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The Energy Transition in the Arab Gulf: From Vision to Reality

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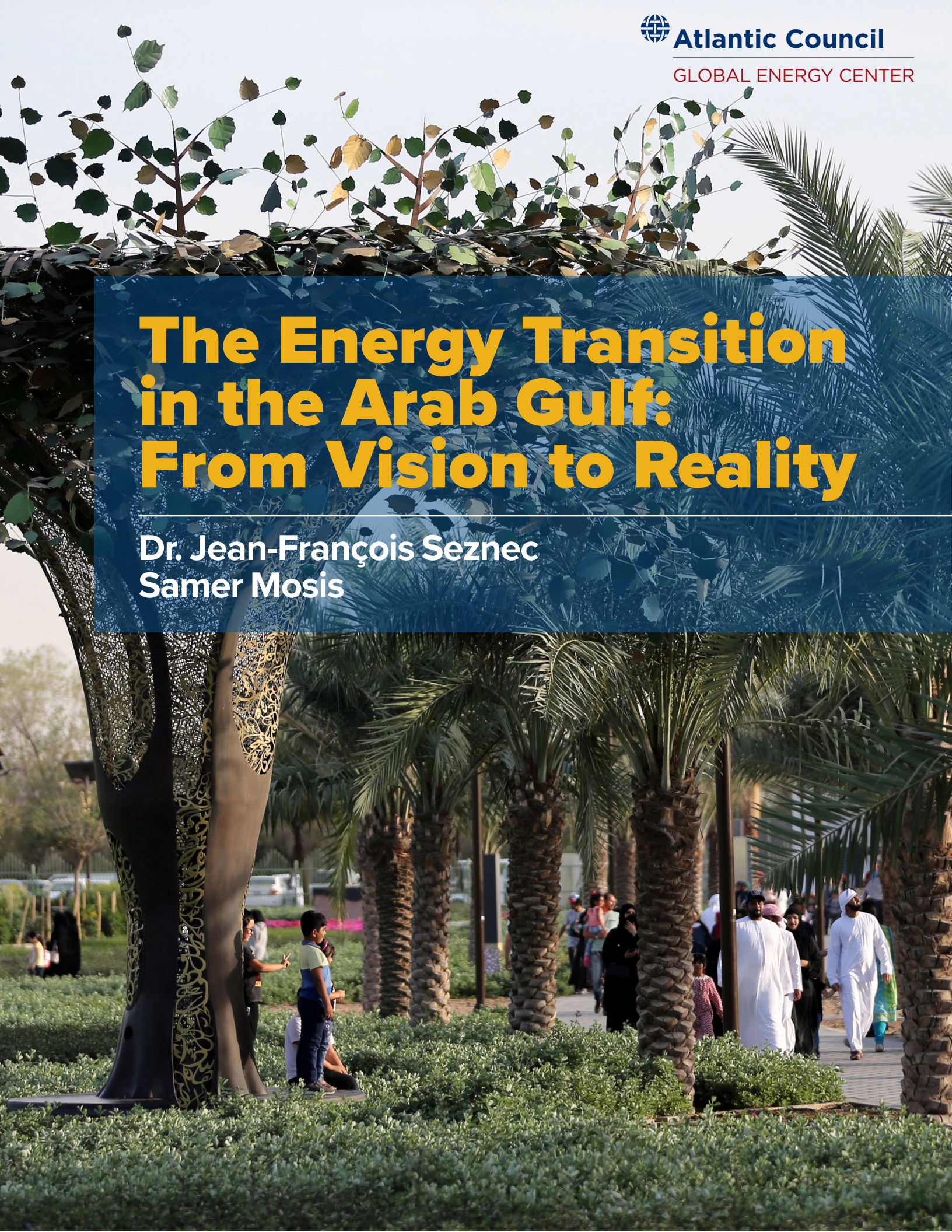

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Cover: Solar panel trees are seen on the pathway at Dubai's Quranic Park in the United Arab Emirates (UAE), in April 2019. REUTERS/Satish Kumar

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TABLE OF CONTENTS

Executive Summary

The energy transition is having a significant impact on the Arab Gulf states as they work to move away from economic reliance on hydrocarbons exports. The Kingdom of Saudi Arabia (KSA) and the United Arab Emirates (UAE) have emerged as regional leaders of the energy transition, both domestically and in their efforts to rethink the ways in which they participate in the global energy system; however, both countries will confront challenges as they seek to establish their global leadership in the energy transition. Saudi Arabia would likely benefit from a more defined internal organization, since numerous ministries and organizations hold overlapping, duplicative, or even competing priorities and mandates, which detracts from forward momentum in implementing critical policies related to the broader energy transition. In the UAE, there is a clearer sense of energy leadership, but there are still key differences between the different emirates—especially Abu Dhabi and Dubai—that should be resolved.

While the Arab Gulf states hold some of the most economically competitive hydrocarbon reserves in the world, it is not the only competitive advantage the region holds in the energy space. Indeed, the Gulf states have other critical assets they can turn to in the transition to the post-carbon economy. These include natural resources for renewables, especially solar power, as well as the potential to invest hydrocarbon revenue in capital-intensive, low-carbon energy technologies, like nuclear power. The Arab Gulf states hold enormous solar energy potential, and Saudi Arabia and the UAE have been found to be among the top fifteen countries globally in terms of practical PV power potential. Saudi Arabia and the UAE also have large amounts of available capital, much of which is presently being invested abroad and can be redirected to investments in domestic clean energy development.

