The Economic Imperative and Employment Opportunities of a Global Energy Transformation in Middle East North African Nations

An Economic Narrative

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Contents

What is purpose of this report?

With a greater emphasis on energy efficiency, resource productivity, and the scaling up clean energy resources, this economic narrative highlights key trends associated with both the global economy and the Middle Eastern and North African (MENA) countries. In particular, it provides an initial framework for understanding the structure of a prototype employment assessment tool that can evaluate the impacts of investments in greater energy efficiency and renewable energy in MENA countries.

What is the scope?

The report lays out the economic rationale and associated analytical framework with insights into the direct, indirect and induced net job creation associated with more productive, clean energy pathways and transformation strategies in MENA countries. The transformation strategies are anchored around the transformation of the energy sector on both the demand and supply side, with markets shifting from large, centralized and publicly owned energy suppliers to smaller, distributed and private players, and driven by investments and large-scale implementation of energy efficiency (EE) and renewable energy (RE) technologies and solutions.

What geographies does the report cover?

This report focuses on the Middle East North African (MENA) nations of Egypt, Morocco, and Yemen, but also retains a global perspective. The assessment relies on both technology and national data from various agencies as the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), the Organisation for Economic Cooperation and Development (OECD), the U.S. Energy Information Administration (EIA), and the World Bank, among others public sources. The economic rationale, assessment and recommendations can also be applied to other MENA nations.

Who is it for?

The report is intended primarily for country policy makers and private sector stakeholders and partners working with the World Bank in the MENA region, particularly in Egypt, Morocco and Yemen. It provides insights into the potential employment impacts of various clean energy technology pathways as they might create more energy-efficient, clean energy economies that can become more robust and sustainable over the period 2020 through 2050.

What methodology was used?

Three forms of tools and evidence were used in this report. First, the assessment draws on international economic, energy and employment data for the world economy, and also for the MENA and OECD nations. It provides first estimates of the likely magnitude of jobs and career development impacts that might emerge from investment in what we refer to as a "global energy transformation" (or a series of energy innovation scenarios anchored around the scale-up of EE and RE outlays) that MENA countries might follow. Second, it draws upon a wide range of interviews, analytical critiques, and literature reviews conducted during the period the July 2019 to September 2019. Finally, it draws on a variety of analytical tools such as the DEEPER Modeling System to lay the foundation of an employment assessment tool that, in turn, will enable MENA countries to evaluate their clean energy plans and policies for their net job benefits in ways that also enable a more robust and sustainable economy.

Who are the authors?

The underlying research tasks and analysis was carried out by a team associated with Economic and Human Dimensions Research Associates in collaboration with the World Bank. The larger framework and writing of this analysis are provided by international resource economist, John A. "Skip" Laitner with helpful analytical support from economist Jim Barrett. The report is the property of the World Bank which holds the intellectual rights.

Disclaimer

Abstract

In 2018 businesses, households and government enterprises throughout the global economy spent an estimated $8.2 trillion to meet the many demands for various energy services. Current projections suggest the present scale of annual expenditures may increase 60 percent to $13.2 trillion by 2050 (with all costs expressed in real 2018 dollars). While energy is a key driving force of economic well-being, current consumption and production patterns carry significant costs. Access to sufficient energy remains an issue in developing countries, while the environmental impacts of traditional energy supplies carry local and global implications that are becoming increasingly dire. Shifting toward more environmentally sustainable energy systems implies a fundamental transition that must be achieved while also ensuring energy access and meeting larger economic development goals.

Fortunately, within the countless energy markets throughout the global economy—whether the Middle East North Africa (MENA) countries, or the so-called advanced economies, there are substantial opportunities to help meet these challenges. With improved lighting in homes and schools, new means of transporting people and goods to new places they might need to be, or powering the many commercial or industrial processes within any given nation, there are huge opportunities to improve the productive use of clean energy resources in ways that reduce the overall economic burden of conventional energy supplies. And those same energy efficiency and renewable energy upgrades can also reduce greenhouse gas emissions that drive climate change, as well as lessen other impacts on both people and the global environment.

At the same time, shifting to a more sustainable energy system can provide employment and other economic benefits as well, both during the transition and beyond. There are several reasons for this positive outcome. First, the production of energy—whether the generation of electricity or the supply of oil and gas resources—tends to be more capital rather than labor-intensive. Other sectors in the economy are just the opposite. In other words, they are less capital and more labor-intensive. For this reason, as an economy encourages a cost-effective transition away from the dependence on higher-cost conventional energy resources, to less expensive energy efficiency and renewable energy services, the resulting energy bill savings are likely to be respent for the purchase of more labor-intensive goods and services. This will provide a greater demand for jobs within that economy. Concomitantly, the demand for those other goods and services is likely to encourage other local production in ways that also support the local economy. That, in turn, will further stimulate more employment opportunities.

As summarized in the full report, there are a total of seven major drivers of employment and economic benefits for what has been called a *Global Energy Transformation*. A preliminary analysis suggests such a transformation might promote a full range of new job opportunities—especially within the MENA region. A prototype employment assessment tool is under development for use in the MENA countries which can improve the evaluation of technology investments and capture a more complete analysis of jobs and greater career development opportunities. While there are emerging studies that highlight new work opportunities from greater energy efficiency and renewable energy investments, most of these assessments tend to be a limited accounting of the direct and indirect jobs associated only with those investments. In other words, they more often overlook other economic drivers which point to the potential for significant new employment benefits. A detailed discussion of these key ideas, together with a description of the new employment assessment tool that can provide similar insights for individual countries, follows in the full narrative.

