Perspective

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A New Source of Power
The Potential for Renewable Energy in the MENA Region

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EXECUTIVE SUMMARY

The Middle East and North Africa (MENA) region has an opportunity to reinvent its energy sector and even its countries' overall economies. Recent developments in renewable energy, combined with the region's latent potential in wind and solar power, could create significant advantage for those countries that move decisively to capitalize on them. As renewable energy approaches cost parity with conventional sources, the MENA region could reap its numerous benefits: decreased pollution levels; reduced carbon emissions; better leverage of oil and gas resources for export or higher-value industries such as petrochemicals; and the creation of new, skilled-labor jobs.

To develop a viable renewable energy sector, regional governments will need to take a number of critical steps:

- *Develop a renewable energy strategy that positions the sector as a key element of the overall energy strategy*
- *Put in place an adequate institutional setting at the government level*
- *Develop a favorable policy and regulatory framework to promote the development and use of renewable energy*
- *Enable technical grid integration*
- *Develop long-term capabilities and a deep talent pool*

The competitive landscape in the renewable energy sector is still evolving. Those countries that act quickly at this stage could eventually become the sector's world leaders.

KEY HIGHLIGHTS

- MENA countries have been on the sidelines of the renewable energy movement, but that will have to change as the region's power demands increase, its pollution worsens, and demand rises for its energy reserves.
- The region has great potential in solar and wind energy, and these technologies should be exploited for economic gain.
- MENA countries will need to build a renewables strategy that takes into account the region's existing approach to energy-sector organization, incentives, and distribution structure.
- Countries' strategies should allow for the creation of long-term capabilities so that renewable energy technologies meet all economic and development goals.

A NEW WORLD LEADER IN RENEWABLES

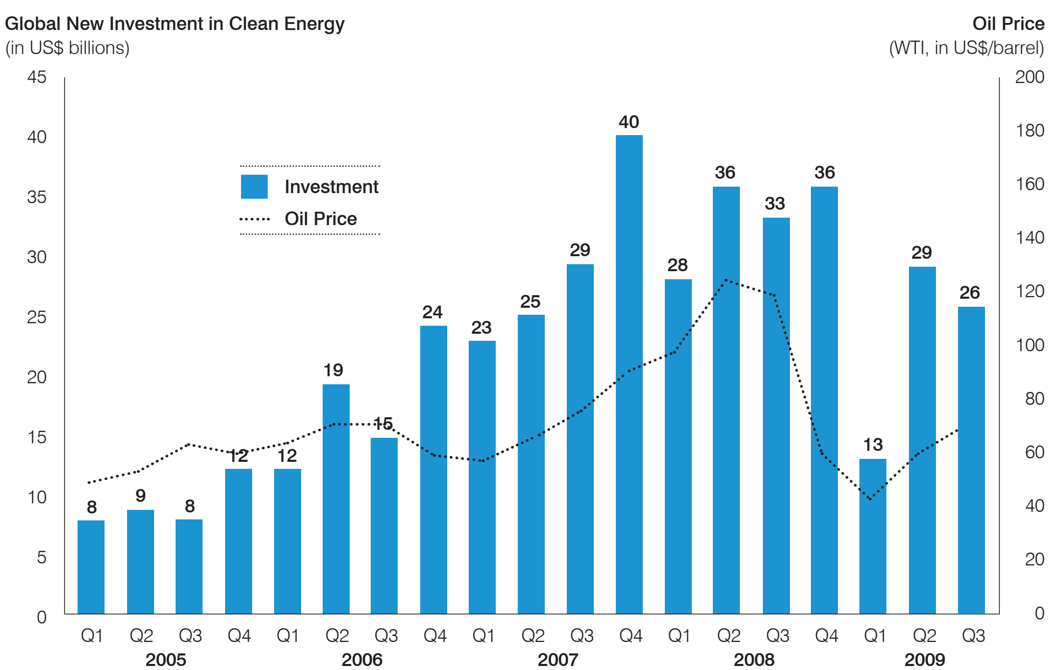
The MENA region has the potential to become one of the world's foremost producers of renewable energy. To date, this potential has gone largely untapped, owing to a series of policy decisions favoring conventional energy. Given the region's considerable fossil fuel resources, these decisions were understandable. However, considering the new demand for power driven by the region's economic growth and swelling populations, policymakers will have to seek new sources of supply. Furthermore, if the region developed its renewable energy sector, oil and gas could be used to generate value as high-margin inputs into industries such as petrochemicals—greater value than they currently offer as feedstock for power generation. Finally, the use of renewable energy would reduce air pollution levels and create self-sustaining industries that would diversify regional economies. These considerations should encourage the governments of the MENA region to undertake a full review of their renewable energy opportunities.

The process of investing in renewable energy sources is not simple, however. Countries will need to analyze which technologies are best suited for their geographic characteristics, power needs, and financial resources. And because of the region's strong state involvement in the energy industry, it is critical that any renewable energy initiative be implemented through a coordinated process integrating not only energy policymakers, but also regulators, educators, private-sector players, and other stakeholders.

A GLOBAL BOOM

Global interest in renewable energy sources is not new. It has gone through various waves of popularity, particularly in the 1970s and 1980s, when investment was driven by oil price spikes. As these momentary oil crises passed, so did interest in renewables. Investments in clean energy continued to fluctuate along with oil prices as the 21st century began *(see Exhibit 1)*. Although the current surge, like those in the past, is occurring in conjunction with a rise in oil prices, the current global boom in renewables is characterized by four major trends that are likely to make

Exhibit 1
Clean Energy Investments Wax and Wane Depending on Oil Prices



Source: New Energy Finance; Bloomberg

it a sustainable trend rather than a temporary bubble.

Global concerns over accelerating climate change: The Intergovernmental Panel on Climate Change (IPCC) concluded in its Fourth Assessment Report, released in 2007, that evidence for the "warming of the climate system is unequivocal" and that it is "very likely" these changes have been caused by human activity.[1] These concerns have prompted governments to set clear and legally binding targets for emissions reductions and increases in renewable energy use for the first time. The E.U.'s 2008 commitment to reduce its overall emissions to at least 20 percent below 1990 levels by 2020, as well as increase the share of renewables in energy use to 20 percent on the same time line, is the largest and best-known example. In October 2009, the U.S. was in the process of adopting similar measures, with a major climate bill under consideration in Congress. The aim of the United Nations Climate Change Conference in Copenhagen in December 2009 is a global agreement that commits every nation to reducing emissions, taking into account its circumstances.

