## CONCLUSION: SYNTHESIS AND RECOMMENDATIONS

There is no doubt that energy choices matter for a country's long-term economic growth, social well-being and environmental health. Although resource variation and history affect the present day energy situation in every country, those factors do not condemn any country to any one path into the future. Throughout the world, countries have been able to affect their long-term energy trajectories through specific and concrete decisions. Policy decisions at the government level can influence the suite of technologies that are profitable and can provide a signal of stability for long-term investment. Decisions within industry and the private sector can influence firms' long-term profitability and guard against price volatility and policy risks. Additionally, energy decisions at the consumer level can have a real impact on household budgets and quality of life.

After decades of strong growth supported by the energy industry, Qatar and other Gulf Cooperation Council (GCC) countries are now in a position to evaluate their possible energy futures. Just as for any country, each GCC state will have different resources and historical factors that have led it to its present-day economic structure and energy system. But most also have the capacity and capital now to choose from a wide set of optional energy futures. The preceding four chapters have reviewed a wide variety of considerations for this choice: a deep examination of the global interest in climate change and in greenhouse gas emissions reduction; an assessment of the state of carbon capture and storage (CCS); energy efficiency; and alternative energy and solar technology. Each of the chapters concludes with a review of specific opportunities in Qatar and other GCC countries and an overview of possible policy options to address market failures and encourage different energy pathways. However, while sectoral policies are essential, energy systems are clearly much more than a collection of sectors, and it therefore makes sense also to review options from a broader perspective. For example, individual policies on appliance efficiency or CCS research may be partly effective in isolation, but more likely to succeed and succeed definitively in the context of a broad national vision. Such a national vision would include goals for the energy pathway as well as a broad-based and diverse set of policies across sectors that act in concert to influence individual decisions and mold expectations about the future. In addition, such national visions are most effective when anchored in clearly articulated and broadly shared national goals such as energy security, social well-being, international leadership, human health and sustainability. Such approaches have been effective in previous examples of major energy transitions undertaken at the national level.

History has shown that cases of successful energy technology development have often required a strong and sustained national priority in conjunction with a natural evolution from existing domestic infrastructure—bioethanol in Brazil, bioenergy in Sweden, wind in Denmark and solar photovoltaics in Japan are just a few examples. If Qatar and the other countries of the GCC wish to pursue similar strategic energy technology development, they will have to assess their place in the innovation and manufacturing value chain. A comprehensive approach to strategic energy-technology choice would require the development of a range of competencies and related human capital in everything from pre-competitive research and development, to the launch of capital-intensive industrial and manufacturing processes, to the management of investments in demonstration projects both regionally and globally. The development of institutions able to support such industries will require close coordination

between the public and private sectors. With a strong national vision in place, it is then helpful to examine the areas that offer early and substantial opportunities for reaching the vision. As an organizing principle, such areas can provide focus to sectoral policies and help make concrete any national energy action plans. Across the GCC, several such areas stand out as attractive: technology innovation, industrial efficiency, alternative sources of supply, restructuring the energy market and effective governance.

## POLICY PROGRAM 1: TECHNOLOGY INNOVATION

Many of the biggest challenges facing countries today—economic growth in high-value activities with broadly shared benefits, poverty reduction and environmental quality—could be addressed substantially with clean and sustainable technologies that raise productivity and create new markets. Such innovation, which often has broad social benefits, has the potential to unlock solutions to challenges like climate change, energy access, environmental degradation, sanitation and water scarcity. Moreover, embracing new pathways that are more environmentally and socially sustainable need not divert resources from economic productivity, but rather can serve to fuel the engine of economic growth.[203]

The GCC region as a whole presents a few factors that could provide a basis for fostering new, low-carbon technologies. It has a combination of substantial risk capital, existing domestic technical capacity across a number of energy engineering areas, strong global partnerships in energy industries, and a growing set of research and technology development institutions. Using these factors to their full advantage could involve a combination of policies to encourage R&D in the region but also to encourage domestic interest and demand for these technologies. While governments should be careful about excessively supporting individual sectors ("picking winners"), several technological areas could clearly benefit from GCC regional research—CCS, liquid biofuels, building efficiency techniques for extreme climates, and development of more robust solar and wind technologies. Qatar and the GCC region as a whole have substantial resources and R&D capabilities that can be used to address climate change. The country's capacity to develop climate change technologies is a key strength and could create new markets for Qatar both at the regional and international levels as a leader in low-carbon technologies.

