Energy Security Initiative
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OPTIONS FOR LOW-CARBON DEVELOPMENT IN COUNTRIES OF THE GULF COOPERATION COUNCIL

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About The Brookings Energy Security Initiative

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Foreword

This paper was informed by the proceedings of the Doha Carbon and Energy Forum, a two-day workshop held in Doha, Qatar from November 8-10, 2010. The forum comprised a series of working group discussions among 150 experts from around the world on current and emerging energy and greenhouse gas challenges in the Gulf Cooperation Council (GCC) region.

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Executive Summary

Over the next twenty years the countries of the GCC are likely to experience some of the fastest economic and energy-consumption growth rates anywhere in the world. Already almost exclusively dependent on hydrocarbons for their energy supply, the GCC member states face increasing environmental and economic costs from continued heavy reliance on oil and gas in their power-generation and industrial sectors. Several of the GCC countries have asserted their interest in diversifying diversify their economies away from the export of raw materials and energy-intensive industry in order to achieve sustainable long-term economic growth and security. The extent to which such a diversification is likely to occur in the short-term should not be overestimated. The principal source of foreign-exchange earnings for the GCC countries is through rent on oil and gas exports and the exploitation of a comparative advantage in low-cost energy-intensive industry. Any large-scale switch away from energy-intensive economic activity is likely to act, at least in the short-term, to the detriment of the GCC countries' competitiveness and terms of trade. However, there are opportunities for the countries of the GCC to achieve the parallel objectives of reduced carbon emissions, reduced domestic consumption of valuable oil and gas resources, and increased economic diversity without a major structural change to their economies and with significant potential net benefits both in terms of carbon-reduction and economic performance. These opportunities lie in the development and adoption of technologies and improved management systems in the areas of alternative energy, energy efficiency, and carbon capture and sequestration (CCS).

In the field of alternative and renewable energy, the GCC countries have the potential to take greater advantage of their proven wind, solar and geothermal resource base in their power generation mixes. While there are several well-funded academic and research institutions in the region working on the development of technologies in these areas, there is large scope for the acceleration of renewable energy penetration through the implementation of policy goals, formalized networks and regional coordination. In addition to the potential for increased integration of established alternative energy technologies, the countries of the GCC have an opportunity to develop new renewable technology niches in applications suited for their climatic conditions, such as algal biofuels and dust-resistant solar photovoltaics. This strategic approach to alternative energy development could provide an important source of diversification for the region's economies and a source of competitive advantage in a carbon-constrained global economy.

In CCS, the GCC countries have both the means and the motivation to be a leader in the development of a technology that will play a major part in achieving global emissions-reduction targets. With huge projected increases in their power sector capacities—most of which, notwithstanding the progress made on alternative energy sources, are likely to be met with natural gas—the countries in the region have the opportunity to serve as a platform for global development of carbon-capture technology. With large amounts of available investment capital, economies optimized for energy-intensive industry, and a near-term economic incentive for the use of captured carbon-

dioxide through enhanced oil and gas recovery, the GCC countries have a unique opportunity to invest in "first-mover" research and development to accelerate the commercialization of CCS.

In the area of energy efficiency, the countries of the GCC have great potential to institute technologies and systems that improve their performance at the firm and consumer levels. Through the development and implementation of efficiency standards for buildings and appliances, they have the ability to reduce their carbon-emissions profile at low—or even negative—net cost. They also have the ability to apply international best practice in energy efficiency and related management systems through partnership initiatives with the private sector. Any effort to seriously address the challenge of emissions reduction and increased adoption of non-carbon energy sources in the power-generation mix in the GCC must acknowledge the significant potential for pricing reform. Given the fragility of the current political situation in the region, however, it is unlikely that any major implementation of fiscal instruments for demand-side reduction is on the horizon. Instead, GCC energy planners have an opportunity to focus on greater investment in the development of domestic and regional research networks, the creation of standards and goals, and increased collaboration with the private sector for transfer of best practice, and the commercialization of technologies likely to be a source of competitive advantage.

At the regional level, the countries of the GCC face many of the most pressing challenges of the global economy in the 21st century: a self-interested need to reduce carbon emissions while meeting increased energy demand and a desire to develop new technologies that will provide a source of long-term economic growth. Through adoption of policies that encourage the role of alternative energy, energy efficiency, and carbon capture and sequestration, the GCC can meet its own environmental and economic objectives and remain at the center of the energy economy for decades to come.

SECTION I: INTRODUCTION

A combination of brisk economic expansion and population growth is fueling a rapid increase in energy demand in the countries of the Gulf Cooperation Council (GCC; Saudi Arabia, the United Arab Emirates, Qatar, Kuwait, Bahrain and Oman).[1] GCC energy consumption has grown 74 percent since 2000, and is projected to nearly double its current levels by 2020.[2] While Qatar is leading the bloc in its energy-demand growth rate (its share of GCC energy demand is projected to increase from around 10 percent to 15 percent between 2010 and 2020), all of the GCC nations are projected to see a substantial rise in energy demand.[3] With around 37 percent of the world's proved oil reserves and 23 percent of the world's proved gas reserves, the GCC countries are endowed with unparalleled hydrocarbon resources.[4] Three of the six countries (Saudi Arabia, the United Arab Emirates and Kuwait) were within the top ten oil producers in the world in 2009.[5]

Sales of oil and natural gas have been the foundation of economic activity in the countries of the GCC for decades, and this is unlikely to change in the foreseeable future. In addition to their exports of raw commodities, the GCC economies present an increasingly attractive opportunity for industrial and energy companies looking to take advantage of low-cost hydrocarbon inputs and favorable tax regimes for the production of higher-value products such as steel, aluminum, refined fuels, petrochemicals and plastics.

The recent growth in GCC energy demand—and electricity demand, in particular—comes at a time of rising global concern over carbon-dioxide (CO_2) emissions and climate change. As of 2008, all of the GCC member nations generated electricity exclusively from oil and gas (see Table 1). Due principally—although not exclusively—to their hydrocarbon-intensive power sectors and industrial activities, the countries of the GCC are among the highest per capita emitters of CO_2 in the world.[6] In the absence of carbon-reduction technologies, alternative sources of energy and significant energy efficiency measures, CO_2 emissions will continue

[1] "World Development Indicators for Population Growth," The World Bank, 2011. Accessed at: http://data.worldbank.org/indicator/SP.POP.GROW.
[2] J. Kinninmont, "The GCC in 2020: Resources for the Future," *Economist Intelligence Unit.* 2010.
[3] Ibid.
[4] "Statistical Review of World Energy," *BP,* June 2010.
[5] Data from the United States Energy Information Agency. Accessed at: http://www.eia.doe.gov/emeu/international/oilproduction.html.
[6] United States Energy Information Administration. "*Per Capita Carbon Dioxide Emissions from the Consumption of Energy, 2009.*" Accessed at http://tonto.eia.doe.gov/cfapps/ipdbproject/iedindex3.cfm?tid=90&pid=45&aid=8&cid=regions&syid=2005&eyid=2009&unit=MMTCD.

to increase with detrimental consequences. According to the World Bank, the social, economic and ecological impacts of climate change are likely to be higher in GCC countries than in other parts of the world.[7] Rising global temperatures are likely to put increased pressure on scarce water resources and arable land in the region.[8] Other environmental and climate change-related concerns include rising air pollution and increased likelihood of flooding in coastal areas.