Energy security: The run-up in global energy prices in 2008 caught many energy importers unprepared. For example, in January 2009, a dispute over gas prices between Russia and Ukraine interrupted Russia's delivery of vital natural gas supplies to Europe in the middle of winter. Many governments recognize today that locally produced renewable energy sources are necessary for energy security.

Supply and demand fundamentals: Rapid industrial growth in China, India, and other developing countries has boosted global demand for energy. At the same time, on the supply side, renewable energy prices continue to decline and are approaching parity with traditional alternatives.

Technological improvements: In the past decade, advances in renewable energy technologies have made them highly reliable and scalable. Today, renewables have the capacity to power entire countries. More than half of the power generation capacity constructed during 2008 in Europe and the U.S. was renewable.[2]

MAKING THE CASE FOR RENEWABLES IN THE MENA REGION

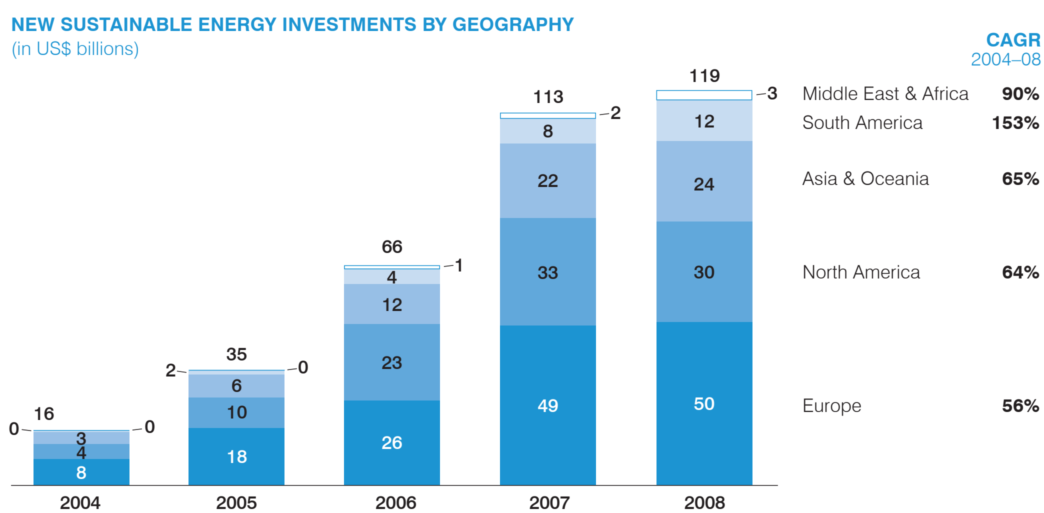
Despite this boom in activity, renewables in much of the MENA region are underfunded or not funded at all *(see Exhibit 2)*. The lack of renewables activity in the MENA region is rooted to some extent in the region's abundant supplies of fossil fuels. The recent economic crisis has not helped matters: Cheaper oil has made renewable energy relatively less cost-effective, and a global lack of liquidity has made financing of renewables projects more costly.

Yet the case for renewable energy is actually stronger in the region than in many other geographic areas that have been far more active. There are at least six reasons that the MENA region should be a world leader in renewable energy.

1. The region has an advantageous geography and climate. The MENA region has the world's greatest potential for solar power generation, offering 45 percent of the world's total energy potential from all renewable sources. If the region achieved this potential, it could generate more than three times the world's total current power demand. The region also has some potential for large-scale wind farms, especially along the relatively sparsely populated coasts of Morocco, Mauritania, Egypt, and Saudi Arabia *(see Exhibit 3)*.

2. The region's current energy supply may not be sufficient to meet future demand. At present, the MENA region has 146 gigawatts of installed capacity for electricity generation. With demand forecasted to grow at more than 7 percent per year for the next decade, MENA countries are less prepared than their governments may realize; they will need to build 80 to 90 gigawatts of new capacity by 2017 to meet demand. The need for new energy sources to meet this demand is particularly acute in most of the countries in North Africa and the Levant (with the exception of Algeria and Libya), which do not

Exhibit 2
A Global Boom, But Not in the MENA Region

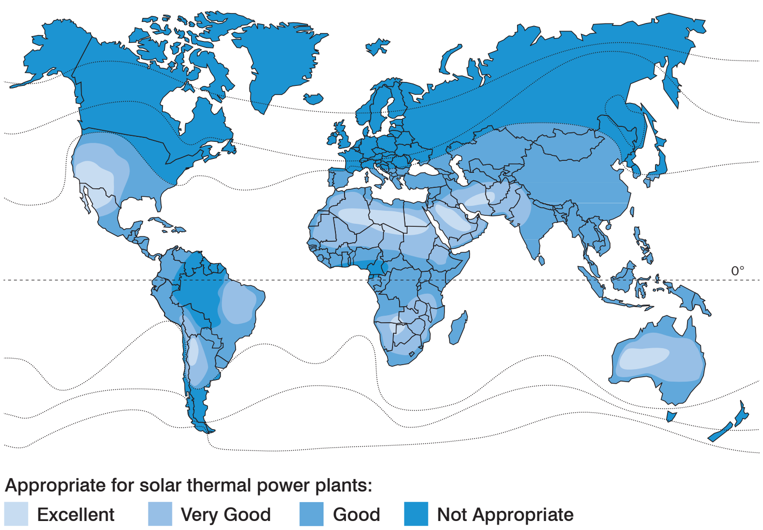


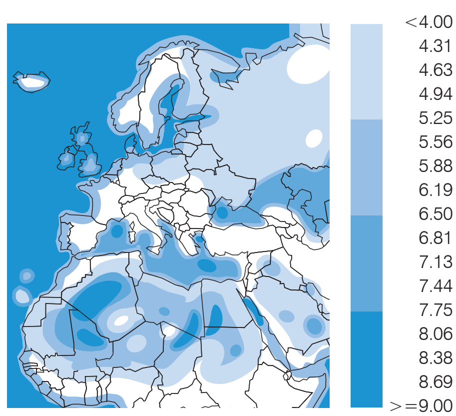
Source: UNEP / New Energy Finance, "Global Trends in Sustainable Energy Investment 2009" have sufficient oil and gas resources to cover their own rapidly growing needs. Renewables could play a major role in meeting increasing demand and, if built appropriately, could complement the region's unique energy needs. In the Gulf Cooperation Council (GCC),[3] for example, about two-thirds of residential electricity used is dedicated to cooling. Solar energy could be used for cooling, either by being converted into electricity to be used in conventional cooling systems, or in direct thermal cooling applications, in which solar heat is converted into cooling via absorption chillers or desiccants. Such applications offer higher conversion efficiencies and cheaper means of storage, reducing peak loads on the power grid. Also, renewables (particularly solar photovoltaic and small-scale wind power) may be more efficient than conventional means in providing power to sparsely populated areas of the MENA region, because they eliminate the cost of constructing a power grid.