### R&D Programs for Select Technologies

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 in which the region has a comparative advantage. Moreover, GCC member countries are in an 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. These technological areas include:

- *Carbon capture and storage*. In terms of developing CCS technology, Qatar's current efforts on the development of CCS technology are fragmented and initiatives to date have been project oriented. A more focused effort to develop expertise on CCS could make Qatar a leader in the region and contribute to domestic climate change goals. Qatar could consider whether it wants to develop an industrial-scale CCS demonstration plant. This could be done as part of EOR or GTL activities. Qatar could also seek to develop specific CCS technologies that build on domestic experience with gas extraction

and using $CO_2$ for EOR with an eye to the commercialization of these technologies for use in other countries.

- *Efficiency*. Existing GCC research establishments—such as the Qatar Science & Technology Park or Masdar in the United Arab Emirates (UAE), as well as the many technical departments in regional universities—have the opportunity to conduct scientific research into energy applications and systems specific to regional conditions. These applications include catalysts, lubricants, solar panels, hydrogen storage and optimal design of building "envelopes." GCC countries have the potential to serve as development and demonstration bases for efficiency technologies developed both inside and outside the region. There is also encouraging precedent for public-private partnership on R&D in Qatar, where Chevron and the Qatar Science & Technology Park have partnered to create the Center for Sustainable Energy Efficiency. The center will focus its research on lighting, cooling and solar technologies adapted for use in the climate of the Middle East. The center has the potential to serve as a venue for further public-private partnerships in the transfer of efficiency best practice within Qatar and as a model for other countries in the region looking to harness the expertise of their private-sector investors.

- *Alternative energy.* As discussed earlier, algae biofuels and dust-preventive or dust-resilient technologies represent two potential specialization areas. The area with the most promise for Qatar involves the development of solar energy technologies. Qatar is already undertaking R&D initiatives under its national renewable energy deployment target, including a new solar test facility and advances on biofuels.

- *Smart grid and energy management.* A final, cross-cutting approach to energy in the GCC region is to look at opportunities over all sectors to deploy new and more intelligent technologies to achieve superior energy services with less waste. Such information and communication technology (ICT)-based innovations would include ICT infrastructure and equipment, ICT-enabled buildings and construction, ICT-enabled transport, and ICT-enabled carbon/energy management and reporting, which can deliver great energy savings.

### R&D Finance

While national policy is the key contextual driver of any innovation ecosystem, international partnerships can help fill the gaps that currently exist by fostering strong innovation ecosystems and increased innovation outputs. Financial contributions by Qatar could help underpin these partnerships while providing the country with access to cutting edge R&D in the U.S. and elsewhere. For instance, the pledge in 2007 by Gulf countries in OPEC of $750 million (including $150 million from Qatar) to a new fund to tackle global warming through research for a clean environment could be model for developing international climate change and clean energy research partnership at a government-to-government level. A national fund for Qatar to support and finance mitigation and adaptation projects as part of its comprehensive climate change policy framework could support domestic climate change and energy goals such as the development of renewable energy projects and climate change technologies. By setting up its own national climate fund, Qatar could attract international finance for domestic investments in clean technology and generate revenues through the taxation of existing resources such as in the oil and gas sector. A carbon price would also support the economic viability of clean energy technologies like CCS. An economy-wide carbon price is the most efficient way of reducing GHG emissions. By equating the marginal cost of abatement with the carbon price, emissions costs are equalized across the economy and this equalization, in turn, would incentivize the development of technologies for reducing $CO_2$ emissions.