In addition to environmental concerns, there are energy security and economic implications of a "business as usual" approach to energy policy in the GCC region. As domestic power demand increases, GCC member nations are diverting to domestic markets oil and gas resources previously allocated for export or industrial usage. As a result, they are losing potential foreign-exchange revenue and, in some cases, are relying on imports from neighbors.[9] In September 2010, Bloomberg calculated that Kuwait could earn $22.7 million a day by exporting the 12 percent of its daily oil production used for domestic power generation.[10] The CEO of Saudi Aramco, Saudi Arabia's national oil company, has predicted that oil required for domestic energy demand will increase to 8.3 million barrels per day (mbpd) by 2028 compared with 3.4 mbpd in 2009.[11]

Table 1. Sources of Energy for Domestic Consumption in GCC States, 2008

	Natural Gas	Oil
Bahrain	84.2%	15.8%
Kuwait	37.4%	62.6%
Oman	69.3%	30.7%
Qatar	75.3%	24.7%
Saudi Arabia	37.6%	62.4%
United Arab Emirates	82.4%	17.6%

Source: International Energy Agency

The governments of the GCC states realize that an overreliance on hydrocarbons for energy provision and trade leaves them vulnerable to economic and environmental risks. Expressing a sentiment that is increasingly prevalent among government officials in the region, Qatari Deputy Prime Minister and Minister of Energy Abdullah bin Hamad Al Attiyah noted in a speech in Doha in November 2010 that, despite the country's importance to the global hydrocarbon supply, "[Qatar] must also lead in reducing the impacts of energy use on the environment—in Qatar and the region."[12] All the countries in the region have made economic diversification part of their development strategies. Several, including the UAE and Qatar, have included environmental objectives as part of their

[7] "Adaptation to Climate Change in the Middle East and North Africa Region," World Bank. Accessed at http://go.worldbank.org/B0G53VPB00.
[8] "The Middle East and North Africa at Risk 2010," presented at the World Economic Forum on the Middle East and North Africa in Marrakech, Morocco, on October 26, 2010, pg. 4.
[9] The UAE, which has the seventh largest natural gas reserves in the world and produced 1.725 trillion cubic feet in 2009, according to the US Energy Information Administration, is now a net importer of natural gas, with imports of around 2 billion cubic feet per day from Qatar entering the country through the Dolphin Pipeline.
[10] Tsuyoshi Inajima and Yuji Okada, "Kuwait Plans to Build Four Nuclear Reactors as It Seeks Alternative to Oil," Bloomberg, September 9, 2010. Accessed at http://www.bloomberg.com/news/2010-09-10/kuwait-joins-gulf-push-for-nuclear-power-with-plans-to-build-four-reactors.html.
[11] Khalid Al-Falih, President and CEO, Saudi Aramco, speech to the MIT Club of Saudi Arabia in Riyadh, April 19, 2010. Accessed at http://www.saudiaramco.com.
[12] "Attiyah opens first ever carbon, energy forum," *The Peninsula,* November 9, 2010.

vision statements and have created academic and government institutions aimed at promoting the development of sustainable resource management, environmental stewardship and alternative sources of energy.

Enacting meaningful policy to encourage integration of low-carbon technologies and behaviors has lagged behind the number of flagship projects and high-profile international conferences. While a small number of solar and wind projects have been established throughout the GCC, the contribution of these sources to overall energy provision is minimal. Saudi Arabia and the UAE are the only countries in the region with any significant official energy efficiency measures in place although other states are studying or in the process of implementing standards. Efforts to control emissions through carbon capture and storage (CCS), while much vaunted as a means of enabling the countries of the GCC to continue hydrocarbon-based development with less cost to the environment, have not yet made it to demonstration phase in the region.

This paper assesses policy options open to the governments of the GCC in three areas of low-carbon development: the use of alternative (non hydrocarbon-based) energy sources for power generation, the development and deployment of CCS technology in the industrial and power sectors, and energy efficiency measures. In each area, it assesses the drivers, the region-specific opportunities, and the range of policy options for increased adoption. It divides the policy options into two categories. Near-term options are those that can be implemented by individual countries within the current policy frameworks and within a timeframe of two to three years. Longer-term policies are those that will take several years to implement and may require the formation of new domestic or regional institutions. The objective of the paper is to provide a suite of options for GCC policymakers that take into consideration regional environmental constraints, and local and regional political dynamics.

SECTION II: ALTERNATIVE ENERGY

1. Drivers and Options for Alternative Energy in the GCC

The GCC will require up to 100 gigawatts (GW) of additional electricity generation capacity over the next ten years to keep pace with rising electricity demand. An estimated $25 billion will be spent in the GCC over the next six years on new capacity installation.[13] The economic and environmental costs of using fossil fuels for power generation outlined above provide an opportunity for growth in alternative energy technologies.[14] Such technologies also offer the opportunity for countries in the region to diversify their economies through the development of a base of engineering and technological expertise, and a competitive advantage in new products.

Several alternative energy technologies are well-suited to the needs and conditions of the GCC countries.

Solar

The GCC countries enjoy one of the world's most abundant solar resources. Estimates of the solar potential in the GCC put the region's annual average global radiation (available to photovoltaic cells) at about 6 kWh/m^2/day. Estimates of the direct normal irradiance (DNI, available to solar concentrating technology) are around 4.5 kWh/m^2/day.[15] Such figures suggest that a land area of approximately 1,000 km^2 (0.2 percent of the GCC) covered with photovoltaic cells at 20 percent efficiency could produce 438 TWh every year—more than the 400 TWh typically consumed by the region. All six nations of the GCC have either embarked upon, or committed to, investments in solar projects, with solar photovoltaic (PV) and concentrated solar power (CSP) being the principal technologies of choice. Other potential solar-related applications applicable to the region include solar-derived bioenergy and solar-generated hydrogen. In addition to their carbon-mitigation potential, these technologies present a major area of economic opportunity for the region. Solar power has the potential to serve as a source of regional power supply, as an opportunity to develop regional technological expertise, and as the basis of a new export market for the region. The latter prospect will be particularly compelling if the GCC can overcome

[13] W.E. Al-Naser, "Solar and Wind Energy Potential in GCC Countries and Some Related Projects," *Journal of Renewable and Sustainable Energy*, Volume 1, 2009.

[14] For the purposes of this document, "alternative energy" is defined by the principal non-hydrocarbon energy sources open to the GCC region, including wind (on and offshore), solar (photovoltaic and concentrated solar), biomass (for power generation), biofuels (as replacements for hydrocarbon-derived liquid fuels) and nuclear power.

[15] Al-Naser, 2009.

some of the technical challenges that solar power faces in its regional climate, such as the high levels of dust (for PV and CSP) and efficiency losses due to high average ambient temperatures (for PV).

Wind

While wind installations are at a less developed stage than their solar counterparts in the GCC, some studies indicate that the region has moderate to significant wind resources, particularly offshore. Several studies suggest that wind speeds average around 6 meters per second (m/s) in the GCC, although speeds vary substantially between countries.[16] Saudi Arabia receives over 1,700 hours of full load wind annually, while the UAE received less than 1,200 hours; Kuwait, Oman and Qatar all have full load wind of over 1,400 hours per year. Countries with more than 1,400 hours of full load wind and an average annual speed at or above 6.5 m/s are considered to have economically viable wind potential.[17]

Smart Grid and Storage

Smart grid technology and storage provide improvements in overall power system efficiency through greater power demand-side management and connection of renewable, intermittent resources such as solar and wind power. With the integration of storage technologies, such as batteries, these systems allow more even distribution of electric load, and less need for peak-power generation. Given the region's rapid pace of infrastructure construction, the GCC has an opportunity to integrate, at scale, some of the most advanced smart grid technologies currently being developed around the world, and to serve as a pilot platform for technologies considered by countries with a legacy of older electricity transmission and distributions systems.

Nuclear Power

Civil nuclear power is a proven, scalable, low-carbon technology. Following its approval of a civilian nuclear cooperation agreement with the United States, the UAE has embarked on an ambitious program of civil nuclear development. Several other countries in the region, including Saudi Arabia and Kuwait, have shown serious interest in nuclear power to meet growing electricity demand and to initiate their transition to low-carbon development. However, given the many regulatory, technical and security-related complexities associated with the establishment of a nuclear power program, it is not subject to further consideration in this paper.[18]

Biofuels and Geothermal

Other potential sources of alternative energy include biofuels and geothermal power generation. Through initiatives like the UAE's biodiesel plant in Al Ain Industrial City and the Qatar Advanced Biofuel Platform (QABP), the GCC countries are looking to the potential of biomass-derived alternatives to fossil transportation fuels. While the region boasts sizeable geothermal potential, this resource has been relatively unexploited; the drilling of two geothermal wells in the UAE's Masdar City represents the region's principal progress in this field.

Despite limited progress in each of the areas listed above, the GCC faces several barriers to the greater adoption of alternative energy sources in its power-generation mix. Some of these barriers are specific to the region. Given their abundant hydrocarbon resources and relatively low costs of production, most GCC economies are rationally optimized around the sale or industrial use

[16] H. Khonkar, "Complete Survey of Wind Behaviour Over the Arabian Gulf," King Abdulaziz City for Science and Technology Energy Research Institute, 2009.