3. Renewables could help address the region's environmental problems. The region is facing rapidly rising pollution levels and the accompanying high costs and widespread reduction in quality of life. The MENA region currently has the world's second-highest air pollution levels (behind South Asia), and the estimated particulate matter (PM) concentration is nearly 50 percent higher than the world average *(see Exhibit 4).* Damage costs due to PM emissions in MENA countries are equivalent to about 0.9 percent of GDP—nearly double the world average of 0.5 percent. Clean energy sources that don't burn fossil fuels and release particulates would significantly improve air quality. Countries in the region also have some of the highest per capita carbon footprints in the world: In 2007, Qatar emitted three times as much carbon dioxide per capita as did the United States.

4. Renewables could generate value in their own right, as well as freeing oil and gas for more profitable uses. The region has long exported hydrocarbons or used them at their most commoditized level. If renewable energy sources could replace the oil or gas currently used for power

Exhibit 3
The MENA Region Has a Natural Advantage in Both Solar and Wind Energy





Annual average wind speed at 80 m above ground level (m/s)

Source: Solar Millennium AG

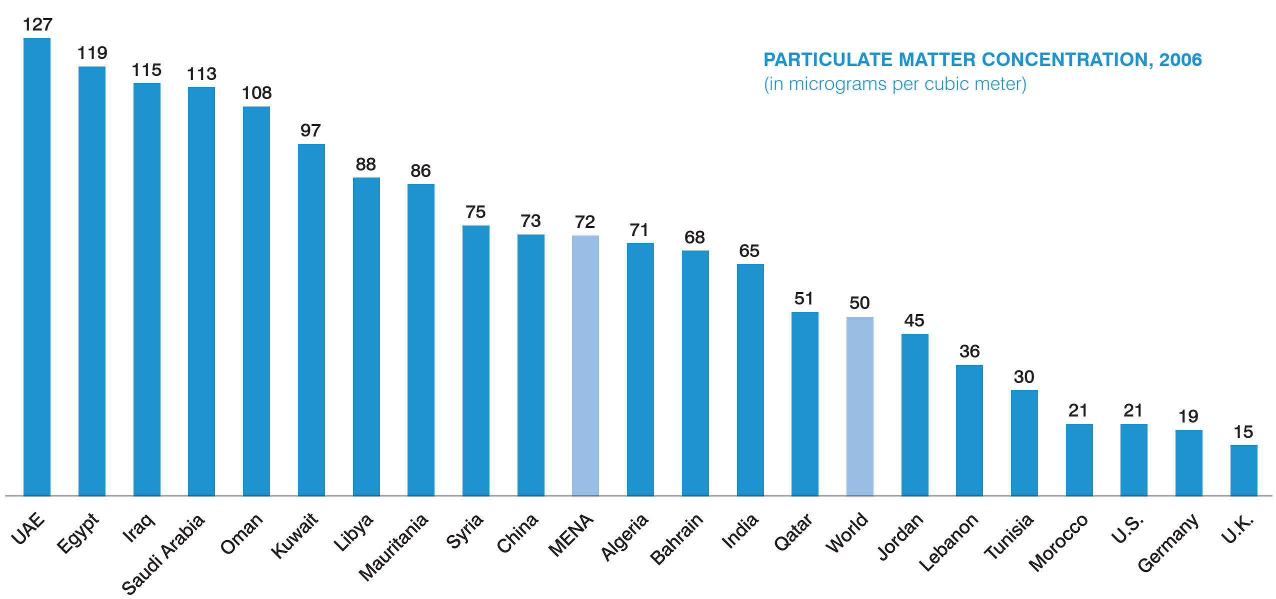
Source: German Aerospace Agency (DLR)

generation, the surpluses created could become available for more profitable downstream applications, such as aluminum or petrochemicals. Recognizing this value, Saudi Arabia has already placed a moratorium on the construction of new gas-fired plants. Renewable energy sources could themselves be a strategic export industry: Europe has committed to reducing carbon emissions substantially, and its proximity to MENA countries makes Europe a welcome market for solar power in particular. Europe's electricity markets could be connected to the region, and a "supergrid" Desertec initiative linking Europe to the MENA region was recently launched with the goal of bringing enough solar power to Europe to supply it with 15 percent of its capacity by 2050.

5. Renewables could enhance the export value of the region's traditional energy assets. Even under the most optimistic forecasts for renewables, fossil fuels will remain the dominant source of energy for the foreseeable future. In addition, OPEC's share of world oil supply is expected to grow from its current figure of 42 percent to 52 percent by 2030, according to the OPEC World Oil Outlook 2008. Given that the oil and gas–producing countries in the region will bear the burden of boosting capacity, their policymakers should see renewable energy initiatives as a way to free more oil and gas for export and enhance their position as a major energy exporter for the world.

6. The renewable energy industry could drive economic diversification and create jobs. The oil and gas sector contributes 47 percent of the GCC's GDP, but only 1 percent of employment. Countries struggling with high unemployment rates could generate employment opportunities in renewables, ranging from highly skilled positions in R&D to unskilled jobs in manufacturing and assembly. A strong renewable energy sector could help alleviate and potentially even reverse the "brain drain" occurring in the MENA region today.

Exhibit 4
Pollution Is a Regional Scourge



Note: Weighted average for urban population
Source: World Bank Little Green Book 2009

REVIEWING RENEWABLE OPTIONS

Not all renewable energy technologies will be viable for the region. Without question, wind and solar offer the greatest potential.[4] Other forms of renewable energy (including geothermal and biomass) may be promising, but most MENA countries do not have the natural resources to make them viable.

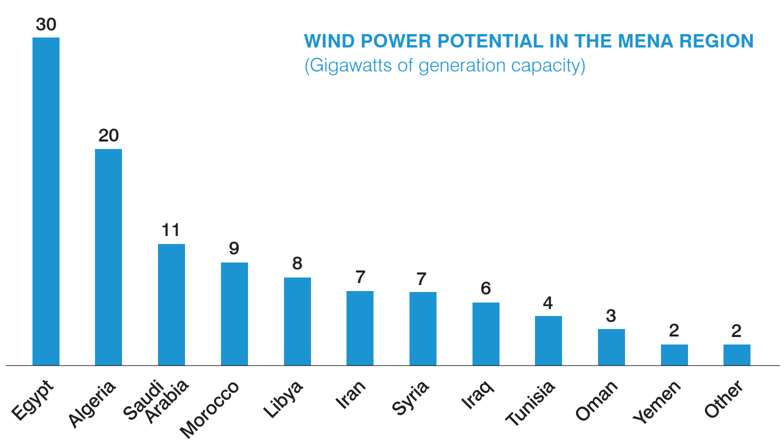
Wind

Wind energy technology is well established, and the basic design of modern wind-powered generators has not changed in several decades; this proven technology means that there should be no concern over investing in technologies that may quickly become obsolete.