I. Introduction

In 2018 the world's population of nearly 7.6 billion people (World Bank Data 2019) consumed the equivalent of 14.4 billion tonnes of oil to run the global economy (Enerdata 2019). Whether for petroleum, natural gas, and coal, or for nuclear, renewable and other energy resources, each inhabitant globally averaged a corresponding equivalent of 624 gallons of gasoline consumption. In doing so they spent a cumulative $8.2 trillion to heat their homes, power their industries, transport their goods and deliver an array of business, health, education, and personal services. This is now about 6 percent of the global Gross Domestic Product (GDP), an amount which could increase easily to $13.2 trillion (or more) by the year 2050 (with values reported in constant 2018 dollars; see, Laitner 2019).[1]

There is little question that our social and economic well-being fundamentally depends on the availability of energy to build, operate and maintain household appliances, medical devices, construction equipment and the larger infrastructure of any given nation. But as we highlight in the discussion that follows, the inefficient use of energy, as well as an inefficient mix in the use of those necessary energy resources, may also contribute to the deterioration of the global environment and climate, as well as a long-term erosion of our social and economic well-being. Indeed, the inefficient use of energy may be both a reflection, and a cause, of a lagging economic productivity that limits job creation and career development—even as it constrains the future availability of personal and household incomes. At the same time, however, the insufficient use of energy may also constrain both job creation and a robust economy. As explored in a following section of the report, this appears to be especially true of the emerging economies of the Middle East North Africa (MENA) nations.

While climate change understandably has been the focus of market investment strategies and energy policies (IPCC 2018), there is an economy-wide perspective that needs better attention and understanding (Ayres and Warr 2009, Kümmel 2011, and Laitner 2015). The balance of this manuscript—implicitly acknowledging the need for a proactive, productive, and clean-energy response to climate change—further explores the impact of how that same proactive, productive, and clean-energy response can also improve long-term resilience and future

[1] Global estimates of economy wide energy expenditures are difficult to find. The main reason is that, although agencies like the International Energy Agency (IEA 2019) track prices for many different forms of energy (e.g., dollars per tonne of oil, or per megawatt-hour of electricity) they do not aggregate such prices and quantities into global energy expenditures. The estimate cited here is adapted from a 2018 report for the International Partnership for Energy Efficiency Cooperation (Laitner et al. 2018). Utilizing a different approach, Stanford University (Jacobson et al. 2017) suggested worldwide energy expenditures of about $10.3 trillion in 2012 with projections rising as high as $17.2 trillion by 2050 (expressed in 2013 real dollars). For convenience, but subject to modification, the IPEEC report forms the initial basis for the discussion here.

economic opportunities. Those opportunities further include prospects for the creation of new jobs in both the developed and the emerging economies of the world.

In the sections that follow, with a focus on the global economy as well as the Middle East North Africa (MENA) nations, the narrative explores the critical linkages which are necessary to build a clean, more energy and resource productive economy. The review includes: (i) understanding how investment in the more productive use of capital and energy can enhance new employment opportunities; and (ii) exploring an analytical framework that can evaluate how a global energy transformation—as characterized, for example, by the International Renewable Energy Agency (IRENA 2019)—will enhance the many dimensions of job creation in ways that positively shape the common good.

II. Rethinking the Underpinnings of Energy-Related Employment

The latest analysis from the Organization of Economic Cooperation and Development (OECD), suggests that "growth is taking a dangerous downward turn."[2] A smaller economy means fewer economic resources in the future that may be available to deal with issues like meeting basic needs, infrastructure upgrades, health care, education, and climate change. That may also mean reduced resilience as the disruptions of climate change and other risks unfold. For the global economy, it would also mean fewer jobs than might otherwise be available in 2050.[3]

Fortunately, a greater emphasis on the deployment of energy efficiency and renewable energy systems can help address all of these issues.[4] Table 1 highlights seven key drivers that can support a more robust economy as a result of any given "Innovation Scenario" and its resulting roadmap. Those seven individual effects, and each of their primary outcomes, are described next as each driver can also become a positive influence in creating net employment benefits for any given country.

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[2] OECD Chief Economist, Laurence Boone, highlighted this concern in a statement released September 19, 2019. See, https://oecdecoscope.blog/2019/09/19/growth-is-taking-a-dangerous-downward-turn/

[3] As an example, if we explore even a small 0.5% difference in annual economic growth rate, that may not seem like an especially significant impact. Yet, over the period 2018 to 2050, that half-percent reduced growth rate actually implies a 14% smaller economy by 2050. At the same time, 2018 data from the World Bank (2019) indicated that the global economy supported (or required), 27.2 jobs per million dollars of GDP activity on average (with GDP measured in 2011 international dollars, including purchasing power parity). Based on the actual GDP estimates for 2018, and with a 0.5% difference in growth, but also including a 1.3% assumed rate of labor productivity, that means about 800 million fewer jobs by the year 2050.

[4] Often lost in many discussions about renewable energy is that, in addition to its impact as a cost-effective, relatively clean and dependable energy resource, it can become a major energy efficiency strategy if successfully deployed. The reason is that heat rates for conventional power plants might range from just 20% to 40%. In other words, of all the coal or natural gas used to generate electricity, as much as 60% to 80% of the combustion energy may be lost in the production of electricity. By obtaining electricity more directly from renewable energy resources—in effect, achieving a primary energy-to-electricity ratio that is closer to 1:1, most of the energy wasted in the combustion process is made unnecessary. For example, what the United States wastes solely in the production and distribution of electricity (about 26 exajoules per year) is more than Japan uses to power its entire economy (about 20 exajoules per year). See EIA (2019), and various other international data from the U.S. Energy Information Administration.

