CHAPTER 4: SOLAR AND OTHER ALTERNATIVE ENERGY

INTRODUCTION

This chapter provides an assessment of the need for alternative energies given global energy demand and efforts to reduce greenhouse gas emissions at the international level. Also discussed are benefits of alternative energy sources, an overview of the types of alternative energy technologies that could be relevant for Qatar and the Gulf Cooperation Council region, and international initiatives, financing and policies for alternative energy. Qatar and the other GCC countries are examined in terms of the potential advantages and challenges to introducing alternative energy, as well as an overview of the existing initiatives and efforts to introduce these technologies in the region. The chapter concludes by outlining several policy options that could help encourage wider development of an alternative energy economy in the GCC.

ALTERNATIVE ENERGY IN A GLOBAL CONTEXT

GCC Energy Demand

Overall economic activity is expected to grow rapidly in the GCC region in coming decades. This domestic economic growth will likely cause many GCC countries to experience increases in the fraction of energy that is consumed domestically, which, of course, renders it unavailable for export. Expectations for rising living standards and increasing dependence on energy-intensive desalination compound the energy challenges. Demand for electricity, which is typically generated by domestic gas, is already outstripping supply in some GCC countries and is expected to rise by 7 to 8 percent per year on average for the coming decade.[172]

In addition, increasing use of fossil fuel energy presents potential hazards to the regional and global environment. Because of their current industrial structures and consumption patterns, Qatar, the United Arab Emirates (UAE), Kuwait and Bahrain have some of the highest per capita CO_2 emission rates in the world. At the same time, many world regions are investing in alternative fuels and energy efficiency, and are developing previously untapped resources, especially shale gas. This increase in production will likely enhance the competition in energy markets for GCC member states.

Benefits of Alternative Energy Sources

Alternative energy offers some benefits when compared with conventional energy sources. For example:

- Alternative sources are often cleaner than fossil fuel combustion, and can improve public health and the local environment by reducing regional air pollutants.
- Some alternative sources such as wind and solar power do not require water for their operation and therefore do not pollute or strain water resources.
- Renewable sources of energy can have important climate change benefits: Greenhouse gas (GHG) emissions throughout renewable energy's life cycle, including manufacturing, installation, operation and maintenance, and dismantling and decommissioning are minimal.[173]
- Renewable energy contributes to economic diversification and job creation in manufacturing, installation, maintenance and other dimensions of the supply chain.
- Renewable power utilizes inexhaustible natural resources that can lead to reduced consumption of

fossil fuels for countries with abundant domestic sources of such fuels. This allows additional exports of oil and gas that are often more valuable on world markets than in domestic markets.

Alternative Energy Technologies in the GCC

While there are many types of alternative energy being developed globally, the GCC countries have some geographic and economic characteristics that offer opportunities for development of several technologies:

- **Solar energy:** Based on annual insolation (aggregated sunny hours adjusted for solar intensity), the Gulf region has some of the highest solar potential in the world. The region's annual average global solar radiation (GSR, available to photovoltaic cells) is estimated at about 6 kWh/m^2 per day. Estimates of the direct normal irradiance available to solar concentrating technology are around 4.5 kWh/m^2 per day. These figures suggest that a land area of approximately 1,000 km^2 (0.2 percent of the GCC) covered with photovoltaics (PVs) at 20 percent efficiency could produce 438 terawatt-hours (TWh) every year—about the entire electricity demand of the region.[174] Peak energy demand in GCC is during the daytime in August and September, when air conditioning use is the highest, coinciding with the highest GSR levels over the year.
- **Wind energy:** This alternative source is also available in the GCC countries, particularly in the coastal and gulf areas. Countries with more than 1,400 hours of wind per year are considered to have economically viable wind energy. Saudi Arabia has the most recorded hours of full wind load per year among GCC countries, at 1,789 hours.[175] Data from the Saudi Arabian Presidency of Meteorology and Environment have shown considerable wind potential in the Arabian Gulf in November, December, January and February, with wind speed averages at 5.39 m/s, 7.27 m/s, 7.35 m/s and 6.26 m/s.[176] However, better data and mapping for offshore wind resources are needed.
- **Biofuels:** The Gulf region also has potential for algae biofuels. Its large non-arable lands, extensive coastline and high annual solar irradiance create ideal conditions for the growth of algae. Its existing physical infrastructure and human capital in areas such as oil refineries, power plants, desalination plants, and sewage and wastewater treatment plants provide the capacity for CO_2 capture, salt reuse and water treatment in the algae biofuel industry. Furthermore, the International Energy Agency (IEA) estimates that biofuels will make up about 30 percent of aviation fuel supplies by 2050.[177] As the GCC establishes itself as a world-class aviation hub and tourist destination, biofuels, when done right, can bring significant economic benefits and emission reductions for the region's airlines.