On good sites, onshore wind power is already cost-competitive with fossil-fueled generation. Offshore wind power systems are about 40 percent more expensive to build than onshore systems, but those costs are partially offset by the stronger and more consistent winds at sea.

Some of the best onshore wind sites in the MENA region are in the Gulf

Exhibit 5
The MENA Region Has Significant Potential for Wind Energy



Source: "Concentrating Solar Power for the Mediterranean Region" (MED-CSP), German Aerospace Agency (DLR), 2005 of Suez and on the Egyptian and Saudi Arabian Red Sea coast, which have very high average wind speeds. Morocco and Algeria have excellent potential as well *(see Exhibit 5)*.

The major limitation on wind is intermittency; the wind does not always blow when electricity is needed. That problem can be partially mitigated by the dispersal of wind turbines over a large geographic area. In addition, planners can capture excess wind-supplied energy by linking wind turbines to hydroelectric plants, which can be used to offset intermittency and absorb wind power surpluses. Both Egypt and Morocco have significant hydropower capacity on their grids and thus should be able to integrate large shares of wind power without much difficulty. A number of MENA countries are already building or planning significant wind power capacity *(see Exhibit 6)*.

Solar

There are two major forms of solar-generated power. Concentrating solar power (CSP) uses mirrors and lenses to concentrate solar energy within plants that are utility-scale generators. Photovoltaic (PV) solar power directly

Exhibit 6
Some Existing and Planned Wind Energy Projects in the MENA Region

COUNTRY	PROJECT	CAPACITY (MW)	STATUS
Egypt	Zafarana Wind Farm	305	Operational; construction is under way to add 240 MW by 2010
Morocco	El Koudia El Baida	50	Operational
Morocco	Cap Sim (Essaouira)	60	Operational
Morocco	Lafarge (Ciments Factory of Tétouan)	10	Operational
Morocco	Ain El Alak, El Haoud & Beni Mejmel (Tanger)	140	Under realization
Morocco	Tarfaya	200	In bidding process; planned operation in 2011; option to increase to 300 MW
Tunisia	Sidi Daoud Wind Farmas	50	Operational
Tunisia	Metline and Kchabta Wind Farms	120	Contract signed
Jordan	Al Kamshah Wind Farm Project	30–40	In bidding process

Source: Booz & Company

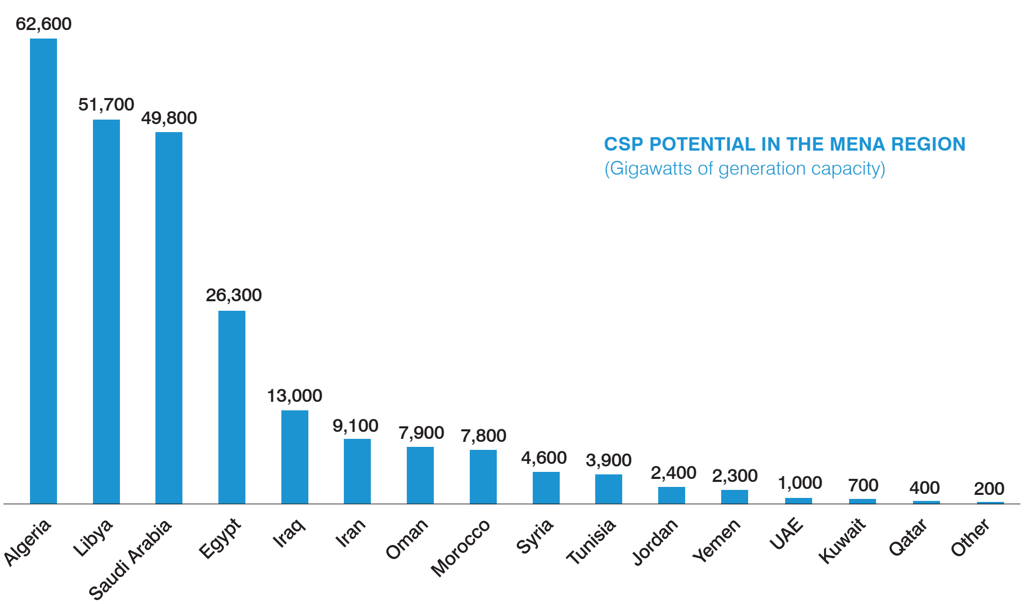
converts sunlight into electricity using semiconductors, and is often used on a smaller scale.

The key ingredient for any solar technology—solar radiation—is abundant in the MENA region. However, the prevailing desert conditions also result in extreme summer temperatures and high dust levels, both of which have a negative impact on solar energy. MENA governments are establishing research institutions to tackle these technological challenges.

Despite these difficulties, both solar technologies could be deployed widely throughout the region *(see Exhibit 7)*.

Each has advantages in certain circumstances, and the best approach for many MENA countries will likely be to use some combination of the two. In determining whether CSP or PV is the better fit for a particular need, planners must consider the location and the application. The major differences between the two lie in scale, infrastruc-

Exhibit 7
The Region Has Great Potential for Utility-Scale Solar Power



Source: "Concentrating Solar Power for the Mediterranean Region" (MED-CSP), German Aerospace Agency (DLR), 2005 ture requirements, and consistency of power output.

CSP technologies can store energy in the form of hot fluids such as molten salt. This is a key advantage since it addresses the intermittency of solar power and permits power generation even after sunset.

These technologies generally require significant infrastructure investment and support. Since they power conventional generation blocks, such as gas or steam turbines in the multi-megawatt range, their operation and maintenance costs are much higher than those of PV technologies and require specialists to build and operate. Also, most CSP plants require significant volumes of water, a scarce resource in the region, for operation.