However, the lack of centralized and transparent planning has complicated Saudi Arabia's shift to cleaner energy and economic activity. Outside of the Saudi Ministry of Energy's Renewable Energy Project Development Office (REPDO), there appears to be an absence of a centralized body responsible for the coordination of Riyadh's overall decarbonization planning. Other institutions also exist within the KSA that are involved in the build-out of renewable capacity, but they are each moving forward in a generally independent manner. The notion of the circular carbon economy lends an overarching strategy to Saudi Arabia's approach to the energy transition, but Saudi Arabia still has farther to go in establishing a unified vision for decarbonization.

Compared to Saudi Arabia, the UAE's strategy toward the energy transition is relatively more focused; however, due to the federal structure of the country, there are diverging strategies in the key emirates of Abu Dhabi and Dubai. While Abu Dhabi has had considerable success establishing expertise in clean energy deployment, Dubai is bringing online the region's first coal-fired power plant, putting energy security ahead of carbon reduction.

In order to establish themselves as regional and global leaders, Saudi Arabia and the UAE should take the following steps:

- **Promote greater transparency in government agencies:** Saudi Arabia and the UAE should ensure that the governmental organizations that are leading each country's respective energy transition increase their levels of financial transparency.
- **Provide consistency in the planning of the transition**: Regional leadership should show consistent support for transition efforts.
- **Strengthen the private sector**: Saudi Arabia and the UAE should invest in the private sector, in addition to their investments in state-owned companies.
- **Invest in education**: The countries should help universities and existing state entities and commercialize locally developed technologies.
- **Invest in existing clean energy technologies and in clean energy innovation**: Both countries should set a goal of making CCUS commercially viable; emphasize local content requirements in all renewables and circular carbon economy projects; and encourage national oil companies—like ADNOC and Saudi Aramco—to match the goals set by many IOCs of getting to zero net emissions by a target date.

Introduction

The global transition to an energy system with lower carbon dioxide emissions will have an enormous impact on the economies of the Arab Gulf states. As producers, refiners, and exporters of hydrocarbon-based products for the past eighty years, these states have been profoundly shaped by the global economy's dependency on hydrocarbons. Yet now, faced with the global energy transition, the Gulf states are working to move away from their focus on hydrocarbon exports and toward global leadership in decarbonizing the energy sector. Saudi Arabia and the UAE have emerged as regional leaders of the energy transition, both domestically and in their efforts to rethink the ways in which they participate in the global energy system. For this reason, this paper looks to both the KSA and the UAE as two critical case studies by which to understand a broader transition occurring throughout the region, and the challenges and opportunities therein. This report examines their efforts to lead the energy transition, and it argues that both will need to address internal issues first, before leading on a global scale. This report also discusses some of the efforts of other Gulf states in the context of these two case studies.

Saudi Arabia has the capacity—namely, the wealth and technical expertise—to spur its internal energy transition and emerge as a regional and global leader. It has ambitious plans for renewable power as well as managing emissions to develop a circular carbon economy, however, the KSA is not developing these efforts and reducing emissions as quickly as it should.[1] A large part of this can be attributed to the fact that, as in many of the Gulf states, numerous ministries and organizations hold overlapping, duplicative, or even competing priorities and mandates. In effect, this detracts from forward momentum in implementing critical policies related to the broader energy transition, likely due to confusion over which government entity has the authority to lead the energy transition. In the UAE, there is a clearer sense of energy leadership, and the move toward clean energy enjoys the full backing of Abu Dhabi's leadership. However, its clean energy credentials are partially undermined due to Dubai's build-out of a new, massive coal plant.

Although both the KSA and the UAE have internal issues that need to be addressed to increase their leadership roles in the global energy transition, each has made great progress in diversifying its respective energy sector. Both countries have sought to deploy renewables in power generation, leveraging the wealth of sun and—in some areas—wind resources available across the region. At the same time, both countries are looking beyond renewables toward expansion of clean technologies such as nuclear energy or decarbonizing the oil and gas industry. The KSA and the UAE have increased their expertise in—and deployment of—carbon capture, utilization, and storage (CCUS). While solar, wind, and nuclear will provide new sources of carbon-free energy, CCUS is being pursued with the notion that, in time, it will allow the Gulf oil and gas producers to continue using their own carbon-based production while still reducing their overall emissions profile, especially when paired with new economic models such as the development of a circular carbon economy.

Across the Gulf, the broader shift away from liquids, such as fuel oil and crude, and toward natural gas and renewables in the power sector has brought significant progress in reducing overall national emissions. If this dynamic is maintained, it will assist in meeting Paris Agreement targets in places like Saudi Arabia.[2] Beyond this, though, further technological and policy implementation will be necessary. While the deployment of renewables and CCUS has been promoted by oil exporting countries across the Gulf for over a decade, only since late 2019 have these technologies begun to gather critical momentum and enter the strategic objectives of regional decision makers. While it will be several decades until any of these countries can realistically near any goals for zero or net-zero emissions, governments and local energy companies are now genuinely pushing for massive increases in the use of renewables and CCUS and advocating for lower carbon emissions.