In the Gulf region, natural resources vary over specific geographical locations, which means that not all technologies will be appropriate for all places. Moreover, the policies and industrial structure in individual countries vary, which means that the existing barriers and appropriate policy options for each country might be different across those countries as well. Nevertheless, the region as a whole, much like other world regions, exhibits a few general characteristics that are currently hindering more rapid deployment of renewable energy. A few examples include price distortion from fossil fuel subsidies, market failure to value the public goods nature of renewables, inadequate information, high transaction costs, and outstanding barriers to international trade and investment. Because these problems have been an issue across the globe, other countries have tried a diverse set of policies to promote renewable energy. Lessons from those experiences can be applied to the specific context of the GCC.

In this chapter we will focus on policies that address several particular barriers. For example, high initial capital requirements can present a barrier to renewable energy deployment, but this is an area that many

countries within the GCC can address through government action or the catalyzing of private sources of finance. In addition to common challenges in renewable energy deployment, GCC countries also face some specific policy and technological issues in developing alternative energy in the region, including the effect of high temperature and dust on solar energy, the lack of detailed studies of wind characteristics in the region, and the lack of understanding of the costs and benefits of biofuels being developed recently. Such areas are also manageable with some direction from governments and coordination with the many new energy research centers in the region.

INTERNATIONAL INITIATIVES

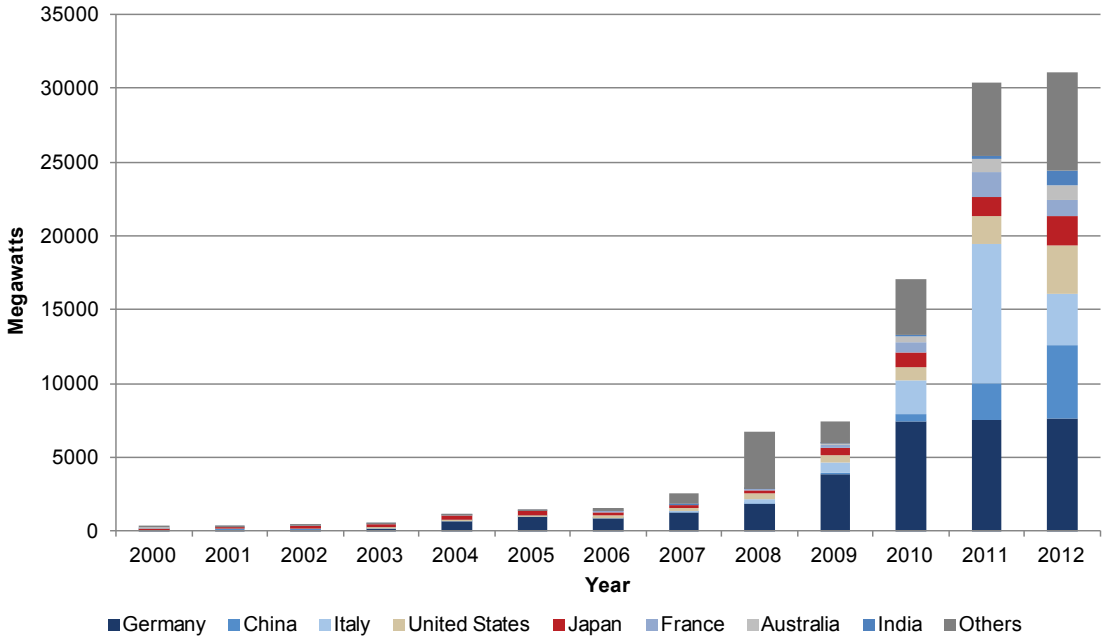
International Solar and Alternative Energy Initiatives