Even though CSP plants have significant drawbacks, utilities prefer them because of their more consistent power output. In addition, CSP plants can be coupled with thermal storage

Exhibit 8
Some Existing and Planned Solar Projects in the MENA Region

COUNTRY	TECHNOLOGY	PROJECT	CAPACITY (MW)	STATUS
Egypt	Solar Thermal	Kuraimat combined gas and solar power station	62 (solar component)	Under construction; commissioning planned for late 2009
Algeria	Solar Thermal	Hassi R'Mel	25 (solar component)	Under construction; expected completion by Q4 2009
Morocco	Solar Thermal	Ain Beni Mathar	20 (solar component)	Operation in combined cycle in April 2010
UAE	Solar Thermal	Shams I	100	Award of build-own-operate contract expected shortly; commissioning expected by late 2011
UAE	Photovoltaic	Masdar City PV plant	10	Operational
UAE	Photovoltaic	Masdar City Rooftop PV	140–200	In planning stage; total size will depend on the power needs of Masdar City; expected completion by 2017
UAE	Photovoltaic	Dubai Solar Power Plant	N/A	Conducting feasibility study
Jordan	Photovoltaic	Maan Solar Power Plant	100	In fund-raising stage; commissioning expected in 2012

Source: Booz & Company

units or backup fossil-fuel burners to maintain smooth operations. Thus, utilities can depend on CSP plants for power output and do not have to keep other power plants in reserve. In the MENA region, Algeria, Iran, Egypt, and the UAE all recently announced plans to build CSP plants paired with natural gas *(see Exhibit 8)*.

For remote and small-wattage needs, PV may be a better and more economical choice than CSP. The primary advantages of PV systems rest in their scalability. Systems can generate as little as a few watts at a time or reach several megawatts. PV systems can be deployed with a single panel, delivering a few hundred watts of peak output. Further maintenance is generally limited to occasional cleaning of the panels, which does not require specialized expertise. Smaller systems are more expensive because they do not achieve economies of scale, but they eliminate transmission and distribution costs, since they can be installed close to consumers. In regions without access to the electricity grid, PV in combination with storage can offer a way to replace or complement expensive diesel generators without extending the grid into remote areas. Because electrical storage is still expensive, countries with high cooling demand could use thermal storage on the cooling side instead of deploying excess energy to pre-chill systems during hours of low demand.

The Masdar Initiative in Abu Dhabi recently commissioned the first large-scale PV installation in the MENA region. Smaller installations are proliferating, mainly in areas far from the grid.

Geothermal

Geothermal technologies use underground heat sources to generate either hot water or steam that can be used directly or converted to electricity. Geothermal potential in the MENA region has not been assessed in detail but is likely to be limited; there are few geologically active zones in the region. The best high-temperature (up to 200 degrees Celsius [392 degrees Fahrenheit]) geothermal resources tend to be in

For remote and small-power needs (less than 50 megawatts), PV may be a better and more economical choice than CSP.

geologically active regions close to volcanoes or fault zones, such as Iceland, Italy, and Indonesia. High-temperature resources in the MENA region are likely to be restricted to the area running from Suez through the Red Sea toward toward Africa's Great Rift Valley (along the coasts of Egypt, Saudi Arabia, and Yemen).

Low-temperature (60 to 120 degrees Celsius [140 to 248 degrees Fahrenheit]) resources are more common, but are more difficult and expensive to exploit. Most of the time, it is not economical to use these flows for electricity generation. However, the hot water they produce can be used for various other purposes, such as heating, domestic hot water, steam baths, and cooling via absorption chillers. Low-temperature resources are more widespread in the MENA region; Oman, the UAE, Lebanon, and Iran may all have such geothermal potential.

Where such resources are available, countries will need to develop geological expertise and political and regulatory support for the energy source if they are to make it commercially viable.

Biomass

Biomass energy is generated by burning plant residues or specially grown energy crops; fermenting wet biomass, sewage sludge, and other refuse to create biogas; producing liquid fuels like ethanol or biodiesel from energy crops; and, more recently, using algae or other aqueous microorganisms to convert sunlight to biomass and subsequently fuel.

For a number of reasons, biomass is unlikely to be a sustainable option in the MENA region. The use of biomass can create competition for agricultural lands, potentially interfering with food production. Land-use changes can also have a negative impact on the local environment or even produce more carbon than is saved by the green energy produced.[5] The large amount of water necessary to grow energy crops is another concern, especially in the water-constrained MENA region.

Although the use of agricultural residues, landfills, and sewage gas offers some potential for expansion—for example, in Morocco and Egypt—the total volume of these sources is minimal in comparison to other renewable energy sources. Novel ways of growing algae or other microorganisms in saltwater tanks or ponds may offer possibilities for increasing the biomass potential, but only if cost-effective ways can be found to grow and harvest these organisms.

COST-COMPETITIVENESS OF RENEWABLES IN MENA REGION

In the MENA region, as in most other areas of the world, conventional energy is generally cheaper than renewable energy. However, this comparison generally fails to account for two factors: the significant subsidies that conventional energy sources enjoy in the MENA region and the external costs of using fossil fuels for power generation, including pollution and opportunity costs.

MENA governments subsidize conventional power to stimulate economic growth and spread the national wealth derived from oil and gas production. This practice is not unique to the region—many countries subsidize conventional power in some way. But subsidies in the MENA region are more substantial than they are elsewhere, and they provide conventional power with a significant unnatural advantage over renewable energy sources.

For example, GCC utilities traditionally pay approximately US$1 per million British thermal units (MMBtu) for natural gas, which is roughly the equivalent of buying oil at $10 per barrel—a mere fraction of world market prices. Ultimately, those utilities are therefore able to produce power at prices far below market rates. Once transmission and distribution costs are added in,

Subsidies for conventional power sources act as an automatic brake on the private sector's development of renewable energy sources.

it costs GCC utilities about 5 to 6 cents per kilowatt-hour to provide electricity, which is approximately half the price of electricity for end consumers in the United States. Consumers' electricity bills in the GCC are often further subsidized; in some countries, electricity is actually free for citizens. The final cost to consumers who do pay for electricity is less than half what it would be without explicit and implicit subsidies *(see Exhibit 9)*.

This implied subsidy of nearly 8 cents per kilowatt-hour acts as an automatic brake on the private sector's development of renewable energy sources, because such sources need to compete with an energy source that is already very cheap and widely available.