[17] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Program on Wind Powering America. Accessed at http://www.windpoweringamerica.gov/wind_maps.asp.

[18] For further analysis on this subject, see Ebinger et al: "Models for Nuclear Power Development in the Middle East," The Brookings Institution, 2011.

of oil and gas. Any expectation of a major shift in the economic structure of the economies in the region is, therefore, unrealistic. The politics of energy pricing and limited potential of fiscal policy in the Gulf region also make the financial case for the adoption of alternatives energy more problematic. The GCC countries can be classified as "rentier states," polities in which the government derives its income from rents from the sale of natural resources in the global market.[19] In the case of the GCC, these rents are shared with citizens in the form of transfers and incentives that promote economic and political stability. Energy subsidies have therefore been seen as an important element that supports a broader political balance.[20] According to the International Monetary Fund, in 2009, implicit fuel subsidies amounted to 7 to 8 percent of GDP in Kuwait and the UAE, 4 to 5 percent of GDP in Qatar, and 3.5 percent in Oman. Any economic reform that threatens this bargain—and therefore the internal political and social dynamics of the GCC countries—is likely to face objections from government representatives and, potentially, from citizens themselves.

Other challenges to the adoption of alternative energy technologies in the GCC are common to other regions. These include the challenges of adequate data collection and analysis, the scaling up of immature technologies to commercial quantities, intermittency and back-up capacity (for wind), storage (for wind and solar) and siting and land use issues (for most alternative sources). The following section assesses both the short- and longer-term options for greater alternative energy penetration in the region.

2. Near-Term Opportunities

2.1 Resource Assessment, Measurement and Data Collection

Decisions on renewable energy deployment depend in large part on detailed resource assessments. Satellite data and experiential evidence suggest that the GCC is particularly well-suited for solar technology. There is also some evidence that wind power is a viable option for large-scale electricity generation.

However, while the numbers on renewable resources cited above are encouraging, they are rough estimates at best. Little is known about the actual value of direct normal irradiance around the GCC; most figures are interpolations of rough satellite data rather than ground measurements. Researchers at the UAE's Masdar Institute of Science and Technology (MIST) have conducted initial studies on the discrepancy between satellite-based and ground-based measurements that they argue justify the need for more extensive ground-based measurement efforts.[21] Moreover, the region's wind resources remain uncertain, and further efforts to measure these resources on- and offshore would be helpful. Any comprehensive plan for renewable energy strategy in the region would, therefore, benefit from a program of systematic data collection on renewable resources. Regional academic institutions and research organizations could be tasked with these efforts, preferably in coordination across the region, and possibly in partnership with experienced international organizations.

2.2 Standards

Energy standards are mechanisms for governments to impose minimum levels of achievement

[19] For an excellent discussion of energy policy in the GCC rentier states see: Reiche, D. "Energy Policies of Gulf Cooperation Council (GCC) countries possibilities and limitations of ecological modernization in rentier states." *Energy Policy*, 2010, p.2-9.

[20] This is particularly relevant in the wake of the "Arab Spring" uprisings, which have prompted several GCC governments to increase financial assistance to their populations.

[21] Author interviews with Masdar Institute Officials, July 2010.

in a range of categories, from renewable energy penetration, to energy efficiency, to automotive performance. Because they can be established with measurable targets and with clear penalties for noncompliance, they can generally be enforced using existing policy tools. The targets can be absolute levels or performance-based, relative to an agreed baseline. One standard that has particular relevance to increased alternative energy adoption is the renewable portfolio standard (RPS). RPS policies are designed to increase the contribution of renewable energy sources to the energy mix. RPS mechanisms generally place requirements on electric utilities to produce a target fraction of their energy from renewable sources, and are usually specified with a target and date (for example, the EU has an RPS target of 20 percent of energy from renewables by the year 2020).

RPS requirements generally rely on private investment, often with government support, to spur renewable energy growth (as opposed to feed-in tariffs, which use public funds). There is some precedent for RPS implementation in the region. The government of Abu Dhabi has committed to provide 7 percent of its total power generation capacity from renewable sources by 2020. To incentivize the adoption of renewable energy to meet an RPS requirement, governments in the region could provide power companies with production tax credits and investment tax credits, grants for renewable energy installations, or preferential cost-recovery and depreciation mechanisms for renewable investments. Such policies could be strengthened—and partially funded—by a simultaneous effort to reform electricity subsidies (see sections 3.3 for more details).

Another standards-related challenge of alternative energy development is that of interconnection requirements (on amplitude, frequency, reliability, etc.), which projects must fulfill before they can be integrated into the national grid. To facilitate the deployment of new alternative sources of power generation, GCC national governments have the opportunity to develop common technical standards and permitting requirements, and to share data among their respective agencies.

2.3. Alternative Energy R&D

Research programs present a third near-term opportunity for alternative energy development in the GCC region. Implemented properly, basic and applied research programs can develop regionally specific technologies and systems, build local capacity to manage them, and promote regional cooperation. There is already a firm foundation for alternative energy R&D in the GCC. One of the world's most visible low-carbon demonstration efforts is Masdar city, a clean-technology cluster in Abu Dhabi. The facility, which is run as a profit-making entity by Mubadala, a wholly-owned investment vehicle of the UAE government, has developed several large-scale pilot and demonstration plants in the fields of solar, wind and geothermal technologies. The co-located Masdar Institute of Science and Technology offers seven graduate-level degrees in engineering and computer science, with a focus on alternative energy. It also has over 30 energy-related research projects underway and research partnerships in place with several global industrial companies. Saudi Arabia's King Abdullah University of Science and Technology, the King Abdulaziz City for Science and Technology, and King Fahd University also host centers of research and development in the field of alternative energy. The continued creation and strengthening of basic and applied-level research programs in other countries of the region, as well as research on the most effective practices for encouraging renewable energy adoption, would provide the technical and intellectual capacity necessary for the creation of a long-term commitment to alternative energy technologies.

3. Longer-Term Opportunities

3.1 Strategic choice in alternative energy development programs

All the alternative energy technologies shortlisted above could form part of an expanded energy supply mix for the GCC region. However, the rapid build-out of generation capacity over the next two decades provides an opportunity much greater than the relatively simple goal of supply diversification. Seen against the backdrop of a much larger and longer global effort to reorient energy supply away from carbon-intensive fuels, this regional change, if done strategically, could also bring major benefits to the regional economy. By carefully identifying and then developing niche technological expertise and products that are globally competitive, governments and companies in the region have the potential to invest capital in technologies that will ultimately provide new sources of economic growth. With large amounts of foreign exchange reserves, the governments of the GCC could become major funders of demonstration projects for these technologies in other regions, at the same time overcoming major hurdles to their market launch and retaining enough interest in the resulting intellectual property to make them worthwhile, long-term financial investments.[22]

The pathway to such technologies, however, requires careful planning to ensure that the investment leads to useful products and development of globally competitive technical expertise and human capital. It is particularly important to view the comparative advantage of any potential technology in the wider global context. Not all alternative energy technologies are equally suitable for such a strategy. Wind, solar PV and nuclear, for example, are established technologies with long histories of public and private-sector investment. While these technologies may be useful elements for integrating into the regional supply mix, it would be difficult to develop a new industry in the region that could directly challenge existing global firms that currently manufacture the technologies and hold the intellectual property.

In contrast, any regionally-directed technology research program in the GCC could benefit from the development of new niche applications—whether a new line of technology or a regionally-specific application. Algal biofuels present one such opportunity. This technology is still in its early phases of development, providing an opportunity for new research to contribute significantly to the global states of the art. It is also an area in which the oil-producing nations of the GCC have a large incentive to develop expertise: as oil-consuming nations enact policies to reduce their dependence on gasoline in the transportation fleet, expertise in alternative liquid fuels will provide an important source of diversification. Dust-preventive or dust-resilient technologies present another area of potential specialization. Dust is potentially a major obstacle to widespread PV, CSP and wind technology development—not only in the GCC region but also in other arid and high solar resource areas like North Africa, Australia and South Africa. Technologies that reduce dust-related efficiency losses could therefore be in great demand as the world moves to increasing solar deployment.

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 PV in Japan are just a few examples. If the countries of the GCC wish to pursue similar strategic energy technology development, they will have to assess their place in the innovation and

[22] The authors are grateful to Charles Weiss at Georgetown University for his input to this section.