Renewable energy is now the fastest-growing power generation sector globally. From 2000 to 2012, cumulative global installed renewable energy capacity has grown by 96.5 percent, from 748 GW to 1,470 GW.[178] In absolute terms, global renewable generation in 2012 reached 4,860 TWh, more than the estimated total electricity consumption of China, and represents about 21.7 percent of global electricity.[179] In just five years, solar PV capacity increased from below 10 GW in 2007 to over 100 GW in 2012. In addition, the amount of annual installation has increased rapidly: In 2012 alone, global capacity of wind (onshore and offshore) rose by approximately 45 GW (an increase of 19 percent) from 2011, and solar PV by an estimated 30 GW (an increase of 42 percent).[180] The amount of annual consumption of renewable energy has also increased sharply: In 2012, wind power consumption increased by 18 percent to 521 TWh, and solar power increased by 58 percent from 2011, to 93 TWh.[181] The IEA estimates that renewables will make up almost a quarter of the global energy mix by 2018. The share of non-hydro renewable sources such as solar, wind, geothermal and biomass will double, reaching 8 percent by 2018, up from 4 percent in 2011 and just 2 percent in 2006.[182] Another recent report by the International Renewable Energy Agency (IRENA), projects renewable energy trends to 2030 and estimates that, by doubling the rate of energy efficiency improvements and providing universal access to modern energy services via renewables, the renewable energy share could rise to as much as 36 percent by 2030.[183]

By the end of 2012, the countries with the greatest renewable energy capacity were China, the United States, Brazil, Canada and Germany; the top countries for non-hydro renewable energy capacity were China, the United States, Germany, Spain, Italy and India (see Figures 4 and 5). Notably, the BRICS nations accounted for 36 percent of total global renewable capacity and almost 27 percent of non-hydro renewable capacity.[184] This rapid increase in renewable energy was spurred by falling prices and strong policy support from governments in China, Germany, Japan, Spain and others. The price of crystalline silicon photovoltaic cells dropped from $76.67/watt in 1977 to an estimated $0.74/watt in 2013.[185] This decrease has recently accelerated with scale economies—even in the past two years, prices have dropped by 60 percent.[186] In the EU, some mid- and small-sized solar projects are being developed without subsidies. In southern Italy, where net metering and self-consumption are being incorporated, solar projects are delivering electricity at $1.20/watt. Solar power in India comes at $1.52/watt, and Australia's residential solar power, before subsidies, is at $1.90/watt.[187]

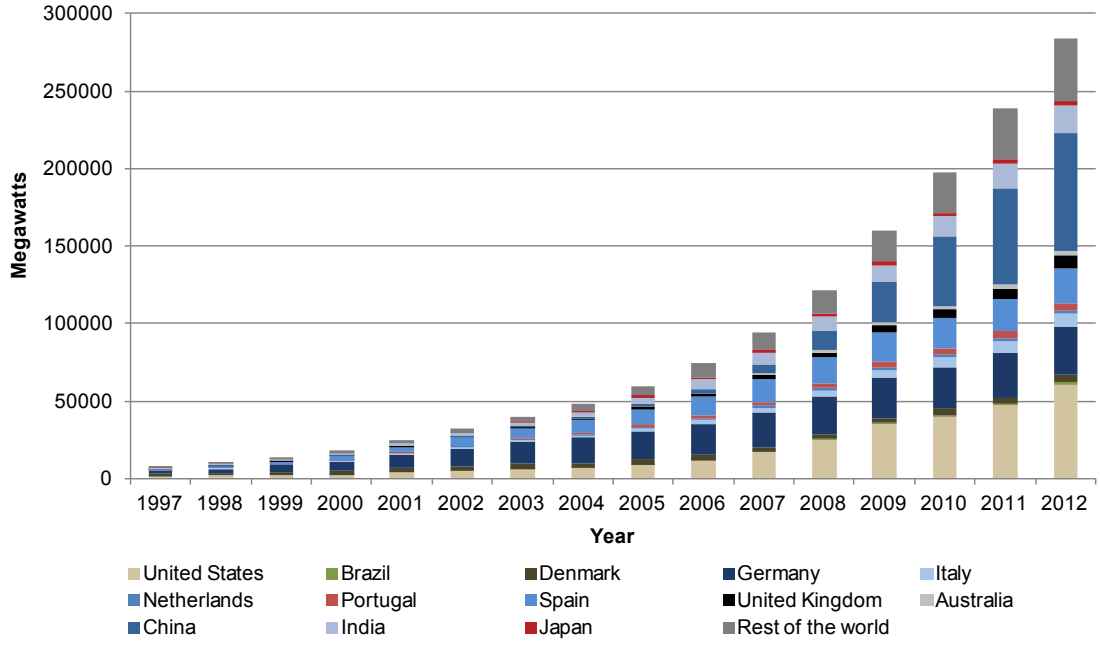
Wind energy prices have also been decreasing. The levelized cost of energy (LCoE) for wind is estimated to be at an all-time low in 2012-2013. Relative to their 2008 peak price, wind turbine prices have fallen by approximately 25 percent in western markets and by 35 percent in China by 2012.[188] According to a joint study by NREL and LBNL, the best wind sites in the