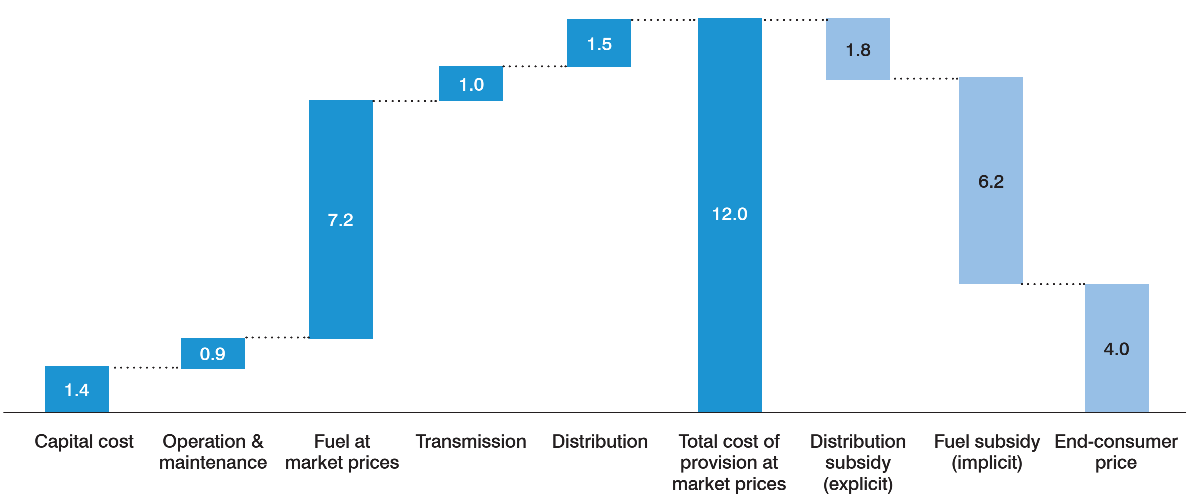
In addition, the cost of carbon emissions from fossil fuels should be included in the comparison of different options for power generation. Although MENA countries have not agreed to any emissions reductions under the Kyoto Protocol and therefore do not have to pay for carbon abatement measures, it is possible for them to monetize carbon credits through the United Nations' Clean Development Mechanism, as demonstrated by a number of projects in the region.

The costs of other emissions are more difficult to value, as they impose an indirect burden on the health and environment of the countries' citizens. Calculations by international institutions suggest that the effect is significant (around 0.9 percent of GDP for the MENA region), and it should not be ignored in comparative evaluations.

Finally, because subsidies encourage the use of fuel for power generation, this fuel is diverted from being a feedstock for higher value-added products, such as downstream petrochemicals. The potential market value of such products and the positive impact their effective use could have on GDP are not fully factored into the cost of using fuel for power generation.

Exhibit 9
How Power Stays Cheap in the GCC

COST AND INCOME STRUCTURE OF A TYPICAL GCC UTILITY
(in US cents per kilowatt-hour)



Note: Analysis based on a newly built natural gas combined cycle (NGCC) plant, a fuel price paid by the utility of $1 per MMBtu, a market fuel price of $7 per MMBtu, plant life of 25 years, overnight cost of $700 per kilowatt, and a real cost of capital of 4.5 percent.
Source: Booz & Company analysis

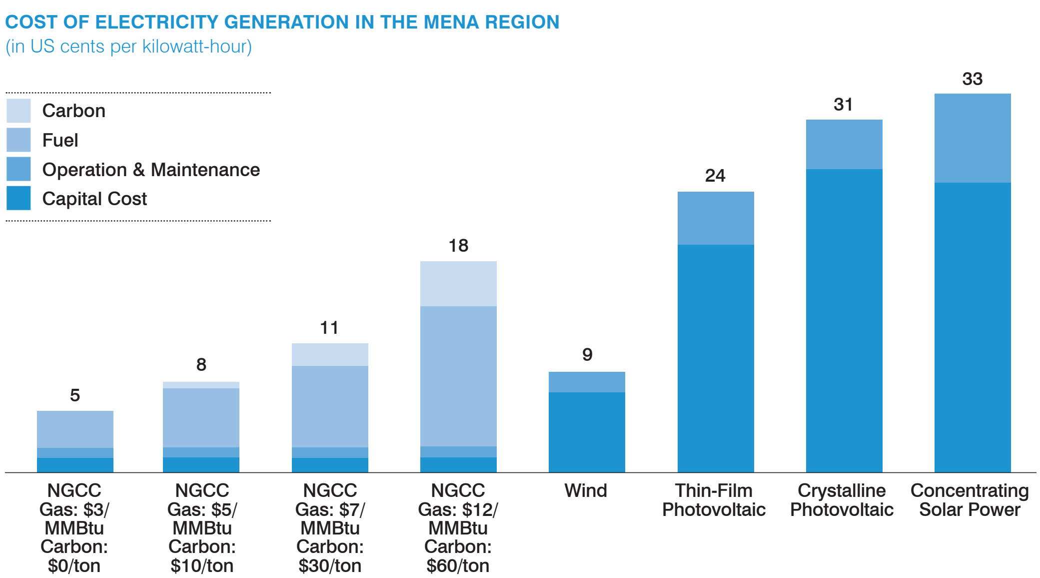
RENEWABLES' COST-COMPETITIVENESS TODAY

Renewables' cost parity with conventional sources varies according to countries' resources and existing power sources. In countries where no cheap hydrocarbons are available, the price of wind power can already compete with that of power attained through conventional generation. Egypt and Morocco, in particular, have very good sites for wind power and are actively starting to exploit these sources.

In terms of solar energy, the price of PV power generation typically compares favorably with that of power generation from diesel generators. This means PV technology can be a cost-effective replacement for generators in remote locations, as it does not require additional infrastructure or fuel transport. The picture looks different for large-scale, grid-connected solar power, however; it cannot currently compete with the region's fuel of choice, natural gas *(see Exhibit 10)*. This holds true even with gas prices at the extreme levels seen in the summer of 2008 and relatively high costs of carbon emissions.

Large-scale, grid-connected solar power cannot currently compete with natural gas, the MENA region's fuel of choice.