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 (see section 3.4 for more details).

3.2 Regional Collaboration

Many of the policy tools for encouraging renewable energy growth in the domestic policy context can also be used to encourage cooperation on an international level. Bilateral agreements on technology cooperation are increasingly common around the world; funding routed through multilateral lending agencies is also increasing. Regional coordination on setting standards or deciding strategy could enhance the leverage of any initiative relative to individual country actions. Multilateral initiatives could include the development of a robust and transparent mechanism to collect data and assess progress toward defined goals.

All alternative energy technologies require a trained workforce to build, operate and maintain the infrastructure. Building this capacity in the region will require a network of university training programs, support for small businesses and research centers to train new generations of technical experts, engineers and skilled installers. Regional collaboration on research efforts would be another way to promote capacity building. By drawing from talent across the region and promoting shared results, an international research partnership could accomplish more than the sum of its individual constituent research efforts. Broad participation would allow the efficient delegation of investigations, promote specialization by certain key players, and increase the depth and significance of the results. Such regional initiatives will require an increased and sustained level of collaborative political will among the region's policymakers.

3.3 Energy-Pricing Reform

Generous fossil fuel subsidies have promoted low-cost energy consumption in the GCC for decades. While some alternative energy sources can compete with fossil fuels at world market prices, subsidized fossil fuels present a substantial barrier to widespread adoption of alternatives. Allowing alternative and conventional sources to compete according to market prices would act to incentivize alternative energy production. However, given the region's political and economic dynamics, the prospect of any comprehensive and immediate energy price rationalization is unrealistic. Instead, reforms to pricing could be made incrementally by initially seeking to address two types of subsidies. The first type is explicit subsidies governments pay out to oil and gas producers (who also operate national utilities) to keep unit energy prices low. The diversion of some of these payments to producers of electricity from renewable sources through a feed-in tariff (preferential rates paid to generators for a set period of time) could help to build up a portfolio of low-carbon alternatives. The second form of subsidy, commonly referred to as an "implicit subsidy," involves the trade-off between domestic consumption and export. Governments with huge fossil resource endowments effectively consider their supplies to be limitless within a relevant time window. This implies that all fuel diverted to domestic markets does not detract from available exports. In economic terms, this policy does not account for the "opportunity cost" of domestic consumption. By changing subsidy structures so that consumers and governments realize the true cost of burning hydrocarbons for domestic power generation, countries can create a level stage for energy source competition. Doing so would enable the

use of market-based mechanisms to encourage alternative energy production and could free up government revenue for the implementation of incentive mechanisms such as feed-in tariffs. Any changes in the domestic pricing regime for fossil fuels should be coupled with appropriate social policies to prevent energy price increases from overburdening segments of the population who are incapable of bearing the costs, or for whom doing so would cause serious economic harm.

3.4 Public-Private Partnerships

Public-private partnerships (PPPs) are joint initiatives developed and managed by a public sector agency and a private sector partner. While PPPs are developed to further a defined policy goal, they also allow the individual parties involved to achieve their own objectives. Benefits for the private entity may include an enhanced revenue stream and increased market access, while the public party stands to fulfill a political objective, social obligation or development need. As a result, consumers also benefit by gaining access to a good or service at a cost below that achievable on a business-as-usual investment trajectory. PPPs are characterized by shared goals, shared or complementary resources (financial capital, political influence, knowledge and expertise, human capital, time) and shared risks and benefits.

If the countries of the GCC region are to realize the potential of alternative energy development, they will need to develop new models for public-private partnership that address the relevant aspects of new energy technology development. The requirements of launching a strategy such as that outlined in section 3.1 are greater than those that can be met by the traditional model of a government-supported research organization. To successfully carry out a renewable-energy based industrial policy, the public and private sectors will need to find creative ways to link government departments, universities, financial entities and energy companies. There are precedents for success in this regard, including Sematech, the U.S. industry-government partnership on semiconductor manufacturing, and the Fundacion Chile, which joins together public sector, academic, private sector and civil society to harness innovation.[23] Given their close links with global energy companies, the governments of the GCC countries have a good base for instituting public-private partnerships in the field of alternative energy technology.

Collaborations between publicly supported research institutions and corporations can foster increased public-private cooperation, engender more direct communication about research needs, and encourage increased focus on underdeveloped research areas. By drawing industry into energy policy discussions, governments can aim to create an "innovation ecosystem," a self-reinforcing relationship that identifies and efficiently addresses common energy challenges.

Whatever the strategic decision on the areas of focus, the creation of an innovation ecosystem requires several core components, including the development of an overarching vision and technology roadmap for alternative energy to give clear signals to industry as to where investments will be most beneficial, the development of an industry-wide system for handling intellectual property, industry investment in shared, basic research, and the investigation of best practice for the financing of new technologies with a particular emphasis on regional needs. Such financing could flow through existing channels or may require the establishment of new ones.

In summary, through alternative energy development, the GCC has an opportunity to simultaneously diversify its energy supply mix and its economy, create new areas of research and technical expertise, and establish itself as a global ex-

[23] The authors are grateful to Charles Weiss at Georgetown University for his input to this section.

porter in one or more technological niches. In the near-term, several policies can be initiated rapidly, such as resource assessment, the setting of new standards and the establishment of research programs. In the longer-term, pricing reform, regional collaboration and public-private partnerships can help further this development.

SECTION III: CARBON CAPTURE AND SEQUESTRATION

1. DRIVERS AND OPTIONS FOR CCS IN THE GCC

While alternative sources of power generation have the potential to mitigate some of the GCC's carbon emissions, a major shift in the region's use of oil and gas in power and industrial production is unlikely. Carbon capture and storage (CCS) is an advanced technology that has the technical potential to help the countries of the GCC maintain their hydrocarbon-driven economic advancement while mitigating the negative effects of increasing CO_2 emissions. A full CCS technology system consists of the integration of a number of processes, including CO_2 separation, compression, transport (typically by pipeline), injection into underground reservoirs, and long-term monitoring. Many of these processes is operated commercially, at scale, in the oil and gas sector. However, they have yet to be proven in large-scale commercial applications in the power sector—which accounts for the most CO_2 emissions and, therefore, offers the largest potential for CO_2 capture—or in the industrial sector. By separating or capturing carbon from power production and industrial applications, and transporting it to a repository for long-term storage, CCS could provide a means of enabling the GCC countries to exploit their natural competitive advantage in hydrocarbon-intensive processes, and to meet burgeoning electricity demand at a lower environmental cost.

CCS projects have been explored and developed around the world for several years. Statoil's Sleipner field off the coast of Norway has been operational for nearly 15 years.[24] There are 23 CCS active projects around the world and another 53 are planned.[25] However, the commercial viability of the technology remains in question. The Sleipner facility benefited from a robust carbon price imposed by the Norwegian government; such a policy environment has not been created elsewhere. Even in cases where CCS has been demonstrated successfully, there are still a number of technological, legal and regulatory challenges to its widespread adoption.

To reduce costs and increase the pace of technological development, governments are currently considering a number of policy tools including research and deployment funding, demonstration projects, the creation of legal and regulatory

[24] The Sleipner natural gas field is a large natural gas field in the North Sea. The gas contains up to 9 percent CO_2 which, for commercial purposes, must be reduced to a maximum of 2.5 percent. The excess CO_2 is equivalent to nearly 1 million tones of CO_2 per year. Since 1996, rather than venting this excess CO_2, Statoil has been injecting it into an underground saline aquifer below the seabed. Global CCS Institute, Sleipner project page. Accessed at http://www.globalccsinstitute.com/resources/projects/sleipner-co2-injection.

[25] Ibid.

frameworks, the use of captured carbon in enhanced oil recovery (EOR) or enhanced gas recovery (EGR), rebates and international cooperation.

The countries of the GCC have significant financial and environmental incentives for the successful commercial development of CCS, which can be deployed for three region-specific applications: natural gas-fired power generation, enhanced recovery of oil and natural gas, and other advanced, emissions-intensive industrial processes including gas-to-liquid (GTL) projects and liquefied natural gas (LNG) production.