### R&D Cooperation

GCC-wide cooperation such as the EU-GCC Clean Energy Network—an instrument for the development of cooperation activities on clean energy policy and technology in the areas of renewable energy sources, energy efficiency, clean natural gas and carbon capture and storage—provides another avenue through which to pursue international cooperation on clean technologies.[204] Qatar should also consider further bilateral cooperation on clean technology, such as partnerships with the Potsdam Institute for Climate Impact Research (PIK), and involve both government ministries and research institutions. This could be modeled on bilateral partnerships such as the U.S.-China Clean energy partnership, which comprises clean technology energy projects between U.S. Department of Energy laboratories and the Chinese Academy of Sciences on EOR for CCS, biomass gasification and syngas;[205] and the U.S.-China Clean Energy Research Center (CERC), that facilitates joint clean energy R&D on topics such as building energy efficiency, clean coal (including CCS), and clean vehicles.[206] Finally, Qatar also has a stake in discussions at the international level and should therefore ensure that international policy efforts maximize the potential for sharing of knowledge and technologies of mutual benefit, for example, through international research-sharing agreements. Supporting international technology-oriented agreements is crucial and an important complement to other international efforts such as emissions-based agreements.[207]

### Public-Private Partnerships for Research, Development, Demonstration and Deployment

The GCC energy sector is unusually active and globalized, and there are significant opportunities for cross-cutting collaboration between private (international) companies, industry and public-private partnerships that 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. Much of the GCC region's energy consumption occurs in the production and processing of hydrocarbons and other carbon-intensive industrial applications. Even without explicit requirements, the financial incentives to save energy are sometimes large: For example, the opportunity costs of wasting energy assets that could otherwise be sold have prompted many of the multinational companies in these industries to implement efficiency measurement and management processes. An example is ExxonMobil, a major joint-venture investor in the GCC, which has developed a Global Energy Management System (GEMS), a program comprising over 200 best practices and performance measures for process units, major equipment and utility systems in the petrochemicals and petroleum-refining operations. Other oil majors present in the GCC have similar institutionalized efficiency programs. Total, also a major investor in the GCC, has a stated goal to improve the efficiency of its exploration and production and petrochemicals production by 2 percent per year over the period of 2007-2012. In 2008, the company published an Energy Performance Management Guide, aimed at getting its staff to deploy more efficient technologies and management practices. While many of the technical directives and guidelines used by energy companies may be specific to the hydrocarbon production sector, some of the efficiency management systems, data-collection techniques and analysis tools may

also be applicable to other sectors economy—such as power generation—currently under state management.

## POLICY PROGRAM 2: INDUSTRIAL EFFICIENCY

Given the large amount of heavy industry in the region—energy and petrochemicals in particular—there are potential large gains from even small increases in equipment and process efficiency in industry. As with other areas, a broad set of policies across the sector would be most helpful, focusing not only on technologies but also on moving toward market prices. Government can play a large role in not only setting standards for efficiency but also for ensuring that efficient investments pay off at a market rate. An efficiency program in Qatar and other GCC countries could be constituted of several components.

### Lower-Energy Buildings

The share of the residential sector in total electricity consumption exceeds 50 percent in Kuwait, Saudi Arabia and Bahrain, is about 40 percent in the UAE, and is just over 20 percent in Qatar. Moreover, countries in the GCC region are rapidly building out their housing and commercial space, and these buildings could turn into long-term heavy users of energy, particularly for space cooling. This development provides a huge opportunity to improve energy efficiency in the construction and management of buildings that would be important in terms of reduced GHG emissions and would produce cost saving shared by industry and residents. Achieving this energy efficiency outcome could include construction codes or standards for new buildings; building retrofits for improved efficiency; and the incorporation of lower-energy passive measures such as natural ventilation, night ventilation and evaporative cooling.