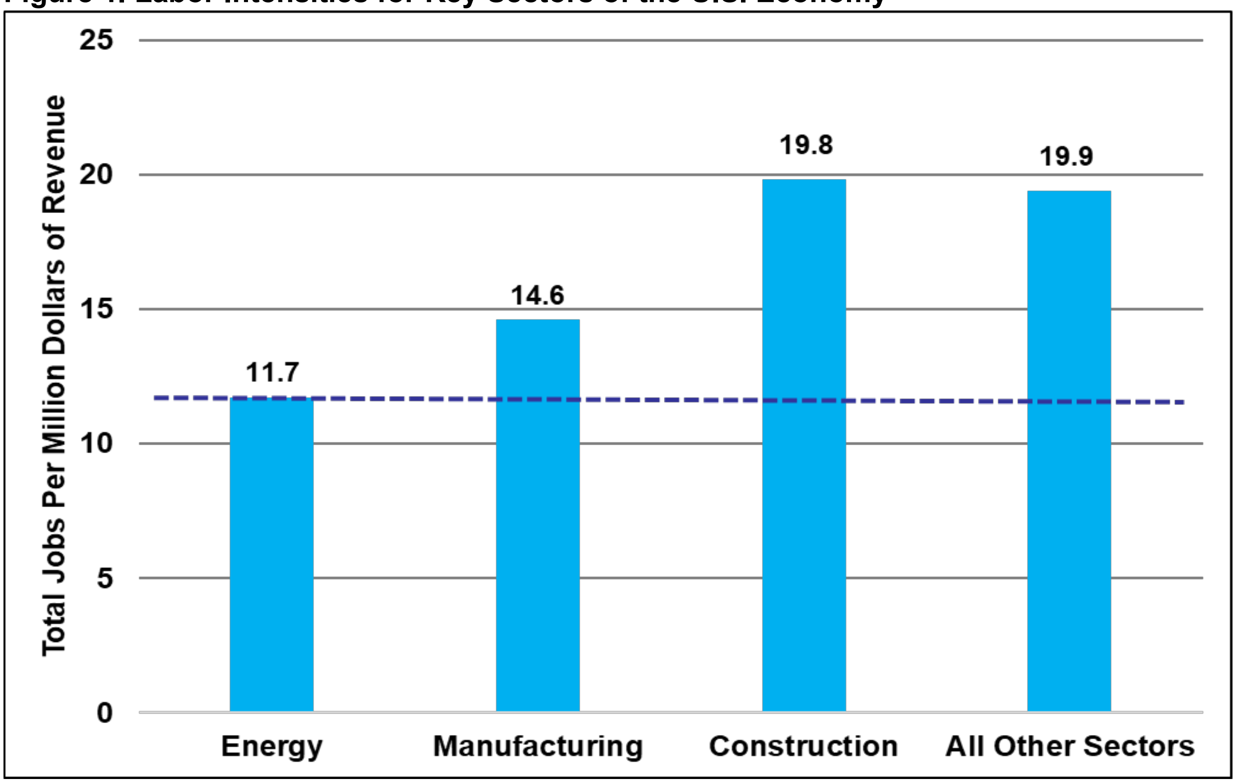
Table 1. The Seven Major Drivers of Employment and Economic Benefits

Driver	Primary Impact
Intensity Shift	Moving away from capital-intensive to labor-intensive activities
Supply Chain Build Up	Building up greater local production and local services
Energy Cost Reduction	Both unit cost and total cost savings for efficiency/renewable investments
Productivity Boost	Expanding the array of non-energy benefits
Managing Volatility	Smoothing out price shocks
Minimizing Disruption	Avoiding the inconvenient interruption of supply
Innovation Plus	Cost and service breakthroughs in the delivery of all goods and amenities

Source: As described and discussed in the text of the manuscript.

Intensity Shift: Just as some energy resources are more carbon-intensive than others—for example natural gas produces less carbon-dioxide per megajoule of energy than does coal, while renewable energy resources produce no direct emissions compared to any form of fossil fuels—different economic sectors have different income and employment intensities. As shown in Figure 1, a million dollars' worth of expenditures in various economic sectors supports different levels of employment. Although these data are from the United States, they demonstrate the fact that more capital-intensive sectors support fewer jobs than labor-intensive ones do.[5]

Figure 1. Labor Intensities for Key Sectors of the U.S. Economy



Source: John A. "Skip" Laitner, using IMPLAN 2017 data for the United States, 2019.

[5] In economics, an input–output model is a quantitative method that represents the interdependencies between different sectors of a national economy or different regional economies. We can think of this as an economic recipe for how different sectors buy or sell goods and services to each other, and how their unique pattern of spending might support total jobs. For a more complete look at the input-output analytical technique, see Miller and Blair (2009).

As discussed in Section III, the immediate improvements in cost-effective energy efficiency and renewable energy systems can have a significant impact on new employment opportunities. This is true across all of the sectors of any given economy. The data in Figure 1 shows that energy sectors within the United States supported a total 11.7 total jobs per million dollars of revenue or economic activity. This total includes three categories of jobs: (i) the direct jobs of those working for an energy company, (ii) the indirect jobs associated with the purchase of goods and services delivered each year to that energy company, and (iii) the induced jobs created by both direct and indirect workers spending their wages throughout the economy. Those 11.7 total jobs for energy services might compare to the 14.6 total jobs in manufacturing, the 19.8 jobs in construction industries, and the 19.9 jobs, on average, for all other sectors throughout the economy (IMPLAN 2019).

Shifting the economy away from traditional energy supplies and toward more energy efficiency and renewable energy resources can create a substantial number of new jobs. As a simple example, a policy or investment that reduces residential energy consumption by one million dollars would shift expenditures away from traditional energy sectors and toward other areas of the economy, so that rather than supporting 11.7 jobs, consumers and businesses will support an average of 19.9 jobs as they respend their energy savings on other goods and services. The net effect of that changed pattern of expenditures creates the prospect for a net gain of 8.2 total jobs.[6]

Supply Chain Build Up: While Morocco, for example, generates a surprisingly large rate of value-added from the intermediate goods and services it purchases, comparable to the United States, it also imports much more of its initial supply than does the U.S. (OECD 2018). To the extent that Morocco is able to increase its local production capacity for goods and services, this will increase both the resilience and vitality of the regional economy. In the context of energy markets, reducing imports of traditional fuels while fostering local markets for efficiency and renewable related industries further enhances local economic development.[7]

Energy Cost Reduction: Investments in energy efficiency and renewable energy reduce the demand for traditional energy sources, generating benefits associated with reduced purchases of traditional energy. Additionally, this reduced demand puts downward pressure on the price of traditional energy, spreading the benefits of clean energy beyond those that consume that

[6] While not explored in any real detail in this narrative, there are also different job intensities among the different types of energy and electric generation technologies. As estimated from 2017 IMPLAN data, for example (made available in 2019), oil refining operations appear to support 9.5 total jobs while fossil-fuel electric generation plants support 11.1 jobs. Solar or photovoltaic generating systems support 14.2 jobs. Similar but different patterns might be expected across the many different economies. It should be noted, however, that all three examples cited here still support fewer jobs than any energy bill savings which might be respent on most other consumer goods and services within that same economy. This is likely to be the case in any other country as well.