Saudi Arabia and the UAE (along with their neighbors throughout the Gulf) hold some significant natural advantages necessary to scale these efforts quickly. The largest of these is an extensive availability of sunlight. A recent World Bank study found that the states across the Gulf, as well as parts of North Africa and the Levant, have among the highest levels of practical photovoltaic (PV) power potential in the world.[3] Further, many of these states hold substantial capital to invest in CCUS, nuclear, and renewables, with their existing sales of oil and gas providing relatively adequate cash flows to invest in lower carbon industries without having to borrow extensively. Finally, the Gulf states—principally the UAE and the KSA, as well as Qatar in the space of power and gas—also have deep expertise in energy, which will be

1 Energy ministers of the twenty leading rich and developing nations, known as the Group of Twenty (G-20), adopted the concept of a circular carbon economy platform in October 2020. See "G20 Promotes the Circular Carbon Economy," Saudi G-20 Presidency (press release), Cision PR Newswire, October 30, 2020, https://www.prnewswire.com/news-releases/g20-promotes-the-circular-carbon-economy-cce-301163945.html.

2 David Wogan, Elizabeth Carey, and Douglas Cooke, "Policy Pathways to Meet Saudi Arabia's Contributions to the Paris Agreement," King Abdullah Petroleum Studies and Research Center (KAPSARC), February 2019, https://www.kapsarc.org/research/publications/policy-pathways-to-meet-saudi-arabias-contribution-to-the-paris-agreement/.

3 Marcel Suri, Juraj Betak, Konstantin Rosina, Daniel Chrkavy, Nada Suriova, Tomas Cebecauer, Marek Caltik, and Branislav Erdelyi, *Global Photovoltaic Power Potential by Country,* Energy Sector Management Assistance Program, a partnership of the World Bank and eighteen partners (Washington, DC: World Bank Group, 2020), http://documents.worldbank.org/curated/en/466331592817725242/Global-Photovoltaic-Power-Potential-by-Country.

invaluable as the region begins to explore, implement, and hopefully export new technologies developed from the extensive downstream refining, research, and distribution expertise honed over the last forty years.

This paper reviews the pace of the global energy transition, and it focuses on how Saudi Arabia and the UAE are positioned to participate in and lead the transition. The paper provides an overview of the efforts in Saudi Arabia and the UAE in developing renewables, nuclear energy, and CCUS. Finally, this project evaluates the capacity of Saudi Arabia and the UAE to become global leaders in the energy transition, as each country seeks to overcome its respective challenges: a lack of central coordination in the KSA, and UAE efforts to balance the interests of its two largest emirates, Abu Dhabi and Dubai.

The Position of the Arab Gulf States in the Global Energy Transition

Historically, energy transitions have been slow moving processes. For example, it took more than five hundred years from the first commercial coal mines to account for 25 percent of global energy consumption (reached in 1871), while it took ninety years from the drilling of the first commercial well for oil to do the same (reached in 1953).[4] While the current transition toward a global energy landscape less dependent on hydrocarbons faces numerous challenges—including the cost and time associated with infrastructure development, path dependency, and the challenges of innovation diffusion—there is ample reason to believe policy action, disruptive technologies, and societal forces could catalyze a much more rapid transition.

Since 2000, the portion of global energy demand met by traditional renewable energy sources (wind, solar, geothermal, tidal, and hydro) has risen by more than 70 percent in absolute terms, growing by just over 23 million barrels of oil equivalent per day (Mboe/d) to roughly 56 Mboe/d in 2021. This absolute growth is largely on par with the growth seen for oil and natural gas since 2000 (up about 20 Mboe/d and 27 Mboe/d, respectively). Since 2010, however, the oil and gas growth rates (1.4 percent and 2 percent annual demand growth, respectively) have trailed the rates for the traditional renewables bucket, which have consistently surpassed 3.3 percent during this period; meanwhile, the growth rates for solar and wind have exceeded 7 percent.[5]

Looking ahead, there are structurally bullish factors that will provide some demand support for oil in the medium term. Through 2030, the global middle class will increase by more than one billion people, economic activity will be skewed toward hydrocarbon-intensive industries across the developing world, and there will be a lag in the rate of penetration of new technologies. While peak oil demand is highly contested, many forecasts show that these factors will prevent global consumption of oil—and its related products—from plateauing before the 2030s.[6] At the same time, vehicle electrification, energy efficiency gains, and environmental pressures will likely act as tailwinds to the penetration of renewables, with the share of traditional renewables in total energy consumption projected to grow by as much as 3 percent annually over the coming three decades, which could propel the renewables share of global energy consumption to more than one-fifth before the middle of the century.[7] The election of US President Joe Biden and successive European Union policy initiatives place further structural pressure in favor of renewables as the policy weight of some of the world's largest economies push more aggressively toward decarbonization.