Exhibit 10
Large-Scale Solar Power Is Still More Expensive Than Conventional Generation



Note: Analysis for gas based on a newly built natural gas combined cycle (NGCC) plant, with construction cost of $700 per kilowatt, a capacity factor of 65 percent, and plant life of 25 years. Analysis for wind based on construction cost of $1,800 per kilowatt, a capacity factor of 35 percent, and plant life of 20 years. Analysis for thin-film photovoltaic based on a construction cost of $3,000 per kilowatt, a capacity factor of 20 percent, and plant life of 25 years. Analysis of crystalline photovoltaic based on a construction cost of $4,000 per kilowatt, a capacity factor of 20 percent, and plant life of 25 years. Concentrating solar power analysis based on a construction cost of $7,800 per kilowatt, a capacity factor of 40 percent (including 7.5 hours of storage), and plant life of 30 years (based on experience of Andasol 2). Real cost of capital is assumed to be 4.5 percent for all technologies.
Source: Booz & Company analysis

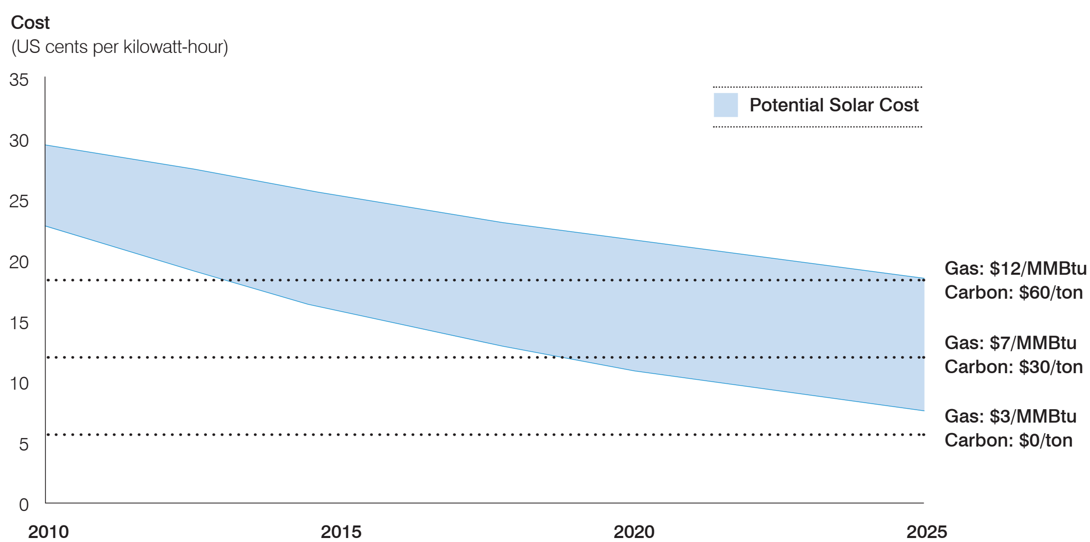
RENEWABLES' COST-COMPETITIVENESS IN THE FUTURE

Solar power's future prospects for cost parity look brighter than the situation today. The cost of solar power continues to drop, thanks to the development of the underlying technology. For example, the price of PV installations has historically dropped by between 3 and 7 percent annually, except for a period from 2005 to 2008 when explosive demand growth resulted in supply shortages of polysilicon. During this time, manufacturers increased margins instead of passing on cost reductions to their customers. When the financial crisis depressed demand and significant new manufacturing capacity came onstream in 2009, module prices caught up with the underlying trend in technology cost, and prices dropped by as much as 25 percent in the space of a year.

Assuming historical trends hold, in the coming years we can expect additional annual cost reductions of 3 to 7 percent for PV installation. The path forward for CSP is less certain. On the one hand, it is a much more mature technology, with correspondingly fewer opportunities for optimization; on the other, several new approaches (e.g., power tower, Stirling dish, and linear Fresnel) are currently being tested and might well result in substantial cost reductions. Unfortunately, little data is available on the cost of these new technologies, as most have only been proven in pilot plants, with commercial-scale plants still in development.

Based on these cost assumptions, the unsubsidized cost of solar PV power in the MENA region could become competitive with that of natural gas between 2015 and 2025, depending on the prices of gas and carbon *(see Exhibit 11)*. These calculations assume average regional conditions in terms of solar radiation, temperatures, and other technical factors and are based on the assumption that free land is available close to existing power lines.

Exhibit 11
When Will Solar Energy Achieve Cost Parity?



Source: Booz & Company analysis

POWERING RENEWABLE ENERGY IN MENA COUNTRIES: A CALL TO ACTION FOR GOVERNMENTS

The private sector's participation in the development of a renewable energy sector in the MENA region is critical for its expertise and its ability to ensure cost efficiency. However, private initiatives are not enough: The region's governments must take a leading role if renewable energy is to become viable.

1. Develop a renewable energy strategy.

A renewable energy strategy will require a number of considerations. First, governments must assess their renewable resources and technical capabilities. For instance, with more than 2,000 kilowatt-hours of solar irradiation per square meter annually, the MENA region is particularly suited to adopt solar technologies. However, solar power includes a wide range of technologies with different cost-benefit profiles. Governments should also consider the economic benefits of creating a manufacturing sector capable of supplying renewable energy projects versus importing the parts for such projects.

Next, they will need to determine the scope of their ambitions. It is not enough to decide on technologies and sites: Countries must also consider whether they want to build a strong renewables sector supported by research institutions, education initiatives, and other efforts, or just act as a technology user.

Regardless of their specific strategy, governments should ensure they abide by three key principles:

- *Start small*, using technology prototypes and demonstration projects whenever possible, so that the inevitable errors that occur in new initiatives are not too costly.
- *Grow quickly* by scaling up as soon as prototypes have proven their reliability and quality.
- *Begin now* to gain first-mover advantage and initiate the long-term process of building infrastructure and human capital.

2. Put in place the appropriate institutional setting for renewable energy.

In most countries in the region, there is no clear ownership at the government level of issues related to renewable energy. Governments must appoint and empower an entity to lead the development of policies and regulations and follow up on their implementation.

In March 2004, Algeria became the first country outside the Organisation for Economic Co-operation and Development (OECD) to create incentives for solar energy production and establish a formal renewable energy governmental entity. New Energy Algeria (NEAL) was established as the renewable energy authority within the Ministry of Energy and Mines. Such an agency can work with other government institutions to develop the necessary regulatory framework for rapid implementation of renewable energy initiatives.

Strong financial support—in the form of guaranteed markets for renewables or similar instruments—is not sufficient to get renewable projects off the ground. Numerous administrative barriers unintentionally block renewable energy projects: Wind turbines often surpass existing height limits for buildings; projects can face excessive permit requirements, limited cooperation from local utility companies in providing grid connections, or overlapping jurisdictions of multiple administrative bodies. An entity that oversees and coordinates the regulation of the renewable energy sector can help clear the administrative thicket. Such an entity could also take charge of the broader climate change agenda and ensure that renewable energy is considered within the overall context of energy diversification, energy efficiency, and climate change mitigation. The Australian Department of Climate Change constitutes a successful recent example of such an entity.