Figure 4: Installed solar photovoltaics capacity in selected countries and the world, 2000-2012 (MW)



Earth Policy Institute (2013) Data center; 2000-2012 data for China and the world and 2011-2012 data for all other countries from European Photovoltaic Industry Association (2013) Global Market Outlook for Photovoltaics 2013-2017; 2000-2006 data for countries excluding China from IEA Photovoltaic Power Systems Programme (2012) Trends in Photovoltaic Applications: Survey Report of Selected IEA Countries between 1992 and 2011; 2007-2010 data for countries excluding China from EPIA (2012) Global Market Outlook for Photovoltaics Until 2016.

Figure 5: Cumulative installed wind capacity, 1997-2012 (MW)



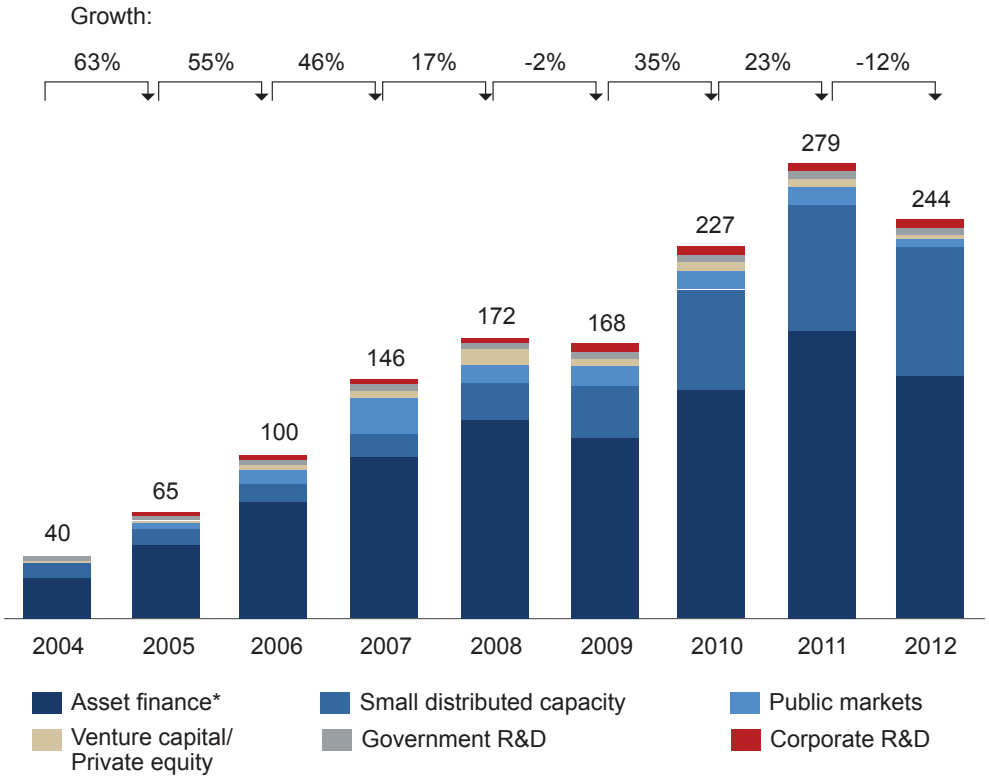
BP (2013) Statistical Review of World Energy 2013.

U.S. can support LCoE at 3.3 cents/kWh, and the lowest wind speed sites, 6.5 cents/kWh.[189] In Brazil, average onshore wind prices fell to 4.2 cents/kWh in December 2012, 12 percent lower than the prior year.[190] These numbers indicate that onshore wind is competitive with natural gas power especially in areas of higher prevailing energy prices. The LCoE of current offshore wind projects in Europe is 17.1 cents/kWh, and those projects entering into service in the U.S. in 2018 are projected to average 19.34 cents/kWh.[191] Roland Berger estimates that offshore wind LCoE will drop to 11.88 cents/kWh by 2020.[192]

Global Investment in Alternative Energy

Global investment in new renewable energy projects, excluding hydropower, was $244 billion in 2012. This is 11 percent lower than the record $279 billion in 2011, reflecting the policy uncertainty in some key countries (Figure 6). For instance, the potential expiration of a production tax credit for wind in U.S. at the end of 2012 slowed down investment in wind capacity. Similar uncertainty surrounding the expired tax- and generation-based financial incentives in India stalled wind investment there.