Some of the most consequential macroeconomic and sociopolitical implications of a more rapid shift in the global energy mix arise in the Arab Gulf. Over the past decade, Saudi Arabia and the UAE, as well as other oil-exporting nations of the Gulf, have seen hydrocarbon rents make up more than 25 percent of gross domestic production, over 15 times the global average.[8] In a future environment where oil demand has peaked or plateaued, this dependency highlights potential for exacerbated revenue volatility and the threat of steep, if not terminal, decline in the value of Gulf Cooperation Council (GCC) member states' most important assets. Without future growth, oil suppliers will face an increasingly competitive environment driven by the fear that oil reserves are consistently losing intrinsic value.[9]

Efforts across the region to reduce dependence on hydrocarbon revenues have varied significantly. The United Arab Emirates and Bahrain, at various respective intervals, have focused on banking and finance, and Saudi Arabia is increasingly focused on value-added downstream plastics and specialty chemicals.[10] These efforts are generally coupled with plans for structural fiscal reform, including reducing public wages and subsidies, delaying capital projects, and expansive external and domestic borrowing. While pursued in good faith, many of these diversification efforts and policy reforms have proven difficult to implement due to public- and private-sector resistance and a lack of political will.

Despite these varied diversification results, the current rapidity of the energy transition has led to a paradigm shift

4 Benjamin K. Sovacool, "How Long Will It Take? Conceptualizing the Temporal Dynamics of Energy Transitions," *Energy Research & Social Science* 13 (2016): 202-215, https://www.sciencedirect.com/science/article/pii/S2214629615300827.

5 Platts Analytics, "Global Integrated Energy Model," S&P Global Platts (website), April 2021, https://www.spglobal.com/platts/en/products-services/energy-transition/future-energy-outlooks.

6 Platts Analytics, "Future Energy Outlook Annual Guidebook," S&P Global Platts (website), February 24, 2021, https://www.spglobal.com/platts/en/products-services/energy-transition/future-energy-outlooks; and Noah Browning, "Factbox: Pandemic Brings Forward Predictions for Peak Oil Demand," Reuters, April 21, 2021, https://mobile.reuters.com/article/amp/idUSKBN2C81XQ.

7 Platts Analytics, "Future Energy Outlook Annual Guidebook," Appendix.

8 World Bank, "Oil Rents (Percent of GDP)," World Bank (website), https://data.worldbank.org/indicator/NY.GDP.PETR.RT.ZS.

9 For more on this shift in market behavior see Spencer Dale and Bassam Fattouh, "Peak Oil Demand and Long-run Oil Prices," BP (website), January 2018, https://www.bp.com/en/global/corporate/energy-economics/spencer-dale-group-chief-economist/peak-oil-demand-and-long-run-oil-prices.html.

10 Jean Francois Seznec and Samer Mosis, *Financial Markets of the Arab Gulf: Power, Politics, and Money* (Milton, England: Routledge, 2018).

A Saudi man walks on a street past a field of solar panels at the King Abdulaziz city of Sciences and Technology, Al-Oyeynah Research Station, on May 21, 2012. REUTERS/Fahad Shadeed

in the way that Gulf nations speak about future energy markets. For example, in October 2020, Saudi-led OPEC integrated peak oil demand into its forward-looking market view for the first time, estimating that world oil demand would peak in the 2040s and thereafter begin to level off in the long-term. While these estimates are relatively more supportive of future oil demand than other forward-looking views, including those of S&P Global Platts Analytics and BP, OPEC's acceptance of peak oil demand alone underscores the competitive pressures the industry faces.[11] Since 2018, these pressures have fueled a substantive shift in strategy for longer-term incumbent international oil and gas companies (IOCs), with many incrementally, and very publicly, developing nuanced tactics for navigating the energy transition to a post-oil dependent world. To date, actions of IOCs have included increasing investments in lower-carbon technologies, reducing the carbon-intensity of their oil and gas production, setting public targets for reductions in greenhouse gas emissions, and employing internal carbon costs. Despite the fact that Arab Gulf national oil companies like Saudi Aramco, Qatar Petroleum, and Abu Dhabi National Oil Company (ADNOC) have similar business models as IOCs like Shell, Total, and BP, the former group is not seen as being as forward leaning as many of these IOCs, despite an acute vulnerability to the transition.[12] Indeed, many IOCs have gone as far as setting net-zero carbon emission targets, an action largely motivated by the desire to proactively position their production portfolio as relatively carbon competitive. While no major Gulf company—oil, gas, or otherwise—has made similar net-zero commitments, Saudi Arabia and Qatar have joined the recently established Net-Zero Producers Forum, which aims to discuss ways to achieve net-zero carbon emission targets but has no binding emissions-reduction commitments.[13]

11 Platts Analytics, "Future Energy Outlook Annual Guidebook," Appendix; and Anjili Raval et al., "BP Warns of Oil Demand Peak by Early 2030s," *Financial Times*, September 14, 2002, https://www.ft.com/content/7a6d5cb2-0e7e-4ea5-8662-5ac75c4c0694.

12 Samer Mosis, Navigating the Energy Transition, Gulf International Forum, December 2020, https://gulfif.org/navigating-the-energy-transition-how-gulf-nocs-can-weigh-in-on-the-climate-crisis/; and Bassam Fattouh, Rahmatallah Poudineh, and Rob West, "The Rise of Renewables and Energy Transition: What Adaptation Strategy Exists for Oil Companies and Oil-exporting Countries?" Energy Transitions 3, no. 1 (2019): 45-58, https://link.springer.com/article/10.1007/s41825-019-00013-x.