[7] We can illustrate how building up greater local supply capacity can increase the robustness of the Morocco economy by adapting the idea of the Keynesian multiplier. In this case we substitute the use of domestic resources (DOM) in place of the marginal propensity to consume (MPC). Hence the formula, OUTPUT = [1 / (1 – DOM)]. For example, if 45% of a nation's total output is the value-added component (including profit and labor income), and if the economy imports 25% of its needed resources, then 30% of its output recipe is the domestic or local use of resources. In that case, the formula of [1 / (1 – 0.30)] suggests a base economic multiplier of 1.43 for each dollar spent by local businesses and consumers. But if the nation reduced economy-wide imports, and if it increased the domestic purchase coefficient from 30% to 40%, then the base multiplier increases to 1.67. In other words, instead of a $100 consumer purchase that supports $143 of overall economic activity, a more internally resilient economy might support $167 of activity, without any other additional costs to the market. Presumably, the number of job opportunities will increase at roughly the same rate.

energy. This is often referenced as the "Demand Reduction Induced Price Effects," or DRIPE (Taylor, Hedman and Goldberg 2015). Lower prices largely stem from two complementary outcomes. The first is that as less conventional energy may be required, only the lesser-cost marginal resources will be necessary for purchase. That can reduce the total wholesale costs for consumers. Second, greater productivity will place an otherwise downward pressure on other remaining resource costs.

Drawing on data from the 2019 Energy Information's Annual Energy Outlook 2050 (EIA 2019), for example, if energy demand in 2050 is 70 percent of the projected level, then energy prices might be 15 to 20 percent lower than would otherwise be the case. The reduced quantity of energy that is consumed, assuming the changes are cost-effective, will directly benefit those who make improvements. The lower cost of energy will benefit all remaining uses of energy which translates into cost reductions in the purchase of other goods and services—whether food and household appliances or business equipment and industrial feedstocks. Again, as both the direct energy savings, together with the savings of less-costly resources more broadly, are respent on more labor-intensive activities within the economy, the demand for employment also tends to increase.

Productivity Boost: Investments in efficiency and renewable energy may impact broader economic productivity as well. For example, a given business might upgrade a variety of industrial processes that not only reduce energy needs, but a more energy-efficient industrial process might also lower the need for quantities of chemical feedstocks and water, even as it also lowers other operating and maintenance costs (Worrell et al. 2003). This, in succession, can also expand further economic opportunity.

We can examine the potential scale of energy-led productivity gains within the MENA as a whole. In 2018 the GDP for the MENA nations was an estimated $8.2 trillion as measured in 2011 constant international dollars. Total employment in the region appears to be about 136 million jobs (World Bank MENA 2019). This implies that each one million dollars of GDP supports 16.6 jobs within the regional economy. Had the economic productivity of the region been just 0.5 percent higher over the period 2000 through 2018, regional GDP would have been $745 billion larger (in 2018), which would support an additional 13.3 million jobs.

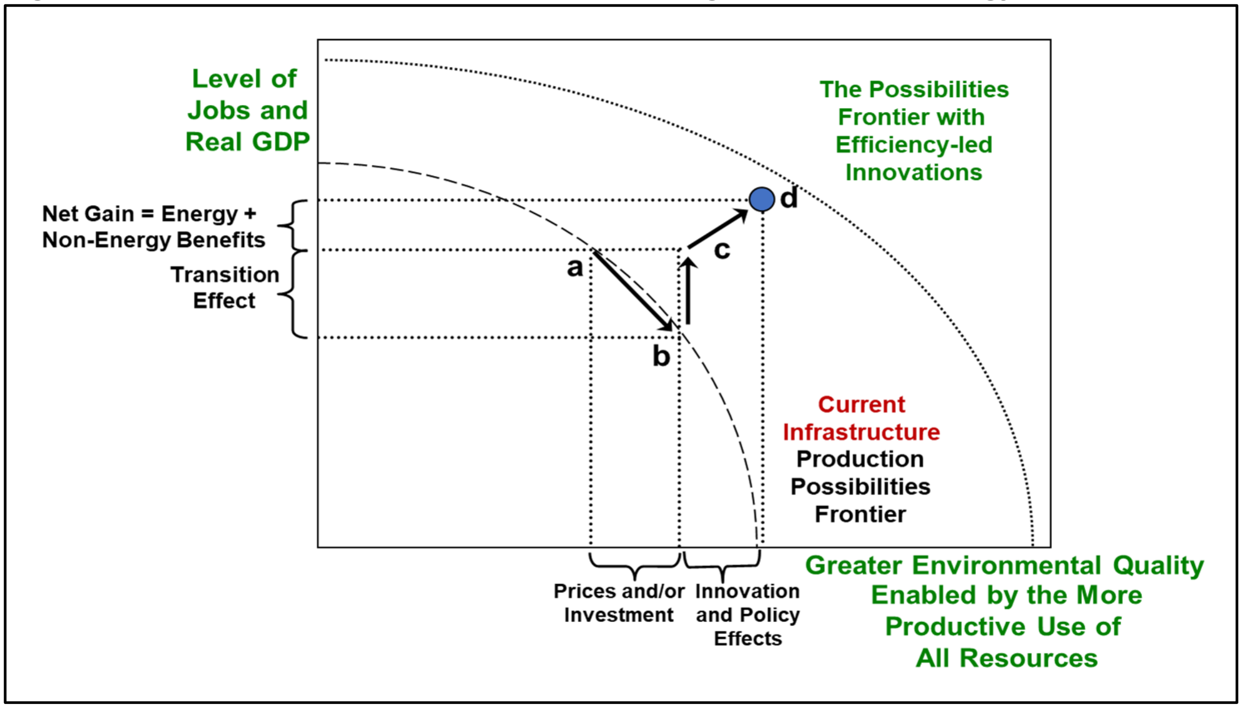
Managing Price Volatility and Minimizing Supply Disruption: These benefits include reducing the disruption in the availability of energy and other resources, while also minimizing the negative impacts of unexpected price volatility. As the economy supports a larger GDP, but one that uses fewer or less-costly goods and services, both the MENA region and the global markets will enjoy a reduced exposure to unexpected market risks and price volatilities. This ensures, therefore, a greater certainty in the availability of those resources which, in turn, provides a strong foundation for both career opportunities as well as a more resilient economy.