In the power sector, CCS has the technical potential to deliver large reductions in emissions while still allowing extensive use of natural gas or coal in the electricity generation mix.[26] This is of particular interest for the GCC nations, as they rely almost exclusively on oil and gas for power generation. Because power generation accounts for the bulk of CO_2 emissions, it also provides the biggest opportunity for CO_2 mitigation. The use of CCS in industrial processes is another significant area of potential carbon abatement in the region. This is particularly relevant in Qatar, which is home to the world's largest GTL plant and is the world's biggest producer of LNG.[27] Oman and the UAE are also significant LNG producers.

However, some constraints remain. CCS for power generation has yet to reach the stage of commercialization, and is a long-term prospect rather than a short-term option. This is especially true for CCS from natural gas power generation; nearly all existing or planned CCS power plants worldwide are coal-fired. Moreover, because natural gas generation is 50 percent less carbon intensive than electricity from coal, there is less carbon to be captured from natural gas power plants. Assuming a carbon price that provides an incentive for capture, the economic returns of carbon capture from natural gas plants, the predominant means of power generation in the GCC, are limited in comparison with those from coal power plants. In any case, even in those markets that do have a price on carbon, that financial incentive is currently nowhere near adequate to justify investment in CCS for power-generation facilities.

A more effective financial incentive for the adoption of CCS among GCC nations is its potential application in enhanced oil recovery (EOR) and enhanced gas recovery (EGR). Currently, many of the countries in the GCC increase the productivity of mature oil and gas fields by pumping in natural gas to increase well pressure. Given the projected spike in electricity demand in the region—and the corresponding increase in the use of natural gas supplies for power generation—the use of gas for oil recovery may become economically unfeasible. By pumping CO_2 into declining oil wells in place of natural gas, the countries of the GCC can free up valuable volumes of hydrocarbons. The gas saved can then be used either for domestic power generation or for export. There is already significant interest in the use of CO_2 in EOR and EGR; Qatar is exploring injecting CO_2 captured from its Pearl GTL plant into the Dukhan oilfield, where production dropped from 350,000 barrels/day in 2003 to 250,000 barrels/day at the end of 2010.[28] The UAE has undertaken similar plans to use CO_2 to enhance the oil production from both offshore and onshore oil wells.[29] Because CCS for EOR and EGR provides an important economic incentive for the technology, commercial-scale deployment of the technology may occur sooner than for other applications.

[26] While CCS is more often associated with coal, given the lack of coal used for electricity generation in the region, this policy brief will focus exclusively on natural gas-fired power generation.
[27] "Natural Gas Information: 2010," International Energy Agency, 2010. pg. 93.
[28] Miles Lang, "Abu Dhabi takes on the CCS challenge," *Petroleum Economist,* December 2010.
[29] Ibid.

CO_2 for EOR is already a commercialized process; however almost all of this activity occurs in the United States and Canada.[30] If the GCC countries were to implement CCS for EOR and EGR applications, they would have the potential to gain valuable lessons for capturing and sequestering carbon for other regional projects.

2. Near-Term Opportunities

2.1 Research and Development (R&D)

Unlike alternative energy, which largely benefits from mature, "off-the-shelf" technologies, CCS is still a commercially unproven technology and the environmental impacts and financial risks are still uncertain. R&D is critical to the development and cost-effectiveness of CCS applications worldwide, and can be used to address some of the remaining challenges associated with both the technology and the context in which it will be used. For the GCC states that have interest in CCS, substantial R&D is still required, including for site and capacity assessments and capture from industrial applications.

Some of the GCC countries have already made investments in CCS R&D. These include Qatar (Qatar Carbonates and Carbon Storage Research Center), the UAE (Masdar Carbon Unit and Hydrogen Power Abu Dhabi), Saudi Arabia (KAUST-Cornell University Center for Energy and Sustainability) and Bahrain (Sitra Carbon Capture System). On a multilateral level, at a 2007 summit meeting of the Organization of the Petroleum Exporting Countries (OPEC) in Saudi Arabia, King Abdullah bin Abdul Aziz pledged $300 million to finance a new research program that would generate research on the future of energy, environment and climate change. With $150 million in contributions from Qatar, Kuwait and the UAE, the $750 million initiative is designed to finance CCS research. However, other than the OPEC CCS Funding Commitment, there has been little regional cooperation to date.

The GCC has the opportunity to establish a coordinated approach to CCS R&D, possibly in the form of a "technology platform" comprising industry, universities, and the government. Such a coordinated, regional approach to R&D will allow the GCC states to identify region-specific solutions to encourage the deployment of CCS. For example, R&D in the region could be targeted towards various applications of CCS from natural gas, including CCS from natural gas power plants, from LNG facilities, or from GTL plants. The undertaking of a regional initiative of this kind may be logistically difficult as the optimal platform would be for a single institution to take ownership with buy-in from governments of other countries, universities, and industry. However, if the region can develop a mechanism to overcome such obstacles, a coordinated initiative would harness the collective investment power and human and technical capacity available in the region for more efficient progress, and would likely expedite technological development.

2.2 Government Financing, Incentives and Mandates

As stated above, industry has the incentive to use captured carbon in EOR and EGR. It also has the capability to assess the feasibility and effectiveness of other end-use applications for CCS, such as CCS from LNG or GTL or CCS from gas power generation. Through large-scale integrated demonstration projects, industry has both the ability to transfer R&D into the commercial arena and the ability to build institutional capacity, human capacity, and transferable knowledge in partnership with academia and government.

However, private investment is often insufficient to bring new technology to the point where it

[30] "Strategic Analysis of the Global Status of Carbon and Storage, Report 2: Economic assessment of carbon capture and storage technologies," Global CCS Institute, 2009.

can be commercially deployed. Owing to its high short-term costs and its negative impact on the profitability of production and industrial competitiveness, CCS faces a potential shortfall of private funding. In addition to the financial uncertainties, the regulatory uncertainties (including health and safety issues, environmental concerns, liability and property rights issues, and permitting and acquisition issues) involved in CCS are disincentives for private sector investment. To accelerate the adoption of CCS, governments have the opportunity to provide committed financing for early CCS developers in the GCC to capitalize on a relatively new market. There is a particular need for "first-mover" incentives. With the global unconventional gas revolution making gas a more attractive fuel for power generation and transportation, the potential rewards for natural-gas CCS "first-movers" in the GCC are enormous. In a gassier global energy market, successful commercialization of CCS for natural gas power plants or for GTL and LNG production could also be very lucrative. The LNG market continues to grow, and exporters (like the UAE and Australia) have expressed interest in expanding capacity. Should Qatar—or the GCC as a region—develop an effective system for CCS in LNG production, it could export the expertise to other nations moving towards natural gas-fired power generation or LNG production in a carbon constrained world.

Another potential method for public sector involvement could come in the form of fiscal or policy support for R&D; in spite of OPEC's aforementioned contribution to research ventures, it still sees the provision of adequate investment as a major challenge.[31] Governments in the region could provide financial incentives and/or mandates for national oil companies (NOCs) and their international partners to invest more in CCS R&D. When the technology reaches a sufficient stage of maturity, CCS adoption could be increased through the issuance of mandates for a minimum percentage of power generation capacity to be equipped with CCS. Such a policy could be modeled on the principle of clean-energy standards elsewhere in the world.

2.3 Education and Information-Exchange Initiatives

Beyond the need for private and government investment in R&D, site assessments, and demonstration projects, a coordinated and sustained education initiative is important to inform both government officials and the public about the benefits and risks of CCS adoption. According to the IEA, "CCS is exposed to public scrutiny and potentially prone to controversy […] public engagement and education on CCS is an important priority that requires additional government resources."[32]

Education campaigns should begin with a discussion within the government on CCS, focusing on the various technologies, benefits and risks, regulatory challenges, and the costs and financing of capture, transport, and storage. Once a clear government-level vision is established for the domestic or regional development of CCS, then public sector engagement is necessary. If the public is not adequately educated on the real costs and benefits, risks and rewards of CCS, the process will likely encounter public opposition, particularly over concerns for environmental risks and over land property rights.

2.4 Domestic and Regional Regulatory Frameworks

For any CCS project with private sector involvement, the government must establish a policy

[31] One example of IOC and NOC collaboration in a CCS project is BP's cooperation with Statoil of Norway and Sonatrach of Algeria at the In Salah project in Algeria. ("Enhancing Global Energy Security through Cooperation and Partnership," Background Paper to the NOC-IOC Forum in Kuwait City, Kuwait, March 30-31, 2009.)