Figure 6: Global investment in renewable energy by asset class (billions of dollars)



Frankfurt School-UNEP Centre, BNEF (2013) Global Trends in Renewable Energy Investment 2013.

Alternative Energy Policies

Worldwide, a number of policies have been enacted to promote renewable energy. As of early 2013, 71 countries and 28 states/provinces had adopted some form of feed-in tariff (FIT), including Jordan, Malaysia, Rwanda and Ukraine, which introduced FIT systems in 2012. Twenty-two countries and 54 states/provinces in the U.S., Canada and India have renewable portfolio standards (RPS) or quotas for renewable power generation. Net metering policies are in place in 37 countries, including Canada (in 8 provinces) and the U.S. (in 43 states, Washington, D.C. and four territories). A host of fiscal incentives exist to help overcome the financial barriers to deploying renewables. In the U.S., the production tax credit for wind was extended to 2013 and revised to expand eligibility. Cameroon removed the value-added tax on all renewable energy products in 2012. Table 6 provides highlights of alternative energy policies from some select countries.

In terms of algae-based biofuels, most development is currently being led by developed countries, with the exception of developing countries like China and India, which are funding algae biofuel R&D collaborative projects among universities, research institutions and industries. ExxonMobil and Synthetic Genomics have a $600 million R&D venture committed to algae-based biofuels. In 2008, a consortium of private and public investors, including the Gates Foundation, the Rockefeller Foundation, BP, Chevron, the U.S. Department of Energy, etc., invested over $300 million towards commercialization of this technology.[193]

ALTERNATIVE ENERGY IN THE GCC

Advantages and Challenges in the GCC Region

- **Solar energy:** It is well known that the efficiency of crystalline silicon photovoltaic solar cells decreases linearly with the rise in temperature,[194] an issue that has real consequences for solar production in the GCC. Nevertheless, even though efficiency decreases as temperature increases, this may be compensated for by increasing solar intensity. Therefore, overall power production from PV panels may go up on a hot sunny day because of the abundance of sunlight. In addition, some technologies, such as thin-film panels based on CuInSe2 and CdTe, are able to maintain efficiency at higher temperatures and do not register significant temperature-dependent degradation until around 100°C.[195] Developing and deploying such heat-insensitive technologies could improve overall solar PV economics in the GCC.

  Another issue in the GCC for solar energy is the accumulation of dust on the panels, particularly as water for washing is in short supply. A number of studies reviewed the impact of dust on the performance of photovoltaic panels and a variety of cleaning methods, including cleaning with water, cleaning with surfactant, using specialized coatings and self-cleaning mechanisms.

- **Wind energy:** One major barrier to wind energy deployment in the GCC region has been the lack of data collection for wind characteristics. IRENA and the German Aerospace Center (DLR) recently launched a collaborative graphic information system of global solar and wind resources in January 2014, the Global Atlas for Solar and Wind Energy project, which is an overview of existing initiatives and outcomes.[196]

- **Liquid biofuels:** Microalgae are a potentially promising feedstock for future transport fuels. Algae can be grown almost anywhere, even on sewage or salt water, and do not require fertile land or food crops. They have much faster growth rates than terrestrial crops. The yield of oil from algae is estimated to be 20,000 to 80,000 liters per acre per year. With a minimum input of additional energy to harvest and process, microalgae can be converted to biodiesel, bioethanol, bio-oil, biohydrogen and biomethane. Algal-based biodiesel can be used for cars, trucks and airplanes.[197]

Table 6: Comparison of solar and alternative energy policies in selected countries				
	China	**Germany**	**India**	**South Africa**
National RE targets	15% RE by 2020	35% RE by 2020; 80% by 2050	15% RE by 2020	13% RE by 2020
Solar PV in 2011	Total installed capacity: 3.1 GW; Annual manufacturing capacity: 66.3 GW	Total installed capacity: 24.8 GW; Annual manufacturing capacity: 5.3 GW	Total installed capacity: 0.5 GW; Annual manufacturing capacity: 2.2 GW	Total installed capacity: 30 MW
Wind in 2011	Total installed capacity: 62 GW; Annual manufacturing capacity: 61.3 GW	Total installed capacity: 29 GW; Annual manufacturing capacity: 9.5 GW	Total installed capacity: 16 GW; Annual manufacturing capacity: 4.6 GW	Total installed capacity: 10.1 MW
National policies	Ambitious targets; fixed FITs; tax incentives and subsidies; grid connection requirements; low finance rates	Ambitious targets; comprehensive RE law w/ FITs, tax incentives and provisions for grid interconnection; investment incentive packages; structured innovation policies and programs, including PPP and workforce development. Started phasing out solar FIT by 2018, enacted subsidy for energy storage	Ambitious targets (for solar); FITs; capital subsidies; tax incentives	Ambitious targets; switched from FIT to a bidding program (REIPPP)
Assessment of policies	Policies mainly designed to boost efficiency and domestic economy; has driven exponential manufacturing and lowered cost of RE globally. Recent push for domestic installation of RE, instead of for export.	Stable and comprehensive policy framework has been key driver to building Germany's RE industry.	Key policies linked to National Action Plan for Climate Change, but growth constrained by limitations in infrastructure, access to finance, and policy inconsistences at state and national level.	Lack of coordination at the policymaking level and uncertain regulatory environment hamper RE development.