3. Develop a favorable policy and regulatory framework to promote the development and use of renewable energy.

In most MENA countries, the regulatory environment is such that national utility companies define power generation requirements, which they are mandated to meet at the lowest possible cost. Accordingly, their delivery models usually involve private developers under independent water and power producer (IWPP) schemes. This procurement model is geared toward large-scale, conventional power stations, which meet specific generation requirements such as dispatchability. Furthermore, IWPPs involve complex contracts justified by the scale of the investments and the nature of the financing involved.

Renewable energy projects, particularly small-scale ones, cannot be readily integrated into this model. Not only can renewable projects not meet dispatch requirements, but for them to be viable and bankable, they must be able to rely on revenue streams that are independent of demand, and commensurate with the investments required. Accordingly, MENA countries must make substantial changes in the regulatory framework to create incentives that would kick-start renewable energy investments.

Policymakers may want to consider investment grants, R&D grants, tax incentives, renewable portfolio standards (RPSs), feed-in tariffs (in which utilities are obligated to purchase renewable energy at a specified price), and tendering schemes that result in competitive bidding for renewable developments. In Denmark, for instance, a combination of feed-in tariffs and investment grants has been instrumental in driving the development of renewable generation. In Denmark's liberalized

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wholesale market, market forces determine the price of electricity, and renewable power generators receive an environmental premium. Not only have these policies led to wind generation that accounts for more than 20 percent of electricity supply, but they have also driven the development of an entire industry: Danish manufacturers produce 30 percent of global wind turbines, and the industry represents more than 6 percent of Danish exports. In the German wholesale market, feed-in tariffs ensure priority access to renewable power producers over conventional generators. The tariffs vary by type of technology and are included in the tariffs on consumers in such a way that German consumers bear the costs of renewable generation with only a minor increase in tariffs. As a result of such policies encouraging the development of renewables, Germany now represents half of solar capacity worldwide.

Regulatory options must be balanced against the needs and specifications of the MENA economies. The European model of feed-in tariffs for renewable power, which equitably involves a large number of participants, is well suited to the region's historically strong private-sector participation in the utility sector. In countries where integrated state utilities determine generation requirements, volume-setting quota systems like RPSs, coupled with tendering schemes, could be more suitable.

Policies and regulations that promote the development of renewables should not solely address large-scale centralized generation. Governments can promote decentralized renewable growth to consumers, and regulators should consider giving households a certain autonomy in activities such as installing rooftop solar panels. Australia's Queensland state is a pioneer in this respect, having initiated a program in 2008 whereby consumers are granted an attractive feed-in tariff for any net positive power generation resulting from their home system.

4. Enable technical grid integration.

Because power production from wind and solar sources is intermittent, these sources must be combined with conventional power generation. Doing so presents a

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technical challenge, but it is not insurmountable. Large shares of renewable power generation have been successfully integrated into the grid in other parts of the world. For instance, certain regions in Denmark satisfy substantial portions of their energy demands from wind energy without major problems—more than 20 percent annually, on average, and even 100 percent on windy, low-consumption days.[6] Similarly, regions in southern Germany have solar PV penetration greater than 20 percent on sunny, low-consumption days.[7]

These countries have overcome the challenge of forecasting and planning power needs, storing energy, and sharing the load as needed. A major study in *Utilities Policy* concluded that the only major barriers to planning for the intermittency of renewables "are the social, political, and practical inertia of the traditional electricity generation system."[8]

Addressing technical issues in the MENA region will involve a number of key strategies. Utilities can use older power plants to provide backup power when renewables are not available. They can also use thermal storage at CSP solar plants to store and deliver power even after sunset. Finally, they can manage cooling loads by using thermal storage in district cooling and managing other power demands through smart grids and smart meters.

5. Develop R&D capabilities and a deep talent pool.

The renewable energy industry needs a skilled workforce of technicians, designers, and engineers. There is a global shortage of such skilled workers, and the problem is even more acute in the MENA region, since its relatively small industrial base has not created a significant pool of trained workers who could be shifted to such tasks.

In addition, the renewable energy sector depends heavily on R&D for advancements in materials, technology, and implementation. Pioneers in the renewables sector are often situated in close proximity to world-class research institutions. The MENA region currently lacks such research institutions, but it is addressing this situation. For instance, Abu Dhabi's Masdar Institute of Science and Technology, a new university focused on renewable energy technologies, welcomed its first class of students in September 2009 (see "The Masdar Initiative," page 24). Other regional governments may consider developing similar institutions.

The Masdar Initiative

Abu Dhabi launched the Masdar Initiative in April 2006 to establish an entirely new economic sector dedicated to alternative and sustainable energy. This entity has five key components:

- The property development unit is responsible for developing Masdar City, the first zero-emissions city in the world.
- The utilities and asset-management unit is building a portfolio of operating assets and strategic investments in renewable energy.
- The industries unit will invest in production assets and develop Masdar's high-tech solar cluster.
- The carbon management unit is developing a portfolio of clean development mechanism projects and a carbon capture and storage network in Abu Dhabi.
- The Masdar Institute is a graduate-level scientific and engineering institution focused on education and research in renewable energy and sustainable technology.

CONCLUSION

Although some countries in the MENA region have begun renewable energy projects, the region as a whole is still rife with potential. Competitive positions in this sector are not yet set, and there is substantial opportunity for first movers to become global leaders by adopting the requisite policies and launching bold initiatives. Countries that move quickly, such as the UAE with its unique Masdar Initiative and its hosting of the International Renewable Energy Agency headquarters, could build a sizable and sustainable competitive advantage.

Endnotes

[1] IPCC Fourth Assessment Report: "Climate Change 2007"

[2] U.S. Department of Energy; European Wind Energy Association

[3] The GCC consists of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates.

[4] Hydropower is not included in this discussion: The water supply in the MENA region constitutes a major challenge that must be tackled through a comprehensive planning approach, not just addressed as a component of a renewable energy portfolio.

[5] For example, in the case of rainforests being burned down to create space for palm oil plantations.

[6] Lennart Söder, Lutz Hofmann, Antje Orths, Hannele Holttinen, Yih-huei Wan, and Aidan Tuohy, "Experience from Wind Integration in Some High Penetration Areas," *IEEE Transactions on Energy Conversions*, vol. 22, no. 1, March 2007, 4–12.

[7] Solar Electric Power Association's Solar Fact Finding Mission to Germany for Utility Decision Makers, "Summary Report," June 9–3, 2008.

[8] Benjamin K. Sovacool, "The Intermittency of Wind, Solar, and Renewable Electricity Generators: Technical Barrier or Rhetorical Excuse?" *Utilities Policy*, vol. 17, no. 3–4, September 2009, 288–296.

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