[32] "Technology Roadmap: Carbon Capture and Storage," International Energy Agency, 2009.

framework that delineates the roles and responsibilities of the public and private sectors, as well as the relationship between the two. There needs be a clear, consistent definition of ownership and responsibilities of the CO_2 repository, as well as clear guidelines for site monitoring and verification. The creation and enforcement of such a policy framework can be undertaken by existing government departments. This approach has been shown to work elsewhere: in Germany, for example, division of CCS regulation is broken down by function: the Federal Ministry of Education and Research oversees research on storage, the Federal Ministry of Economics and Technology oversees the technological and industrial aspects of capturing and transporting CO_2, and the Federal Ministry of Environment, Nature Conservation, and Nuclear Safety deals with the environmental aspects of CCS.

To extrapolate the German example to Qatar, for example, the industrial and EOR applications for CCS could fall under the purview of the Ministry of Energy (property rights and land liability could even, for example, be the responsibility of the Ministry of Energy's Department for Industrial Estates), while the environmental aspects of CCS can be overseen by either the Ministry of Environment or the Supreme Council for Environment and Nature Reserves. However they are administered, regulations and standards should be transparent and should incorporate performance metrics that can be easily monitored, verified and enforced.

A comprehensive regulatory structure must address the potential CCS-related risks to health, safety, and the environment; property rights; mechanisms for the allocation of liability associated with the capture, transportation, and storage of CO_2; and issues of geographic jurisdiction during transport and storage. To minimize any loss of competitive advantage to any country taking steps toward the implementation of comprehensive regulatory oversight measures, the countries of the GCC should seek to work together to harmonize regional standards.

3. Longer-Term Opportunities

3.1 Site Assessments and Demonstration Projects

While enhanced R&D efforts are critical early stage measures that can help reduce costs and increase reliability, assessment initiatives and demonstration projects are equally—if not more— important considerations. Because CCS is a relatively immature technology, demonstration projects are necessary to prove its technological and economic feasibility. Such demonstrations provide an opportunity to explore research findings in a practical context, an exercise that often reveals new challenges. As industries and researchers gain further experience, their successes may translate into political momentum for supportive policies and enhanced public perceptions of the utility of the technology. To develop domestic and regional capacity and to apply best practice in the field of site assessment, the countries of the GCC have an opportunity to partner with each other and with outside organizations with experience in dealing with CCS, such as the E.U. and Australia, which are currently running several research, development, and demonstration projects.[33]

3.2 Carbon Market Stabilization

While many of the GCC states are looking to diversify their sources of economic activity, they are—and will remain—disproportionately

[33] Europe is currently host to over 50 CCS research, development and demonstration projects. In Australia, the Otway Basin project, in the southeastern province of Victoria, claims to be the largest research and geosequestration project in the world. The Gorgon LNG project, a joint initiative by Chevron, Shell and ExxonMobil, in Northwest Australia, is in advanced planning for a major sequestration project to be linked to its production facility. In addition to Otway and Gorgon, Australia has fourteen other CCS projects that have been proposed, are being planned, or are in operation.

vulnerable to any policy that adversely affects the global consumption of hydrocarbons. One such policy is the imposition of carbon pricing, either regionally or through national legislation. Such policies seek to reduce CO_2 emissions either through direct taxation or through the allocation or sale of permits. Carbon prices are in effect in Europe and have been debated by many countries around the world as a means of curbing CO_2 emissions. If exposed without financial assistance to a price on carbon, it is likely that many of the GCC countries would be put at an economic disadvantage. However, a price on carbon is also, under the right conditions, a potential market-based tool for creating economic incentive for CCS. Two policy considerations must be made in the long-term for the establishment of pricing mechanisms that would increase deployment of CCS. First, a price on CO_2 emissions must be stable—and high—enough to limit the risks of market volatility. Second, a "level playing field" is necessary to ensure that any policies imposed by GCC governments do not put their industries at a regional or international competitive disadvantage.

Pricing CO_2 emissions at a level that encourages CCS projects has proven a difficult task in those regions, such as the EU, that have established carbon markets. Carbon prices must be high enough to adequately drive investment and consumer decisions towards low-carbon technologies, yet low enough that they do not drive down energy consumption or drive away investment to a point that unduly damages performance of the overall economy. According to most analyses, the price on CO_2 must be substantially and consistently higher than it currently is for the private sector to have an economic incentive to invest in capital intensive, long-term CCS projects.[34]

Given that an adequate carbon price is unlikely to be achieved in the near-term, other financing mechanisms will likely be required for nearer-term CCS deployment. One potential option is the inclusion of CCS within the UNFCCC's Clean Development Mechanism (CDM), a financing mechanism that facilitates clean energy investment in emerging and developing economies. Both Qatar and Saudi Arabia have expressed support to the United Nations for the inclusion of CCS in the CDM. The UNFCCC Conference of Parties in Cancun in November-December 2010 decided to recommend the incorporation of CCS in the CDM. Rules are targeted to be finalized by December 2011.

With the region's dependence on oil and gas production for government revenue, another option that would earn government and private sector interest is a tax rebate program for using CO_2 for EOR and EGR. Rebates encourage immediate use of the technology by offsetting costs associated with the more expensive method of production. As EOR becomes more widespread, industrial demand for the technology is likely to spur private investment in capture and injection technologies. In the United States, the injection of CO_2 for EOR increased substantially in 1986 after the government codified the U.S. Federal EOR Tax Incentive. The incentive provides a 15 percent tax credit to all costs associated with installing a CO_2 flood, the purchase cost of CO_2, and CO_2 injection costs.[35] The practice is particularly prevalent across the southern and central United States, where eight states have introduced various tax incentives for

[34] For more information on carbon pricing and CCS see: "Strategic Analysis of the Global Status of Carbon and Storage, Report 2: Economic assessment of carbon capture and storage technologies," *Global CCS Institute,* 2009; and "Regulation of Carbon Capture and Storage," *International Risk Governance Council*, 2008.

[35] National Energy Technology Laboratory. "Carbon Dioxide Enhanced Oil Recovery: Untapped Domestic Energy Supply and Long-Term Carbon Storage Solution," United States Department of Energy, March 2010. 17.

incremental oil production. Texas, which produces more than 80 percent of all CO_2 EOR oil in the United States, provides a severance tax exemption on all oil produced from a CO_2-flooded reservoir.[36]

It should be noted that some policies and incentives for CCS may create potential imbalances in regional competitiveness. For instance, under a carbon price, GCC countries that offer CCS incentives may end up driving up costs for their various oil and gas exports. Similarly, CCS from power generation could also drive up the cost and drive down the efficiency of electricity generation, which is heavily subsidized in many GCC countries. To that end, two considerations must be made: First, the most effective approach to policy-making with regard to CCS adoption will involve regional coordination; second, governments must demonstrate a commitment to maintaining and supporting the price of recovered CO_2. A prevalent industry view suggests that the main driver for CCS will be a carbon price that encourages the capture and storage of carbon rather than the payment for carbon emissions.[37] In the absence of a an adequate and predictable price signal, the economic incentive for capture and sequestration will likely be lost and the technology may become a burden on industry.

[36] Ibid.
[37] E. Crooks and S. Pfeifer, "Capture technology faces a more hostile environment," *Financial Times,* January 18, 2011.

SECTION IV: ENERGY EFFICIENCY

1. Drivers and Options for Energy Efficiency in the GCC

Energy efficiency (EE) is often the lowest-cost means of achieving immediate reductions in CO_2 emissions. Many EE technologies provide positive financial investment returns, with guaranteed reductions in emissions. Implementing new technologies at the point of construction is usually the most cost effective approach to EE, but building retrofits and plant upgrades can also provide returns with short payback periods. There is also significant potential for increased energy efficiency in improved processes and management techniques at both the firm and sector levels. Because of the economic benefits of EE and the relative simplicity and maturity of many EE technologies, the implementation of efficiency through policy may be less contentious than other environmentally-oriented measures. Governments can harness several policy tools to promote advances in energy efficiency, including research and development financing, standard setting, technology subsidies and public education campaigns.