Notes: GW: gigawatts; RE: renewable energy; FIT: feed-in tariff; PPP: public private partnership; REIPPP: Renewable Energy Independent Power Producer Procurement Programme

WRI (2012) Delivering the Clean Energy Economy: Why Policy Matters; WWF and WRI (2013) Meeting Renewable Energy Targets: Global Lessons from the Road to Implementation; World Wind Energy Association (2013) World Wind Energy Report 2012; Pienaar (2011) Shifting Policies Stall South Africa's Renewable Energy Growth; Maphelele et al. (2013) South Africa Solar Energy Technology Road Map; and Sawhney (2013) Policy Monitor Renewable Energy Policy in India: Addressing Energy Poverty and Climate Mitigation.

Qatar and GCC Region Solar and Alternative Energy Initiatives

GCC member states have been active in investigating solar power opportunities and initiating new projects. The six countries altogether have approved solar projects worth approximately $155 billion, which will generate more than 84 GW of power when complete in 2017. Saudi Arabia and the UAE accounted for most of these solar projects.

Qatar has established an ambitious renewable energy deployment target of 20 percent by 2030. At this stage, state efforts have focused on developing technical capacity in the country via research centers, universities and pilot projects to jump-start market activity. A few highlights include:

- *A planned 200 MW solar project* to be developed by Qatar Solar Technologies, a venture between the private charity Qatar Foundation, Germany's SolarWorld AG and the Qatar Development Bank. This project aims to produce polysilicon, manufacture photovoltaic panels and install the devices. In May, the venture obtained financing for a $1 billion polysilicon plant in Ras Laffan City from Islamic lender Masraf Al Rayan. The facility will initially produce 8,000 metric tons of polysilicon a year and enough of the raw material for 6.5 GW in panels when at full capacity.
- *A 200 MW mixed renewable project announced at COP18*. The president of the Qatar General Electric and Water Corporation (KAHRAMAA) and Qatar's energy minister announced this project at the international climate conference in Doha in 2012. Phase 1 of the project would involve 5 to 10 MW of pilot plants and would cost around $30 million. Phase 2 will assess the results of the initial projects in attracting private sector involvement for an eventual 150 to 200 MW scheme, developed over the following years, up to 2020.
- *A new solar test facility located in the Qatar Science & Technology Park*. Chevron and GreenGulf, a Qatar renewable energy company, invested $10 million to advance solar energy, solar air conditioning and energy efficiency.
- *A program to develop biofuels*. Qatar Airways has announced plans to partner with Airbus, the Qatar Science & Technology Park and Qatar Petroleum to develop biofuels for use in air transportation.

Saudi Arabia plans to double its installed electricity capacity by building 54 GW of renewable energy (as well as 17.6 GW of nuclear power) by 2032, of which 41 GW (30 percent of total electricity) will be solar power; 25,000 MW will be from concentrating solar power plants; and 16,000 MW will be from solar photovoltaics. This ambitious plan requires an investment of $109 billion. Bloomberg New Energy Finance estimates that, by building solar PV plants and selling the displaced oil on the international market, the state can generate an internal rate of return of approximately 12 percent.[198] Other notable projects include:

- *Saudi Aramco's expansion of its 3.5 MW KAPSARC solar park in Riyadh*, currently the biggest ground-mounted photovoltaic plant in the country, to 5.3 MW. Construction on phase II of the project began in June 2013.
- *Saudi Electricity Company's 500 kW pilot solar plant* on the Farasan Islands came online in 2011 and is Saudi Arabia's first solar power plant.
- *Phase I of the King Abdullah Initiative for Solar Water Desalination* is expected to be operational by the end of 2013. The first phase of the project started in 2010 and resulted in two solar plants being constructed in Al-Khafji and Al-Oyainah, providing a total of 10 MW of solar-generated energy for the desalination plant that would have a capacity of producing 30,000 m^3 of drinking water per day to meet the needs of the 100,000 Al-Khafji residents.