Innovation Plus: Although harder to quantify, the seventh major driver summarized in Table 1 is the greater employment and economic benefits that likely will follow a productivity-anchored energy transition which stimulates the prospects for continuous learning and the encouragement of new innovations. The likely consequence catalyzing a broader set of improvements—whether the development and deployment of new general-purpose technologies, or innovative changes in business models—that can better satisfy the social, economic, and environmental needs within a nation's economy.

We can conceptually summarize all seven of the economic and employment drivers in Table 1 as the graphical illustration shown in Figure 2 which helps pull the key ideas of any likely

"Innovation Scenario" of the *Global Energy Transformation* (IRENA 2019) into a useful perspective. While we cannot know at this time the scale of detectable responses to the complete set of economic stimuli, we can offer a positive overall explanation of how multiple benefits are likely to emerge through the implementation of a collaborative and productivity-led investment strategy.

Figure 2. Conceptual Framework for Evaluating the Global Energy Transformation



Source: John A. "Skip" Laitner, adapted to illustrate the equivalent of a Global Energy Transformation (IRENA 2019).

Assuming that current energy consumption and production patterns continue indefinitely would imply that the MENA nations are already on what is called a production frontier at point "a" in the Figure 2 diagram above. If so, countries are faced with a tradeoff whereby increasing economic growth can only come at a cost to the environment (i.e. through increased consumption of fossil fuels) and vice versa (i.e. that improving environmental quality means a reduction in economic growth). Any change to satisfy a demand for greater efficiencies, or for the reduction in greenhouse gas emissions, must likely result in a move down and to the right to a point like "b." Egypt, Morocco, or Yemen—indeed, all of the MENA nations and the global economy as a whole—might achieve some mix of isolated productivity improvements, and there might be some reduction in greenhouse gas emissions. Conventional wisdom might indicate that this must surely come at the cost of a reduction in jobs and GDP.

Alternatively, a shift to increased deployment of energy efficiency and renewables may instead allow the economy to shift to a point like "c." The transition toward cleaner and more efficient energy systems can improve the environment while also spurring increased local economic growth. The result is an improvement in overall energy efficiencies and the more productive use of clean energy resources, even as the economy remains at a relatively stable level of GDP.

At some point, however, the various energy and non-energy benefits that result from an array of incentives and policy initiatives can boost the performance of the economy to a higher than expected level of performance. Although Figure 2 is not drawn to scale, the migration from point "a" to the eventual point "d" might represent an eventual doubling of energy productivity that drives a concomitant increase in economic activity or per capita GDP. Hence, a net energy savings, together with a transition to an economy powered by 80 percent or better renewable energy systems, in turn, might rouse a significant boost in net jobs, career opportunities and GDP. Equally critical, a clean energy transition can become a way to catalyze the seventh benefit of such strategies—an enhanced push of the production frontier so that future technologies and markets are encouraged, developed, and implemented to the long-term benefit of jobs and the economy.

III. A Useful Framework to Examine Employment Opportunities

For reasons of reducing climate burden as well as creating new prospects for jobs and career development, new policy assessments are surfacing which point to the likelihood of a significant energy transition. The International Renewable Energy Agency, as one example already alluded to, released its *Global Energy Transformation Roadmap to 2050.* The roadmap includes the large-scale deployment of low-carbon technologies based largely on renewable energy and energy efficiency. The intent is to help limit the rise in global temperature to well below 2 degrees Celsius above pre-industrial levels (IRENA 2019).

Stanford University posted 139 country energy roadmaps for the global economy that might enable 100 percent of renewable energy resources that significantly slow global warming and nearly eliminate air-pollution mortality (Jacobson et al. 2017). Nor are energy efficiency improvements being overlooked. The American Council for an Energy-Efficient Economy released a 2012 assessment with evidence that energy use within the United States could be cost-effectively reduced nearly 50 percent from the year 2010 level of demand by the year 2050. It further modeled the possibility of a net gain of 1.9 million jobs for the U.S. economy in that same timeframe (Laitner et al. 2012).

Notwithstanding its concern for a potentially lagging productivity (OECD 2015), a recent OECD report noted that low-greenhouse gas emission pathways, including investments in renewables and energy efficiency upgrades, could stimulate long-run economic output by up to 2.8 percent, on average, across the G20 countries in 2050 (OECD 2017). Moreover, the United Nations Environment Program (UNEP) has suggested that the smarter use of energy and other resources can add $2 trillion to the global economy (Ekins et al. 2017). The *Global Energy Transformation* roadmap (IRENA 2019 referenced earlier) suggests GDP increases by 2.5 percent by 2050. With a business-as-usual projection for a global GDP valued at $123 trillion in 2020 (in 2010 dollars), but that grows 2.7 percent a year through 2050 (EIA 2017), adding the IRENA roadmap benefit of an extra 2.5 percent in 2050 could mean a $7 trillion larger economy by that time. Even though the scale of impact might differ, presumably the economic and job returns from non-OECD and MENA nations might show similar returns.

Because the idea of job creation is central to the kind of advancements envisioned by these emerging energy transition plans, the section that follows provides both a data and an analytical framework that can help policy makers and business leaders better understand and evaluate the likely outcomes from the momentum of such transitions. It then digs into a detailed characterization of what an employment assessment tool might look like from within the analytical perspective.

Analytical Framework of Assessing Energy-Related Net Job Benefits

As a means to explore the scale of employment opportunities associated with a greater reliance on a global energy transition, a prototype "employment assessment tool" is now under development. The core of that tool consists of two critical components. The first is a technology-based cost model to evaluate, by country, the broader economic impacts of a clean energy transition within the MENA region.[8] The second is an input-output framework to take the cost structure of different technology paths (i.e., the “inputs”, or the investments and savings) and then evaluate the resulting job and GDP benefits of those technology paths (i.e., the "outputs"). This section explains the idea of using a more dynamic input-output assessment tool that adds new value to other evaluations that have been previously published—e.g., Jacobson et al. (2017) and IRENA (2019), among others.