The GCC countries have both economic and environmental incentives to consider measures to increase energy efficiency. The GCC nations all ranked in the top twenty for emissions per capita worldwide in 2008, with Qatar, Bahrain, the United Arab Emirates, and Kuwait all ranking in the top ten.[38] In the absence of CO_2-reduction technologies for the production and consumption of energy, emissions in these countries will continue to increase.

The per-capita measurements of emissions in the GCC region cited above mask some drivers of energy consumption patterns. Many of the GGC countries are host to small populations and large fossil-fuel based industrial applications, skewing the figures to create a profile of profligate energy usage at the individual level. Any analysis of reduction of economy-wide energy efficiency must therefore include an assessment of the options for industrial and power-sector efficiency. However, industry is far from the only consideration for improved energy efficiency policy. In a region that is witnessing some of the fastest growing rates of construction in the world,[39] building efficiency and related issues such as construction materials deserve particular attention. Measures that take a "systems approach" to building efficiency—including an integrated approach to layout and ur-

[38] United States Energy Information Administration. "Per Capita Carbon Dioxide Emissions from the Consumption of Energy, 2009" Accessed at http://tonto.eia.doe.gov/cfapps/ipdbproject/iedindex3.cfm?tid=90&pid=45&aid=8&cid=regions&syid=2005&eyid=2009&unit=MMTCD.
[39] John Belsey et al, "GCC powers of construction 2010 Building the future and growing stronger," Deloitte, 2010.

ban design—are particularly suited to a region such as the GCC that is engaged in a significant new-build efforts. Despite its relatively small contribution to overall energy use, the residential sector is also a growing source of demand and any comprehensive energy policy must start to address the issue of end-use efficiency for durable goods, including air conditioners, consumer electronics, and cars.

GCC countries often pursue energy-pricing policies that fail to incentivize conservation to the same extent as in many other parts of the world. There is a strong case to be made for increased energy efficiency through reform of the energy pricing structure. However, with internal political dynamics that leave them with limited number of fiscal instruments at their disposal, the challenge for governments in the region is to promote energy efficiency while maintaining social harmony. Non-price related policy tools for increasing energy efficiency include standards and performance requirements, which can either be mandated by the government or set as voluntary achievements and rated by independent third parties. The countries of the region also have an opportunity to inculcate a culture of improved efficiency through education campaigns that focus on increased awareness of efficiency issues and changes in consumer patterns and behaviors. The following analysis lays out short and longer-term efficiency policies that the GCC countries could consider.

2. Near-Term Opportunities

2.1 Measurement and Data Collection

A lack of comprehensive and reliable data is repeatedly highlighted by industry and public-sector representatives in the GCC countries as an obstacle to the identification and implementation of greater efficiency measures. To address this data paucity, the countries of the region have an opportunity to create robust and unified measurement and management systems at the national level that monitor performance, and provide detailed data to decision makers. Such measurement systems can be used to categorize energy consumption patterns by sector relative to an agreed benchmark (the so-called "market-based approach" to efficiency measurement); or by using "comprehensive" or top-down approach that accounts for all primary energy use across the economy.[40] Both approaches would help to provide a sound statistical base with which policy makers, businesses, and individuals could make more informed decisions.

The implementation of market-based efficiency measures—which are based on "consistent measures of consumption per service unit for a benchmark set of energy services"—would assist managers of industrial and commercial operations to better evaluate the business case for enhanced efficiency measures.[41] Comprehensive energy efficiency measurement could be used to produce an energy-usage profile in each country to foster a level of interest among the public and a demand for efficiency-related action. Reliable energy efficiency measurement can be achieved through a number of established methods. In the industrial and power sectors, energy audits by independent entities have proven to be a useful tool for identifying inefficiencies and benchmarking performance.[42] Other proven means of energy efficiency measurement include standardized surveys for residential and commercial buildings and transportation.

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[40] United States Energy Information Agency, Defining Energy Efficiency and Its Measurement. Accessed at http://www.eia.doe.gov/emeu/efficiency/ee_ch2.htm.

[41] Ibid.

[42] For more information on the usefulness of energy audits, see U.N.: "Expert Group on Energy Efficiency. Realizing the Potential of Energy Efficiency: Targets, Policies, and Measures for G8 Countries" U.N. Foundation 2007.

To design, coordinate and implement a measurement system, a network of dedicated energy efficiency authorities could be created throughout the GCC. 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 of 2030. 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 (See Section 3.1 below). The role of the efficiency authority could be expanded to include responsibility for monitoring and analysis of water usage, including examination of the distribution and desalination systems.

2.2 Standards, Goals and Labeling

Once an overview of energy consumption patterns has been produced, one of the most effective policies for improving efficiency is through the setting and implementation of standards. These can be either mandatory, in which case the government authority sets a level of performance and requires by law that it be met; or voluntary, in which case an independent authority measures efficiency performance relative to a benchmark, often publishing the results. While standards have proven to be an effective policy tool in increasing efficiency, they must be implemented judiciously and with an understanding of the market context; otherwise they can act to distort the market by awarding priority to particular manufacturers and by limiting innovation. There are two sectors of GCC economies in which efficiency standards are most applicable:

Buildings

Countries in the GCC region have a significant opportunity to improve energy efficiency in the construction and management of their building stocks. Options include a universal set of construction codes or standards for new buildings; better promotion of building retrofits for improved efficiency; and a greater attention to the planning and design of new urban and industrial clusters to maximize potential for design synergies and to minimize waste. Rating systems and performance requirements for efficient building materials and building-efficiency accreditations programs such as LEED in the United States and BREEAM in the U.K. are a proven means of increasing building efficiency. 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. The UAE emirate of 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 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.

However, while the principles underlying the QSAS and Estidama programs are sound, the challenge the countries in the region is to ensure that accreditation from such programs is embraced and valued by companies in the construction and real-estate sectors. In a region known for its breakneck rate of development, getting companies to balance cost and time considerations with efficiency and sustainability metrics requires a "push" in the form of government encouragement, and a "pull" in the form of private-sector demand for buildings that are constructed according to minimum environmental standards.

Appliances

Standard-setting for appliances in the GCC countries could comprise a simple ban on an inefficient technology or a minimum performance requirement that is gradually increased over time. Such systems have proven to be effective in achieving substantial improvements in energy efficiency in other parts of the world.[43] In addition to the use of formal standards, the setting of sector-specific and society-wide goals for efficiency performance is another policy measure that can encourage improved end-user efficiency. Such goals could be benchmarked domestically or relative to regional or international levels. To maximize public participation in energy conservation efforts and to raise the profile of a new appliance-standard regime, the governments of GCC countries could consider the use of education and awareness campaigns focussed on end-users. Such initiatives could be enhanced and sustained through government sponsorship of university programs and curriculums focused on energy efficiency.

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 another means of improving efficiency. If such information is presented in a clear and easily understood format, it can have an effect on consumer purchases. Labeling programs such as the U.S. Department of Energy "Energy Star" program have proven to be effective in influencing consumer choices toward the purchase of more efficient appliances. The introduction of rating systems is a way to promote early adoption of efficiency technologies.

The countries of the GCC 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) oversees the implementation and standards of the national energy efficiency appliance labeling program, as well as mandates for appliance efficiency standards. According to an analysis of the standards and labeling programs tracked by the Collaborative Labeling and Appliance Standards Program (CLASP), Saudi Arabia is by far the leader among GCC countries with regard to mandatory labeling programs and energy testing standards. Realizing that heating, ventilation and air conditioning (HVAC) applications account for around 70 percent of power consumption, 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. According to ESMA, the system will be 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. An important consideration for policymakers when aiming to implement labeling programs is to ensure that cooperation with manufacturers and efforts at public education converge around a single universally recognized national program. The eventual harmonization of national programs to create a pan-GCC standard would give provide greater clarity to customers and manufacturers (see Section 3.1 for more on regional collaboration).

2.3 Energy Efficiency R&D

Many of the countries of the GCC have a stated aim to diversify their economies away from a reliance on hydrocarbon and petrochemical production through the establishment of educational centres and knowledge-based industries. One area in which such institutions can provide a

[43] Collaborative Labeling and Appliance Standards Program, Effectiveness of Energy Efficiency Labels and Standard. Accessed at http://www.clasponline.org/clasp.online.resource.php?no=13&page=4.

significant benefit is in the area of government-funded energy efficiency research and development (R&D), both at the basic and applied levels. At the basic level, GCC research establishments have the opportunity to conduct scientific research into energy applications and systems specific to regional conditions; these include catalysts, lubricants, solar panels, hydrogen storage, and optimal design of building "envelopes." At the applied and demonstration levels, the GCC countries have the potential to serve as a development and demonstration base for efficiency technologies developed both inside and outside the region.