The **United Arab Emirates** currently has 20 megawatts of solar energy capacity, including 36 solar installations that generate, in total, 10 MW of electricity and hot water, as well as the first grid-connected 10 MW solar power plant in Masdar City. By the end of 2013, new projects underway are expected to bring the total to 140 MW. It is expect that at least 800 additional MW of solar power will come on stream by 2020, and another 900 MW before 2030.[199]

- *Projects at the city level*, for example, Abu Dhabi announced a target of 7 percent renewable energy generation capacity by 2020 (1,500 MW) in 2009. The $3.2 billion Mohammed bin Rashid Al Maktoum Solar Park in Dubai covers 48 km^2, and aims to generate 1 GW from PV and concentrating solar power installations by 2030. The first part of the park, a PV plant with a capacity of 13 MW, is expected to finish construction by the end of this year. The plant is self-funded by members of the supreme council of energy.

- *Bilateral initiatives*, e.g., Masdar announced that it will invest up to Arab Emirates dirham (AED) 6 billion ($1.6 billion) in alternative energy projects alongside the U.K.'s Green Investment Bank. It is currently evaluating solar thermal technology at its Masdar City project and has installed a field of hybrid solar photovoltaic-thermal system solar thermal panels as a pilot project. Abu Dhabi is also investing in alternative energy abroad, such as the London Array and in Gemasolar. In terms of biofuels, the UAE-based Etihad Airlines is working with Boeing (U.K.) to research whether plants that can be grown in seawater mangroves around Abu Dhabi could be used as biofuel feedstock.

- *Financial incentives*, for example, Abu Dhabi has launched a government sponsored financial incentive program in the form of a solar rooftop plan designed to make the use of solar photovoltaic technology on rooftops more affordable to Abu Dhabi building owners. This project is led by Masdar and the Abu Dhabi electric utility ADWEA. The program aims at achieving 500 MW PV on rooftops within 20 years.

Kuwait has also announced national renewable energy deployment targets in late 2012, aiming to achieve 1 percent by 2020 and 15 percent by 2030. In June 2013, Kuwait invited bids for its first solar energy project, to be built in Shagaya. The first phase of the project will have a capacity of 70 MW by 2016, of which 50 MW will come from solar thermal sources and 10 MW each from photovoltaic and wind sources. The second and third phases will have a capacity of 930 MW and 1,000 MW, respectively, when the project is completed in 2030.

In **Bahrain** the development of renewable energy is at an early stage. The country is constructing a 5 MW solar and wind power station (3 MW from solar and 2 MW from wind), which is due to be implemented in the next five years. The project is a collaboration involving the National Oil and Gas Authority, Bahrain Petroleum Company (Bapco), the Electricity and Water Authority and the University of Bahrain. According to Bapco, nearly 21,000 solar panels, covering an estimated 34,000 m^2, have been installed by April 2013. Another 5 MW solar PV project was launched in 2012 and is a joint venture between BAPCO, NOGA and two U.S.-based firms, Caspian Energy Holdings and Petra Solar. With total investment set to reach $26 million, the solar project is a first for BAPCO and includes involvement from several government bodies. Bapco opened HRH Princess Sabeeka Park in February 2010, which includes a model scientific laboratory for renewable energy.

In **Oman**, Sultan Qaboos bin Said's "Vision 2020" decree set the target of producing 10 percent of its total electricity from renewable energy sources by 2020. A ministerial committee has been established to oversee and coordinate efforts and is chaired by the Ministry of National Economy. Oman is undertaking the development of several projects, including:

- Plans to initiate tenders for two solar projects, each of between 100 MW and 200 MW, in the towns of Adam and Manah.
- In mid-January 2012, Terra Nex Financial Engineering AG and the German Middle East Best Select (MEBS) Group of Funds announced plans to invest $2 billion in PV solar power in Oman, including a 400 MW solar power plant, and silicon production, solar panel and aluminum frame manufacturing. The manufacturing arm of this project is expected to produce 120 MW of solar panels a year initially and create over 2,000 direct and indirect jobs.
- In July 2011, Petroleum Development Oman awarded the first solar thermal enhanced oil recovery project to GlassPoint Solar. The project will use a 7 MW solar array to produce 11 tons/hour of high pressure steam that will be used to extract 33,000 barrels of oil. It will also provide 24-hour heating.
- The potential of wind energy production has been outlined in Oman Power and Water Procurement Company's seven-year outlook for power generation and desalinated water supply in Oman for the time period 2012-2018 and two wind energy-based pilots, each of 3 MW capacity, are planned to be located at Masirah and Thumrait.