A necessary component of this transition toward efficient building stocks is to encourage the private sector to be able to make informed decisions about best practices. Rating systems and performance requirements for efficient building materials and accreditations programs such as LEED in the United States and BREEAM in the U.K. can contribute to best practices. In the GCC, the Qatar Sustainability Assessment System (QSAS) created by the BARWA and Qatari Diar Research Institute provides a template for region-specific building-sustainability programs. The QSAS program, which draws on lessons from a range of international frameworks for rating building sustainability and efficiency, offers an accreditation system for buildings that meet a prescribed set of criteria as well as training schemes for professionals in the construction sector. In 2011 portions of the QSAS criteria were incorporated into regulations by the State of Qatar. Abu Dhabi has also launched an initiative for building efficiency through Estidama, its sustainability program. The Estidama Pearl Rating System is a five-point ("pearl") system modeled on the LEED system. According to an executive order, all new buildings in Abu Dhabi must meet the minimum "1-pearl" rating from September 2010; all government buildings must meet the "2-pearl" rating. Such programs could be officially incorporated in all GCC member states, and those countries that have already implemented them could investigate the possibility of requiring more broad-based or ambitious efficiency targets for future projects.

### Efficient Appliances and Industrial Equipment

Improving efficiency for appliances, equipment and other technological devices can be assisted with a combination of mandated minimum efficiency standards and voluntary labeling for "quality" products that satisfy certain criteria for excellent performance.

Goals could be benchmarked domestically or relative to regional or international levels. Rating and labeling programs that provide information to the consumer at the point of purchase about the energy usage profiles and long-term energy costs of competing products are other means of improving efficiency. GCC countries have a number of nascent initiatives that can provide the basis for increased adoption of standards in both the building and appliance sectors. The Saudi Arabian Standards Organization (SASO), for example, oversees the implementation and standards of the national energy efficiency appliance labeling program, as well as mandates for appliance efficiency standards. Also, the UAE's Emirates Authority for Standardization and Metrology (ESMA) has launched an efficiency rating system for air conditioners. Systems are rated according to a star system (with five stars being the most efficient), and those that do not meet the minimum requirement are not allowed into the country. The system has been expanded to refrigerators and freezers in 2012 and to washing machines in 2013. The application of such systems by other countries in the GCC would be a major step toward increasing overall energy efficiency.

### New Government Institutions to Oversee Efficiency

GCC countries could consider establishing energy efficiency authorities under their existing government energy agencies. Such institutions would be under the control of each government in the region and would have responsibility for managing domestic efficiency-related projects, promoting public-private partnerships and building capacity through the training of technicians and educators. They would also be responsible for coordinating with each other on trans-GCC partnerships. If desired, the role of the efficiency authority could also include responsibility for monitoring and analysis of water usage, including examination of the distribution and desalination systems. There is some foundation for such energy authorities in the region. Saudi Arabia's National Energy Efficiency Program (NEEP), for example, studies the possibility of implementation of energy efficiency measures in Saudi Arabia, and has set targets for reducing the country's energy intensity by 2030. Looking more broadly, India has implemented a successful Bureau of Energy Efficiency that could also serve as a model.

### Utility-Driven and Utility-Led Efficiency Programs

Because of their closer contact with consumers, utilities are in a potentially useful position in terms of encouraging residential and commercial energy efficiency. Moreover, energy efficiency is an important utility system resource that also reduces greenhouse gas emissions, achieves savings for customers and generates jobs. Utilities in the GCC could develop programs to encourage upgrades to more efficient appliances, to do energy audits on buildings, or to encourage peak load reductions through technological or behavioral incentives. Moreover, smart grids hold promise to enable improvements in energy efficiency within the utility sector through both gathering information on use and helping to manage demand and load. However, to harness the full efficiency and environmental benefits of smart grids would require careful program design and implementation, as well as targeted capital investment. In the U.S., for example, utilities are by far the largest driver of large-scale electricity efficiency programs, with customer-funded electric efficiency programs available in 44 states. Their budgets totaled over $6.8 billion in 2011.[208]

## POLICY PROGRAM 3: ALTERNATIVE SOURCES OF SUPPLY

The GCC region is in a quandary with respect to energy supply: Domestic demand is growing quickly, partly in response to artificially low energy prices, but domestic use is not as profitable as export. Unfortunately, the opportunity cost of this domestic demand is to lower the net level of income from selling resources into the global market. While pricing reform and efficiency policies are necessary components of any comprehensive energy strategy, alternative supply also has a role. By replacing domestic consumption, alternative supply can free up resources for export. Alternatives such as solar, wind and biofuels can also create a lower-emissions energy economy, and thereby lower contributions to global climate change. Providing a domestic market for new technologies can also bolster the research and development of technologies appropriate for the region.