Given the region's rapidly growing urban environment, the GCC countries have the opportunity to implement new system-wide approaches to power infrastructure, building architecture, and design of industrial, commercial, and residential clusters. Government-sponsored R&D programs can also promote energy efficiency in combination with government purchasing programs to create a market for efficient products and thereby encourage private sector involvement.

2.4 Public-Private Partnerships

In the GCC energy sector, there are significant opportunities for collaboration between private (international) companies industry and government in the interests of increased efficiency. As stated, the bulk of the region's energy consumption occurs in the production and processing of hydrocarbons and other carbon-intensive industrial applications. Many of the multinational companies involved in these industries have advanced efficiency measuring and management processes. An example is ExxonMobil, a major joint-venture investor in the GCC, which had 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 (E&P) 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 be applicable to other sectors economy—such as power generation—currently under state management.

There is encouraging precedent for public-private partnership in Qatar, where Chevron and the state-run Qatar Science and 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.

3. Longer-Term Opportunities

3.1 Regional Collaboration

Many of the above policy tools for encouraging domestic energy efficiency can also be used to encourage cooperation on a regional level. Indeed, while individual countries in the region are likely not big enough to drive the adoption of regional standards alone, a GCC-wide approach to standard-setting has the potential to achieve "critical mass" with regard to improved efficiency performance. In addition to standard-setting, there is a strong incentive for regional cooperation on research related to energy efficiency in the GCC.

Through the creation of a region-wide network, countries in the region have the opportunity to share knowledge, collaborate on research agendas, avoid duplication, and maximize learning.

There is ample precedent for international collaboration on energy efficiency. The Global Superior Energy Performance (GSEP) partnership between Canada, the European Commission, France, India, Japan, Korea, Mexico, Russia, South Africa, Sweden and the United States established at a summit of energy ministers in Washington, in 2010, is an international public-private partnership to accelerate efficiency gains in commercial buildings and industrial facilities. The partnership will involve three initiatives: a harmonized implementation and certification process for ensuring efficiency gains in each country, sectoral task groups to evaluate best practices for efficiency gains in several sectors, and crosssectoral task groups to facilitate the adoption of specific energy-saving technological solutions. Participants benefit from resource and knowledge sharing, and will implement several pilot projects with high-profile industrial partners. In designing a framework for public-private partnership in the field of energy efficiency, the countries of the GCC have the potential to adapt aspects of the GSEP program to their own regional requirements.

3.2 Energy-Pricing Reform

Basic economic theory suggests that energy efficiency in the GCC could be significantly improved through a policy of greater market-based pricing and reduced subsidization of energy. Despite the 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; a system of "recycling" the revenues from any price increase; differentiated pricing across different consumer groups; 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.

SECTION V: CONCLUSION

The countries of the GCC have significant opportunity to set their economies on a path to lower-carbon development through increased use of alternative energy, carbon capture and sequestration, and energy efficiency. There are several potential near-term policy measures that are specific to each subject area. In alternative energy, governments in the region can start by conducting an analysis of those technologies or institutional designs that are most applicable to their environmental and industrial circumstances. In carbon capture and sequestration, governments can accelerate CCS adoption by the provision of first mover incentives and by developing a regulatory framework to oversee land use, liability, monitoring and verification issues. In energy efficiency, an economy-wide energy audit in each country would provide a base for any future goals or action.

There are also opportunities in all three areas in both short and longer-term that can be grouped according to several cross-cutting themes. Across all three areas, the countries of the GCC have the opportunity to support and foster continued R&D at the basic and regionally-specific applied levels. In the field of alternative energy, the GCC countries have an opportunity to develop materials-specific and deployment expertise in applications that are suited to the conditions of the region. Likewise, in the field of CCS, the countries have an incentive to develop applications in gas-fired power generation, LNG and GTL production, and petrochemical production, which could serve both their own interests and act as a source of a competitive advantage for future exports of new CCS technologies to other regions.

Another area of near-term opportunity in all three areas is that of increased public-private partnership. In alternative energy, this can take the form of government procurement mechanisms to provide a demand for private sector investment. In energy efficiency, public sectors in the region have the potential to learn from private-sector entities—particularly in the energy production and processing sectors—that often operate according to global best-practice. In alternative energy and energy efficiency, there is also significant potential in the establishment of codes, standards and goals. These are measures that can be implemented domestically in each of the GCC countries, many of which already have ministries or government departments that could be used to draw up and implement the necessary policies. For CCS projects, government and industry collaboration is also important. Among other benefits, governments are necessary for helping industry absorb some of the high costs of early stage project deployment while industry can provide the institutional and technical capacity, and can carry the technology to commercialization.

There are also longer-term policy measures that have applicability across technology areas. Given the similar economic and environmental challenges facing the countries in the GCC, a greater degree of regional collaboration would allow them to benefit from shared experience and a strategic division of labor. In the area of CCS, the financial and technical demands of demonstration projects suggest that the GCC combine efforts to develop and learn lessons from projects together. A similar situation exists with regard to many alternative energy technologies. While several GCC countries have set up well-endowed research organizations to develop wind and solar technology, for example, a great deal of duplication may be avoided by greater international collaboration at both the academic and government levels. In energy efficiency, the incentives for regional collaboration are different but no less compelling. Individually, the countries of the GCC (with the possible exception of Saudi Arabia) do not have the size or market power to drive adoption of new standards and codes for appliance efficiency. However, as a bloc, they present an economic whole greater than the sum of its parts with potential heft to influence appliance manufacturers and to implement a lasting and self-reinforcing set of standards.

The final cross-cutting policy measure is perhaps the most politically sensitive: pricing reform and the use of fiscal instruments to affect energy demand. From the perspective of energy efficiency, the case for a more market-based system for the pricing of electricity in the GCC is clear: by introducing a fiscal disincentive for electricity use, governments could eliminate the most egregious examples of energy wastage. The setting of prices for hydrocarbons and the electricity derived from them closer to their opportunity cost in world markets would also have significant impact on the economic case for numerous alternative energy sources, including wind and solar. The careful implementation of a carbon price for emissions from such sources would also strengthen the economic case for accelerated deployment of CCS technologies. However, in implementing the carbon price, governments must be wary in maintaining the carbon price's stability and in ensuring that it does not impinge upon the competitiveness of regional industries. Given the political reality of the GCC "rentier states" and the competitive advantage those states derive from relatively low-priced hydrocarbons, comprehensive pricing reform is unlikely to take place any time soon. In the near- to medium-term, other fiscal policies such as providing incentives for alternative energy through feed-in tariffs and subsidies, as well as the use of revenue generation and recycling for electricity pricing may be a more politically palatable and effective means of increasing alternative energy adoption and energy efficiency. In CCS, tax rebates for EOR and EGR or the inclusion of CCS projects in the GCC in the UNFCCC Clean Development Mechanism may provide an economic incentive for greater adoption of the technology that does not impinge upon the domestic political contract.

Long acknowledged as one of the most important regions of the world in the supply of energy, the GCC will play an increasing global role in the way it consumes energy. The countries of the region face an unprecedented period of expansion and development. Through a combination of alternative energy sources, energy efficiency measures and carbon-abatement technology they have an opportunity to set this development on a more economically and environmentally sustainable course. The successful integration of these elements into the hydrocarbon-intensive economics of the GCC will require strategically intelligent approach to policy making, both in the short- and longer-term.

Table 2. Summary of Options for GCC Energy Policy

	Alternative Energy		Carbon Capture and Storage		Energy Efficiency	
Policy Option	Near-term	Longer-term	Near-term	Longer-term	Near-term	Longer-term
Standards	**	***	*		***	***
Export Market Development	*	***		*		**
National Investment Plan	*	*	**	***		
Research Collaboration	*		**	**	*	*
Pricing Reform		**		*		***
Electricity Market Instruments						*
Carbon Price/ Tax/ Trading				**		**
Public-Private Partnership	*		*	**	*	*

Categories are groups according to near-term vs longer-term measures. "*" is proportional to policy impact (*=moderate, **=large, ***=very large).

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