RECOMMENDATIONS

A strategy to enhance the development and deployment of alternative energy technologies in the region needs to establish technical expertise, ensure robust technologies are available at reasonable cost, and create the market and policy conditions to encourage their uptake by the private sector. Such a program could draw from any or all of the following six recommendations:

Resource Assessment and Data Collection

The ultimate financial return from many renewable energy technologies depends heavily on the quality of the resource—such as wind or solar. Until very recently, little was known about these resources in the GCC because most mapping was done through remote sensing (satellite) data collection and very broad extrapolations from ground measurements. A high priority is therefore to continue and expand progress toward resource assessment in the GCC. Recently, resource assessment and mapping has gained significance as part of the GCC region's rapid ongoing adoption of renewable energy sources such as solar and wind, to complement fossil fuels. In 2012 the UAE Directorate of Energy and Climate Change, Dubai Supreme Council of Energy, and Environment Agency of Abu Dhabi launched the Research Center for Renewable Energy Mapping and Assessment at Masdar Institute. Additionally, a workshop was held in July 2012 at the Masdar Institute to identify collaboration opportunities in resource-mapping activities,[200] and in 2013 the Masdar Institute developed the UAE solar and wind energy resources maps. The UAE Solar Atlas was subsequently made publicly available to the international community through the Global Atlas online portal developed by IRENA.[201] Such programs, as part of a systematic data collection strategy, can greatly enhance siting and assessment of the appropriateness of these technologies. As such, they should retain a high priority for the coming few years as a precursor to broader renewable deployment.

Renewable Requirements

Minimum requirements for the share of renewables can ensure certain milestones are met for renewable energy deployment. In such cases, there has been much discussion of the "feed-in tariffs" that were used frequently in Europe. However, such tariffs may not be effective in many GCC countries because of the more centralized nature of their utilities, and the lack of tax systems rendering feed-in tariffs untouchable.[202] One possible alternative approach is the renewable port-

folio standard (RPS), which mandates that a certain fraction of utility energy should come from a basket of specific technologies, such as wind and solar, or renewables in general. There is some precedent for RPS implementation in the region, as Abu Dhabi has committed to provide 7 percent of its total power generation capacity from renewable sources by 2020.

Region-Specific Technological Research

The region has recently seen the establishment of many research centers and university programs on energy, which can provide the basis for building out effective research programs. But the research areas should be selected carefully in niche areas for which the region can provide some comparative advantage. Moreover, GCC member countries are in the unusual position of being able to support demonstration projects in a few selected technological areas. Appropriate niche applications could include, for example, a new line of technology or a regionally specific application. As discussed earlier, algal biofuels and dust-preventive or dust-resilient technologies represent two potential specialization areas.

Energy-Pricing Reform

Worldwide, fossil fuel subsidies have led to investments that depend on low-cost energy. Undoing those investments may have to be a gradual process, but in the long run the economic costs of continuing subsidies is not sustainable for national accounts or the environment. And while some alternative energy sources can compete with fossil fuels at world market prices, subsidized fossil fuels make the barrier to widespread adoption of alternatives very high. Reforms to pricing could be made incrementally by initially seeking to address two types of subsidies—those paid out either in-kind or as financial support to the private sector, and revenues foregone because of excess domestic demand. The diversion of some of this support to producers of electricity from renewable sources could help those utilities develop a portfolio of low-carbon alternatives. While pricing reform is potentially difficult, planning a gradual transition could be in the long-term interests of macroeconomic health as well as cleaner energy use.

Public-Private Partnerships

Public-private partnerships could help utilities, governments and private sector partners in several ways. First, by engaging industrial partners, governments can encourage innovation in areas that suit both government goals and private sector interests. Ideally, those partnerships can evolve into broader innovation ecosystems that draw in research partners and global expertise. Second, partnerships can help signal to investors the likely trajectory of energy policy and government priorities in the coming decade.

Alternative Finance

One potentially attractive way of financing renewable energy projects in the Arab countries is through Sukuk. Sukuk are certificates representing undivided shares in ownership of tangible assets, usufruct and particular projects or special investment activities. For Islamic financial institutions and corporations, Sukuk offer considerable advantages in liquidity management, fundraising, securitization and balance sheet management. For investors, Sukuk offer the ability to invest in a Sharia-compliant asset class with high tradability. This approach could address one of the big private sector obstacles to smaller-scale renewables: the upfront high capital investment cost.