Most studies that evaluate the job impacts of either energy efficiency improvements or renewable energy systems are, in effect, more of an accounting of immediate jobs rather than an assessment of the full range of economic opportunities. Notwithstanding their positive results, they effectively limit their employment findings to the impact of immediate technology upgrades—or what we might think of as the first of the seven drivers highlighted in Table 1. And they often capture only a portion of the second driver, or the supply chain impacts. For example, the supply chain jobs today might provide 3 of the total 19.9 jobs of average consumer spending shown in Figure 1. But over time, those indirect jobs might increase to 4 of 20.9 jobs at some point in the future.[9]

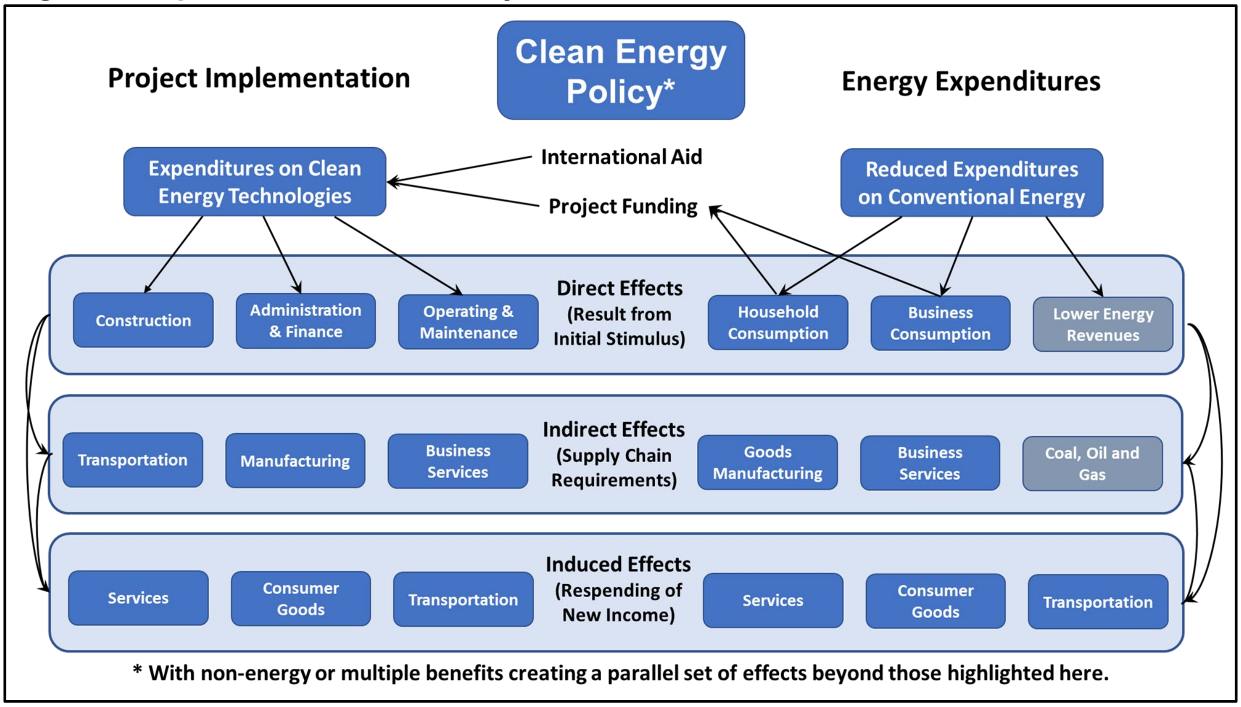
At the same time, most previous studies tend to overlook the positive gains of the lower costs of energy services, and other non-energy benefits as those technology strategies take hold. *These new value-added components* will become part of the economic platform of the employment assessment tool. The use of the input-output framework, as explained next, will enable a more complete valuation of the Table 1 drivers as part of the net employment gains which result from changes in cost and the revitalized patterns energy and technologies.

Figure 3, on the following page, shows at a conceptual level how investments in clean energy projects can impact employment. The schematic is composed of two distinct components: Project Implementation and Energy Expenditures.

[8] Although the initial focus of the employment assessment tool is on the economies within the MENA region, the same principles apply to the developed nations; and indeed, to the larger global economy.

[9] To be fair, the dynamics are more complicated than suggested in this example. Labor productivity many somewhat reduce all future employment demands, but a shift in the pattern of economic activity as well as an increase in overall economic activity can expand both total job and career development opportunities.

Figure 3. Expenditure Flows as They Generate the Direct, Indirect, and Induced Effects



Source: As described in the narrative.

Project Implementation includes all those activities required to design, construct and maintain the project during the implementation phases. In the context of a utility scale solar PV project, for example, this includes manufacturing the panels and other materials, installing and connecting them to the local grid, the costs of operations and maintenance on the PV site, as well as the costs of administering the project and/or the policy initiative that instigated it.

These activities require expenditures that create jobs in a variety of sectors, including but not limited to construction, operations, maintenance, and also the costs of administration and project finance. Jobs that take place on site as well as in the offices of the companies that implement the project are all considered to be in the category of direct jobs.

These direct activities create jobs not only in themselves, but also along the supply chains that feed into them, such as the manufacturing and transportation of the parts and the so-called "balance of systems" that may be required, as well as the necessary business and banking services. These jobs are one step removed from actual implementation are in the category of indirect jobs.

Finally, the increased employment in all of these sectors generates increased income for workers, which in turn creates jobs as it is spent in sectors like services, consumer goods, and transportation. The jobs created as a result of respent worker income are categorized as induced jobs.

Energy Expenditures deal with the impacts of changes in energy consumption patterns—or more critically, a reallocation in the pattern of energy expenditures. Whereas most of the project implementation impacts are focused on a relatively short construction period, the energy expenditure component tracks the impacts of all projects for as long as they remain in service. Again, in the context of a utility scale solar PV project, this includes changes in expenditures away from purchased energy toward new patterns of household and business consumption as they are positively affected by energy bill savings. It also includes the impacts of reduced revenues and lower labor demand in the energy sector. This first round of impacts associated with changed energy expenditure patterns are categorized as direct jobs.