13 US Department of Energy, "Joint Statement on Establishing a Net-Zero Producers Forum between the Energy Ministries of Canada, Norway, Qatar, Saudi Arabia, and the United States," April 23, 2021, https://www.energy.gov/articles/joint-statement-establishing-net-zero-producers-forum-between-energy-ministries-canada.

Amid the energy transition, the Gulf states face two areas in which they must realize structural change: the first is their domestic energy landscape, and the second is the carbon-intensity of their energy exports. As the world moves to a lower-emissions reality, energy exporters will increasingly compete based on the carbon intensity of their exports, with lower carbon intensity inversely correlated with market competitiveness.[14] Even though many Gulf producers can boast of hydrocarbon production that has a relatively lower carbon intensity than other market actors, the sheer size of Gulf national oil and gas exports means their gross emissions are within the same range as these global IOC peers.[15] Indeed, while Arab Gulf efforts toward carbon-intensity reduction, fiscal policy reform, and economic diversification are key, they exclude an integral part of the discussion, i.e., adjustments to the business model of the energy exporters themselves to include clean energy technologies. Doing so will not only allow the Gulf to continue to leverage its leadership and expertise in the energy sector amid a global energy transition, but also seize an opportunity to leverage considerable natural advantages to such a pursuit. However, GCC states must first craft organized and coherent approaches to their domestic energy transitions, and they must recognize that the responsibility for decarbonizing is not solely held by the national oil companies but is instead shared by institutions across the regional political and economic infrastructure.

14 Mosis, *Navigating the Energy Transition.*

15 Mohammad S. Masnadi, Hassan M. El-Houjeiri, Dominik Schunack, Yunpo Li, Jacob G. Englander, Alhassan Badahdah et al., "Global Carbon Intensity of Crude Oil Production," *Science*, August 31, 2018, https://science.sciencemag.org/content/361/6405/851.summary; and Saudi Aramco, "Study Shows Record Low Carbon Intensity of Saudi Crude," Aramco (website), October 7, 2018, https://www.saudiaramco.com/en/news-media/news/2018/study-shows-record-low-carbon-intensity-of-saudi-crude-oil.

Local Resources for the Energy Transition in KSA and the UAE

While the Arab Gulf states hold some of the most economically competitive hydrocarbon reserves in the world, it is not the only competitive advantage the region holds in the energy space. Indeed, the Gulf states have other critical assets they can turn to in the transition to the post-carbon economy. These include natural resources for renewables, especially solar power, as well as the potential to invest hydrocarbon revenue in capital-intensive, low-carbon energy technologies, like nuclear power. Additionally, throughout their history as major producers of hydrocarbons, the Arab Gulf states have built expertise in the energy sector writ large. This expertise can be leveraged in the turn away from hydrocarbons and toward more sustainable energy technologies, like hydrogen.

SOLAR POTENTIAL

First, the Arab Gulf states hold enormous and underutilized solar energy potential, with studies showing that the annual average solar radiation within the GCC countries is relatively equal to 1.1 barrel of oil equivalent per square meter.[16] Saudi Arabia and the UAE have been found to be among the top fifteen countries globally in terms of practical PV power potential, based on, among other things, solar irradiance, geographic and topographic constraints, and technical efficiency factors.[17] In fact, one of the problems of solar development in the region has been that the sun is so strong and hot that it has the potential to actually decrease the power output of solar panels.[18] As solar technology continues to develop, even this challenge can be turned into an advantage, with methods now being developed to use this excess heat to increase the efficiency of the solar panels.[19] This is already an area of interest for Saudi researchers.[20]

Saudi Arabia, the UAE, and Oman also have very large available land mass. Estimates of the GCC's average global horizontal irradiation (GHI), a widely used measure of PV power output potential, are just under 6 kWh/meter^2/day, putting the region among the highest globally. Further, combining this with the roughly 2.6 million square kilometers of GCC landmass highlights the region's theoretically unlimited power-generation capacity.[21] In addition to standard technological impediments, it is not entirely clear who owns the desert. Thus, the states cannot merely take over the land. They will have to make arrangements with the various stakeholders to the land, mostly tribes with traditional usage, i.e., roaming and grazing rights, which may increase the production costs somewhat and which cannot be ignored. On the other hand, if all local stakeholders can benefit from the new solar economy, the production capacity is endless.

This level of solar irradiance and land mass has allowed the Gulf states to initiate some of the largest solar projects in the world, many of which have achieved record low purchase prices. The most recent example can be found in Saudi Arabia's Sudair region, where the record-low awarded tariff for solar power of $0.0104/kilowatt-hour (kWh) broke the previous record held by Abu Dhabi's Al Dhafra solar PV project, which was awarded at $0.0135/kWh in December 2020.[22] The driver for these low tariffs has been the use of competitive auctions by state energy companies, which, when combined with the aforementioned resource potential, economies of scale, and perhaps most importantly, access to low-cost financing and land, create an environment conducive to low tariffs.[23] Given the size of the projects, these low tariffs still allow a narrow profit margin for the developer that, when scaled, can provide competitive rates of return, a combination that is not replicable in other regions.

