	-0.1	-0.1	-0.1
RURAL	2.0	0.9	0.0	0.0	0.1	0.0	-0.1	-0.1
URBAN	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0

Source: Results from the Egypt DCGE and microsimulation model.

Appendix A: Macro SAM for Egypt 2008/2009 (billions £E)

	Activities	Commodities	Factors	Households	Government	Rest of the world	Savings-Investment	Direct taxes	Import tariffs	Indirect taxes	Total
Activities		1,820.8									1,820.8
Commodities	751.5			821.4	98.0	299.8	200.0				2,170.6
Factors	1,069.4										1,069.4
Households			1,067.5		42.0	42.3					1,151.7
Government						3.4		141.3	14.1	-30.9	127.9
Rest of the world		366.6	1.9								368.5
Savings-Investment				189.0	-12.0	23.0					200.0
Direct taxes				141.3							141.3
Import tariffs		14.1									14.1
Indirect taxes		-30.9									-30.9
Total	1,820.8	2,170.6	1,069.4	1,151.7	127.9	368.5	200.0	141.3	14.1	-30.9	

Source: Results from the Egypt DCGE model