As with the implementation component, changes in expenditures have a cascading impact on supply chains as well, so that the industries in the supply chain of household and business consumption also see increased revenues and employment. We have also included the negative impacts of reduced demand for traditional fuels since utilities will consume less of them than they otherwise would. As in the implementation component, these supply chain impacts are categorized as indirect jobs.

Finally, as with the implementation component, changes in employment discussed above create changes in disposable income for the workers in the industries in question, which in turn impacts the broader economy as workers increase or decrease their expenditures on typical consumption goods. These are categorized as induced jobs.

It is important to note that both the project implementation and energy expenditure components have negative as well as positive aspects to them. In the energy expenditures component the negative impacts are included as reductions in purchases of conventional energy and the resulting reduced demand for fossil fuels. In the project implementation component, the project funding is indicated as a payment from households and businesses (including interest expenses and fees) to project implementation.[10]

The sum of these three separate effects yields a **Total Effect** that results from a single expenditure or initiative; in this example, the investment in the solar PV project. While understanding how direct, indirect and induced impacts relate to one another, these impacts are estimated in the model through four primary sources of expenditure or changes in demand, which can be positive, negative or both:

Project Investment Impact: This is the outlay for a potential system upgrade, including equipment and labor costs, as well as related services, necessary to carry out the construction effort. In the case just described, it is the cost of making, installing and connecting the PV system along with any administrative or policy costs. These impacts are all positive as they represent an increase in demand for goods and services.

To accurately account for the impacts of a project, the model must also consider the how the project is paid for, which is generally a negative impact on the economy since it necessarily represents funds that would have been spent elsewhere in the economy. We consider four broad categories of financing for projects. International grants, current budget expenditures, international borrowing, and domestic borrowing. International grants are the one category that has no negative impact on the economy, since these are funds supplied for the project from outside the country that are not expected to be repaid. Current budget expenditures are funds from either a current national government budget or households and businesses that underwrite the project. As they come out of the current budget, they must be paid for in the year the investment is made. We generally model these either as an increase in taxes levied on domestic households and businesses, or changes in spending by households and business in the year the project is implemented.

[10] Because it is a relatively high-level representation, the schematic is simplified to treat project expenditures as payments from businesses and households directly toward project implementation, although in practice it is the utility which may collect these payments in order to pay for the financing of the project. Economically, they are essentially similar in that payments are flowing from energy consumers to cover the costs of the PV installation project.

Domestic and international financing are treated as annual principal and interest payments. The principal repayments have no net effect on the economy since they are simply the return of funds previously borrowed from the finance sector. Interest payments, however, represent positive income to the lenders. To the extent that the project is financed internationally, we treat the interest payment as a leakage from the domestic economy, whereas interest payments to domestic lenders are a stimulus to the domestic finance sector.

In reporting our results, we include these two flows of interest payments in the energy expenditure phase rather than the project implementation phase. This is a somewhat arbitrary assignment; yet the total net impact on the economy does not change regardless of which component we include it in. However, since it is an ongoing repayment of costs over time, it makes intuitive sense to include it in the energy expenditures component so that it can be considered as part of the impact on energy expenditures. We discuss it here since it is a cost of implementation and will indicate what category of impact we include it in below. The same is true for the costs of operations and maintenance that can be considered as a cost of implementation but that may belong more intuitively in the energy expenditure component.

Investment Shift Impact: This refers to the shifting of investment strategies away from conventional energy to renewable and efficiency resources. If a country had planned to increase electricity supplies by building conventional power plants but then decided to invest in a solar project instead, the elimination of the already planned conventional energy strategy should be considered a negative result of the solar project.

Energy Substitution Impact: Once a clean energy project is installed and paid for over time, it will substitute efficiency or renewable energy for some amount of conventional energy use. If that amount generates a net cost savings—either from the avoided unnecessary purchases of energy, or from lower levelized cost of remaining energy purchases—the result will be an increased local spending for other goods and services. This is where we include the impacts of operations and maintenance expenditures, as well as finance costs including associated interest payments and other fees (if any).

Energy Revenue Impact: Any money saved by lower energy expenditures or the reduced wholesale cost of electricity may create a loss of income for the energy provider. If it occurs, the reduction in revenue represents a loss to the energy sector, and the reduced demand for conventional energy will reduce employment in both that sector as well as those which provide goods and services to area energy companies.

Integrating the Impacts and the Economic Drivers

Once all of these impacts are accounted for and allocated to their appropriate economic sectors, the model calculates the projected net employment impact based on the magnitude of the changes, the labor intensity of the various impacted sectors, and the degree to which we expect these impacts to affect the local economy as opposed to imports of goods and services.

Ideally, these parameters are taken directly from the system of national accounts for each country. To the extent that these accounts are insufficient or lack the appropriate level of sectoral data, we will use estimates and proxy data to produce estimates that are of the right sign and order of magnitude.

The four different impact categories actually meld, and to some extent, overlap with the 7 economic drivers referenced in Table 1. To help provide a context for the larger set of dynamics at work, Table 2, that follows, integrates: (i) the three different or total job effects, with (ii) the four impacts, as well as (iii) the seven economic drivers. The network of equations can integrate these many interactions to provide a more robust estimate of the prospective employment benefits likely to emerge from different technology paths or scenarios.

Table 2. Illustration of Positive and Negative Employment Impact Drivers

Employment Catalyst	How Spending Impacts the Seven Economic and Employment Drivers	Expenditure $MM	Total Jobs (Direct, Indirect, Induced)
Policies/programs to support new clean energy upgrades	Enables all 7 employment drivers	+	+XXX
Redirecting funds from elsewhere to support new policies/programs	A transition which lessens some jobs	-	-XXX
Investments to support clean energy upgrades	Stimulates employment drivers #1-3	+	+XXX
Redirecting funds from other projects or spending to support clean energy investments	A transition which lessens some jobs	-	-XXX
Energy savings respent locally	A net gain stimulating all drivers #1-7	+	+XXX
Lost energy company revenues	Results that lessen energy-related jobs	-	-XXX
Expanded non-energy benefits	Benefits amplify overall job impacts	+	+XXX
Total net benefits	**Net gain of job benefits**	**+**	**+XXX**

Source: As described in the narrative.[11]

There is, however, one additional set of wrinkles that an employment assessment tool will need to integrate. If we think of each of cells in Table 2 as capturing both a number of parameters and coefficients which might yield a net positive result, there are still other factors which can otherwise affect overall outcomes and lend a more dynamic set of results. Four such factors come immediately to mind: (a) the need for more, not less energy, (b) trends in future labor productivity and sector output; (c) a likelihood of increased capacity in the local production of goods and services; and (d) the demand reduction induced price effects, or DRIPE.[12]

Moving ahead with the first of the four *dynamic wrinkles*—the need for more, not less energy, we might imagine that the MENA countries will want a larger economic well-being than typically is forecast. In other words, if they are to offer even bigger employment opportunities and a further improvement in their social well-being, more clean energy resources may be needed compared to the developed economies. The need for consuming more productive energy is reinforced as we learn that the per capita energy consumption within MENA economies may be entirely too low to support a more robust level of economic activity.