16 Abdullahi Abubakar Mas'ud, Asan Vernyuy Wirba, Saud J. Alshammari, Firdaus Muhammad-Sukki, Mu'azu Mohammed Abdullahi, Ricardo Albarracín, and Mohammed Ziaul Hoq, "Solar Energy Potentials and Benefits in the Gulf Cooperation Council Countries: A Review of Substantial Issues," Energies 11, no. 2 (2018), https://www.mdpi.com/1996-1073/11/2/372.

17 Suri, Betak, Rosina, Chrkavy, Suriova, Cebecauer, Caltik, and Erdelyi, Global Photovoltaic Power Potential by Country.

18 A. Baras, W. Bamhair, Y. Alkhoshi, M. Alodan, and J. Engel-Cox, "Opportunities and Challenges of Solar Energy in Saudi Arabia," *Proceedings of the World Renewable Energy Forum,* Denver, Colorado, May 13-17, 2012, http://large.stanford.edu/courses/2012/ph240/aljamaan2/docs/Solar.pdf.

19 Robert F. Service, "New Solar Panels Suck Water from Air to Cool Themselves Down," *Science* magazine, May 2020, https://www.sciencemag.org/news/2020/05/new-solar-panels-suck-water-air-cool-themselves-down; and Caline Malek, "Scientists in Saudi Arabia Push the Boundaries of Solar Power Further," *Arab News*, September 2, 2020, https://www.arabnews.com/node/1728056/saudi-arabia.

20 Malek, "Scientists in Saudi Arabia Push the Boundaries."

21 Suri, Betak, Rosina, Chrkavy, Suriova, Cebecauer, Caltik, and Erdelyi, *Global Photovoltaic Power Potential by Country.*

22 Ivan Shumkov, "Abu Dhabi Solar Project of 2 GW Seals PPA at Record-low Tariff," *Renewables Now*, July 27, 2020, https://renewablesnow.com/news/abu-dhabi-solar-project-of-2-gw-seals-ppa-at-record-low-tariff-707692/.

23 Zuzana Dobrotkova, Kavita Surana, and Pierre Audinet, "The Price of Solar Energy: Comparing Competitive Auctions for Utility-scale Solar PV in Developing Countries," *Energy Policy* 118, July 2018, https://www.sciencedirect.com/science/article/abs/pii/S0301421518301708.

These low solar tariffs have become a competition in the Gulf, with the Sudair award representing the third time in less than two years that a GCC nation set a record for low solar PV tariffs.[24] In many ways, this "go big" strategy is similar to the state of play in oil production. This is something that IOCs have taken notice of, with Total's chief operating officer stating in July 2020 that "in the Middle East, they are offering very large projects . . . in the oil business, you have very large fields with low margins. And in the solar business, very large fields, but low margins as well."[25] However, while these auctions generate low renewable power costs, the speed at which they are announced, assessed, and awarded is unpredictable and often very slow, highlighting the risks to efficient project development. For example, a shift in priorities prompted the indefinite delay of Kuwait's 1.5 gigawatt (GW) al-Dabdaba solar tender in 2020.[26]

Both the KSA and the UAE are worthy of examination, even if only for their outsized progress in the transition compared to their Gulf allies. In the GCC states, renewable capacity build-out and research are overwhelmingly concentrated in Saudi Arabia and the United Arab Emirates, which together hold over 92 percent of the block's 2.82 GW of operational utility-scale solar and wind power generation capacity (see Table 1). Expanding this data set to include all tendered and under-tender projects shows that, even when accounting for all projects substantively in the development pipeline, the KSA and the UAE still account for over 80 percent of the region's renewable generation capacity. Part of this is due to the sheer size of their power sectors, especially relative to the rest of the region. Not only do the two collectively hold over 70 percent of the GCC's total power-generation capacity, but Saudi Arabia's gross electricity generation is largely on par with that of Mexico and the United Kingdom, an average annual level that is over ten times that of Qatar or Oman.[27] Accordingly, the pace of renewable penetration and cost formation will be set by these two regional heavyweights.

The advancement of solar capacity and technology will add value as the energy transition proceeds, which the region would do well to consider as investments are made and as countries position themselves in the global supply chain for solar power. The potential applications of solar to hydrogen production could complement the region's early exploration of hydrogen.

CAPITAL AND EXPERTISE

The Gulf states are endowed with large amounts of available capital, much of which is presently being invested abroad and can be redirected to investments in domestic renewable development, as well as foreign expertise in renewables and new fuels. For its part, the UAE's first foray into civil nuclear power generation, through the four-reactor, 5.6 GW Barakah Nuclear Energy Plant, cost between $20 billion and $24 billion. The UAE was able to finance more than 70 percent of this directly from state coffers without straining its resources or borrowing from banks or credit agencies, underlining the investment potential in the region.[28]

For its part, Saudi Arabia has cash reserves of over $446 billion, some of which can be invested in the domestic renewables industry, research and development needed to achieve the objectives set out by the circular carbon economy framework, and perhaps nuclear power.[29] Others, like Oman or Bahrain, do not have the same capacity, but can still depend on support from their wealthy neighbors and even sovereign wealth funds (SWF) from Kuwait, Saudi Arabia, or the UAE. This access to capital is important to fuel the growth of renewables, allowing countries to build new resources in the region and while also investing in renewable energy and new fuel companies globally. This latter aspect is important, since it opens the door to significant technology transfer which, in time, could allow regional players to localize renewable technology and component development, thus making the Gulf countries less dependent on foreign firms. Saudi Arabian research institutes are already researching the steps necessary for this localization.[30]