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 the following 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,[209] and in 2013-2014 the Masdar Institute developed 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.[210] 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" which 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. One possible alternative approach is the renewable portfolio 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. Another is the creation of sectoral performance standards for electricity generation as a means of promoting the com-

mercialization of CCS. Such standards would require a significant percentage of electricity to be carbon free or to meet specific performance standards. The advantage of sectoral performance standards is that they are technology-neutral—allowing the market to choose which technology to build—and they allow for a more stable investment climate for constructing the large and costly infrastructure that technology such as CCS will require.

### 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 (IFIs) 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.

## POLICY PROGRAM 4: RESTRUCTURING THE ENERGY MARKET

Energy security and energy prices are important for every country. All governments have an interest in ensuring that their citizens have easy access to energy at a reasonable cost. Moreover, producer countries often have an interest in enabling their citizens to reap the benefits of their own natural resources. At the same time, allowing the market price of energy to diverge from its underlying cost risks locking in energy-intensive technologies that, over time, makes it increasingly costly to move a country's emissions profile onto a more sustainable level consistent with global climate change goals. Additionally, and as discussed, underpriced energy is a subsidy that has significant fiscal costs, and these costs will be magnified for countries such as Qatar that are experiencing rapid population growth.

In fact, 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. In addition, while some energy sources can compete with fossil fuels at world market prices, subsidized fossil fuels make the barrier to widespread adoption of alternatives very high. 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.

It is now well understood that many aspects of energy production and consumption in the GCC could be significantly improved through a policy of greater market-based pricing and reduced subsidization of energy. In parallel with this could be a gradual longer-term shift to a tax on emissions that would provide additional incentives for investments in cleaner technologies, efficiency and CCS. Despite the well-known political challenges associated with pricing reform, there are means of enacting incremental pricing reform that are likely to have less of a disruptive impact than a wholesale move to market pricing. These include a phased adoption of increased end-user pricing; "recycling" the revenues from any price increase to improve efficiency of use; differentiated pricing across different consumer group; and a mechanism for compensating the most economically vulnerable.

Given the nexus between energy and water use in the GCC, any pricing reform policy for electricity must also take into consideration water supplies. Before any implementation of large-scale pricing reform, countries of the GCC could consider conducting research into the consequences of a change in the pricing structure of energy, including the effects of a phase out of subsidies and other adjustments toward a more market-based approach.

## POLICY PROGRAM 5: EFFECTIVE GOVERNANCE

Creating effective governance structures and an enabling environment for policy creation and external investment is crucial in sustaining a broad national vision for low carbon development. Creating a single government agency, or an effective interagency process, with overall responsibility for climate change issues resting with an identified body would be an important institutional development for Qatar. It would ensure that the impact of climate change action on all economic sectors is fully taken into account. And by providing the decision makers with information on economy-wide impacts and opportunities should ensure an optimal set of climate change policies.

Developing a single agency or coordinating mechanisms responsible for broad climate change issues would also provide a means for assessing and making decisions about the crosscutting nature and complex interactions between climate change policy and energy technology innovation and development. As this synthesis has made clear, policies such as pricing carbon would lead to reduced GHG emissions and also improve the economics of CCS and incentivize greater energy efficiency. Similarly, a climate fund would have implications for developing clean energy technologies as well as how Qatar engages with other countries and international organizations.

Qatar and the broader GCC area are at a pivotal time in making energy system investment choices that will bind their pathway for the coming decades. In this report, we have reviewed concerns about climate change, and the prospects for CCS, energy efficiency and alternative technologies for Qatar and the rest of the GCC. We have also reviewed appropriate policies in the individual chapters and then integrated them into a broad-based program in this synthesis. An integrated approach targeting select innovation areas, energy regulations, pricing reforms and governance could transform the possibilities for this fast-growing region. These choices have the potential not only to influence domestic economic health and the well-being of their citizens, but also, through technology spillovers and international leadership, influence the technological choices and trajectory of other countries, regions and the globe.