If we think of energy as work (see, for instance, Ayres and Warr 2009, and also Laitner 2015), then a greater level of market activity may require that more energy (again, not less) is delivered within those economies—even as those energy resources prove to be both clean and productively utilized. In other words, while the global economy as a whole may significantly reduce overall energy consumption, some nations as Egypt, Morocco and Yemen may actually

[11] While non-energy and other productivity benefits are referenced in the narrative to offer a complete description of the seven economic drivers, their impacts are not among initial set of results captured in the prototype of the assessment tool. However, future versions of the tool may be able to capture, or at least include some of these effects as well.

[12] Technically, the DRIPE effect can be complemented by changes in the energy mix as economies-of-scale, learning-by-doing, and other innovations and business models lowers the cost of clean energy resources over time.

need to increase their forecasted energy consumption by, say, 50 percent or more (or some other amount) in order to move to a higher level of jobs and per capita income.

Continuing with this insight, a typical methodology to assess the prospects for job creation may be often seen as generating a small net loss of jobs similar to the impacts reported by Jacobson et al. (2017) for Yemen. Yet those losses may turn positive in a very big way if more energy is productively deployed. That is, on the one hand. On the other hand, and thinking through the second of the four wrinkles, aggregate outcomes can also be impacted if a modeling exercise also includes the likely prospect of future labor productivity. That means that the actual growth in future jobs, while still positive, may be somewhat less than anticipated as labor productivity increases over time.

As a specific example on the impact of job creation, let us assume a 1.3 percent annual rate of improvement in labor productivity. In that case, the 19.9 jobs today may be reduced to just 13.5 jobs in the year 2050.[13] Said differently, a projection of 19,900 new jobs tomorrow might actually be only 13,500 new jobs. Yet, the remaining two “dynamic wrinkles” might entirely offset the consequences of future labor productivity.

The third dynamic, reviewed briefly in footnote 7, suggests that new clean energy investments might increase local production rather than continuing to impact some goods and services. This might be complemented by the fourth dynamic which is the prospect of the lower cost of energy services. Running counter to the need for a greater use of energy in some countries, the lower demand for energy worldwide might reduce the unit cost of energy in response to the lower rate of consumption, driven through any number of mechanisms. As briefly listed in footnote 12, the mechanisms include such things as economies of scale, learning-by-doing, and downward pressures on unit cost of energy brought about by innovation and/or a lower or changed pattern of demands.

One example of these cost effects might indicate that for every 10 percent drop in total energy consumption, the cost of remaining energy needs might be reduced by, say, 3 percent. So, if a unit energy cost today is $12 per megawatt-hour (MWh), but by 2050 the level of demand is 80 percent of the forecasted level, the new cost may be only $11.2 per MWh. Thus, a 20 percent savings in energy demand may actually become a 25 percent overall savings as a result of the unit cost savings for remaining energy uses.[14] The combination of all four influences within a modeling context can reflect a more complete and dynamic set of employment projections than indicated by either the simple calculations or the properties highlighted in Table 2.

IV. Conclusion and Opportunity

As economist William Baumol and his colleagues noted, “for real economic miracles one must look to productivity growth” (Baumol et al. 1992). Hence, the importance of assessing the contribution of cost-effective changes in patterns of energy demand and energy production together, as those patterns, in turn, can positively impact an economy’s multifactor

[13] The calculation of a 1.3 percent labor productivity improvement over the 30-year period from 2020 through 2050, as it affects the 19.9 jobs supported by savings of $1 million today is 19.9 /$1.013^{(2050\text{-}2020)}$ = 13.5 jobs (rounded to the nearest tenth).

[14] In this case the calculation for a change in unit cost is $12/MWh * $0.8^{0.3}$ = $11.2/MWh. The change in overall energy savings then becomes 20%+(1 - $11.2/$12*80%) = 25% total savings in rounded terms.

productivity.[15] In the conceptual framework of the prototype for an eventual MENA-based employment assessment tool that is described here, a cost-effective change in energy use patterns, together with improved multifactor productivity (or gains in real per capita GDP), become catalysts for larger set of economic and employment benefits!

As long as a cost-effective pattern of changes in energy demand are evaluated and coupled with: (1) the seven drivers of employment and overall economic well-being, as they, in turn, are (2) matched with the three jobs effects and the four categories of impacts, together with (3) a variety of quantity and price variables, those changes in energy demand can drive multifactor productivity at a rate that is greater than the labor productivity rate alone. In that case, the dynamics of these overall demand changes (including both energy efficiency and renewable energy resources) will drive a more robust economy that can increase overall employment benefits—despite instances in which some nations may need to increase the overall demand for energy, and despite a positive growth in labor productivity.[16] Using an employment assessment tool as described here can assist MENA nations (and other countries within the global economy as well) in estimating the net employment benefits of a *Global Energy Transformation*.

[15] Multifactor productivity is a measure of economic performance that compares the amount of goods and services produced (output) to the amount of combined inputs used to produce those goods and services. Inputs typically include capital, labor, capital, energy, materials, and services. Real per capita GDP may be thought of as a useful proxy for multifactor productivity.

[16] In effect, if both population and per capita GDP grow at a net positive rate that is greater than labor productivity alone, then a revitalized recipe for the economy should lead to a net increase in employment opportunities.

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