Doubts around the efficacy of these localization efforts are understandable given the nascency of renewables penetration in the Gulf region. However, this potential localization needs to be viewed in conjunction with existing expertise in the energy system, which is another critical asset that the Gulf states hold. Through their role as the largest exporters and among the largest producers of hydrocarbons globally, Gulf states have built an in-depth knowledge of how the energy markets function, be it hydrocarbon extraction, infrastructure

24 Jamie Ingram, "Gulf States Bring Big Oil Approach to Big Solar," *MEES*, August 7, 2020, https://www.mees.com/2020/8/7/power-water/gulf-states-bring-big-oil-approach-to-big-solar/25543060-d8b0-11ea-80b9-63a2cabacb36.
25 Ingram, "Gulf States Bring Big Oil Approach to Big Solar."
26 David Knott, "IEA Highlights Mena PV Uncertainties," *MEES*, November 13, 2020, https://www.mees.com/2020/11/13/power-water/iea-highlights-mena-pv-uncertainties/686587d0-25c0-11eb-93e1-271ecda1d126.
27 Govinda R. Timilsina, Ilka Fabiana, and Deluque Curiel, "Power System Implications of Subsidy Removal, Regional Electricity Trade, and Carbon Constraints in MENA Economies," World Bank Group, June 2020, https://openknowledge.worldbank.org/handle/10986/33992; *BP Statistical Review of World Energy,* 2019, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-full-report.pdf.
28 "Barakah Power Plant Secures $24.4bn in Financing," *Construction Week*, October 27, 2016, https://www.constructionweekonline.com/article-41424-barakah-power-plant-secures-244bn-in-financing.
29 Saudi Central Bank, Monthly Bulletin, October 2020, https://www.sama.gov.sa/en-us/EconomicReports/Pages/MonthlyStatistics.aspx.
30 Zaid S. AlOtaibi, Hussam I. Khonkar, Ahmed O. AlAmoudi, and Saad H. Alqahtani, "Current Status and Future Perspectives for Localizing the Solar Photovoltaic Industry in the Kingdom of Saudi Arabia," *Energy Transitions* 4, 1-9 (2020), https://doi.org/10.1007/s41825-019-00020-y.

IN OPERATION

Country	Project	Capacity (GW)	Start Date	Type
UAE: Abu Dhabi	Shams	0.1	2013	CSP*
UAE: Dubai	MBR Solar P2	0.01	2013	Solar
UAE: Dubai	MBR Solar P1	0.2	2017	Solar
UAE: Dubai	MBR Solar P3.1	0.2	2018	Solar
Kuwait	al-Shagaya	0.07	2019	Mixed
Oman	Dhofar	0.05	2019	Wind
Saudi Arabia	Layla al-Aflaj	0.01	2019	Solar
UAE: Abu Dhabi	Sweihan	1.18	2019	Solar
UAE: Dubai	MBR Solar P3.2	0.3	2019	Solar
Oman	Amin	0.1	2020	Solar
UAE: Dubai	MBR Solar P3.3	0.3	2020	Solar
Saudi Arabia	Sakaka	0.3	2021	Solar
Total Operating in the Arab Gulf		2.82		
Operating in the KSA and UAE		2.6		

FULLY TENDERED AND UNDER DEVELOPMENT

Country	Project	Capacity (GW)	Estimated Start Date	Type
UAE: Dubai	MBR Solar P4.1	0.7	2021	CSP
UAE: Dubai	MBR Solar P4.2	0.25	2021	Solar
Oman	Ibri 2	0.5	2021	Solar
Bahrain	al-Askar	0.1	2021	Solar
Qatar	al-Kharsaah	0.8	2022	Solar
Saudi Arabia	Dumat al-Jandal	0.4	2022	Wind
Saudi Arabia	REPDO Round 2	1.47	2022	Solar
Saudi Arabia	Sudair	1.5	2022	Solar
UAE: Abu Dhabi	Al Dhafra	2	2022	Solar

UNDER TENDER

Country	Project	Capacity (GW)	Estimated Start Date	Type
UAE: Dubai	MBR Solar P5	0.9	2021	Solar
Oman	Manah 1	0.5	2022	Solar
Oman	Manah 2	0.5	-	Solar
Saudi Arabia	REPDO Round 3	1.2	-	Solar

Source: compiled by authors using data from *Middle East Economic Survey* 63, no. 22.

*CSP stands for concentrated solar power.

build-out and management, downstream refining, or chemical production. More importantly than just acquiring this knowledge, national oil companies in the region and government institutions have made localization of the knowledge key to their policies, just like Saudi Arabia had done in the past to Saudi-ize the chemical industry. Saudi Aramco's in-kingdom total value add (IKTVA) program is an example of this at work, with the program driving Aramco's procurement spend in 2019 to be 56 percent in-kingdom, up from just 35 percent in 2015.[31] Through contract structuring and policy formation, it is easy to see how similar technology transfer and industry build-out could allow for the localization of renewable and new fuel research and development.

In terms of new fuels, the Gulf states also are able to lean on their own natural comparative advantages. For example, in the race to produce green hydrogen, a technology that currently faces a very challenging cost curve, the Gulf's record-setting low renewable power costs and abundance of land could allow for movement toward industrial scale production of green hydrogen. To be sure, much of the Gulf's heavy industry already produces and uses hydrogen at large scale, mainly in the production of fertilizers and some specialty chemicals. While this form of hydrogen is produced using hydrocarbons (a process known as grey hydrogen production), what it underlines nevertheless is the existing foundation for a new kind of energy dominance. The Gulf states are therefore just a few, yet critical, steps away from moving to substantive blue hydrogen. A pilot project conducted by the Institute of Energy Economics, Japan (IEEJ) in partnership with Saudi Aramco demonstrated this potential, producing 40 metric tons of hydrogen made from "blue" ammonia in the KSA and shipping it to Japan in 2020, a small amount but a world first.[32] Indeed, while the Gulf states have focused their energy on mastering the global hydrocarbon complex, the building blocks for a similar mastery around less carbon-intensive energy production and export are already in place, even if at times they appear neglected.

Taken together, these advantages offer the region a unique opportunity to simultaneously adjust domestic energy profiles and prepare leaders in the global hydrocarbons industry for a transition, both in support of broader economic diversification goals. For example, the exploration of sweeping decarbonization reforms, such as carbon capture, utilization, and storage (CCUS) or the circular carbon economy policy, will necessarily leverage the advantages of solar potential, capital, and expertise.

Saudi Arabia and the UAE have addressed the question of how to organize the transition to a less carbon-intensive economy in very different ways. Saudi Arabia, for its part, offers a number of company-led efforts, which deserve recognition for achieving some success, although the lack of any significant coordination of these efforts by Riyadh has minimized their value to Saudi Arabia's overall transition from hydrocarbons to a more diversified approach to the energy transition. The UAE, meanwhile, has stronger central planning, with clear federal policy and stakeholders, but there are still significant differences in the approaches taken by Abu Dhabi and Dubai that may prove challenging to the nation's progress.

31 Jamie Ingram, "Aramco In-Kingdom Spending Rises," *MEES*, February 28, 2020, https://www.mees.com/2020/2/28/news-in-brief/aramco-in-kingdom-spending-rises/0bf5ccb0-5a34-11ea-b4e0-3f1d47737c9e.

32 Verity Ratcliffe, "Saudi Arabia Sends Blue Ammonia to Japan in World-First Shipment," *Bloomberg*, September 27, 2020, https://www.bloomberg.com/news/articles/2020-09-27/saudi-arabia-sends-blue-ammonia-to-japan-in-world-first-shipment?sref=PbY7PFeA; blue ammonia is a method of producing ammonia using steam methane reformation, wherein hydrogen is first derived as a byproduct of carbon dioxide, which has been captured and stored. It is then combined with nitrogen to produce ammonia.

The Energy Transition in Saudi Arabia: Great Potential in Need of Direction

Saudi Arabia is a key example of how the lack of centralized and transparent planning can complicate the shift to cleaner energy and economic activity. The Saudi Ministry of Energy's REPDO has notional responsibility for developing renewable energy inside the KSA, and the ambitious plan to install 27.3 GW of renewables by 2023 is at the core of it.[33] Outside of REPDO, however, there appears to be an absence of a centralized body responsible for the coordination of Riyadh's overall decarbonization planning. Other institutions also exist within the KSA that are involved in the build-out of renewable capacity, but they are each moving forward in a generally independent manner.

If the KSA can be said to have a unified approach to the energy transition, that approach is most likely based on its desire to maintain its carbon-based wealth, while lowering its emission profiles. Key to this new focus is the circular carbon economy concept, which has now become a guiding framework for the KSA's policy during the transition and, in many ways, mirrors the broader regional approach. The concept of a circular carbon economy proposes the reduction, reuse, recycling, and removal (known as the 4 Rs) of carbon emissions throughout the Saudi economy, including hard-to-decarbonize sectors of the economy such as cement or fuel production, reducing total carbon production over time. Considering that the use of hydrocarbons in the world may decline but will certainly remain at a very high level for many decades, there is continuing demand for oil and gas, but with a much-reduced CO_2 footprint. The concepts underpinning a circular carbon economy have been discussed across the industry for many years, but got a major boost in 2020, when Saudi Arabia spearheaded a very strong campaign to promote the circular carbon economy and the four Rs that make it up, including a major push during its presidency of the Group of Twenty (G-20) leadership.

CCUS is a core part of circular carbon economy, embodying the second (reuse) and fourth (remove) of the four Rs. To promote their support of CCUS, Saudi Aramco and the Ministry of Energy sponsored a megaconference in February 2020 on CCUS and a corollary one the day after on hydrogen, which was attended by thousands of participants from all over the world. In all the panels and reports, it seemed that the KSA had made the decision to push aggressively for CCUS. This conference unveiled the KSA's plan to promote CCUS, as indeed this would preserve the value of its assets in the ground. The KSA also has been pushing "blue" and "green" hydrogen, which is to be produced using the KSA's own hydrocarbon resources but linked to carbon capture to reduce carbon emissions. The production of green hydrogen, currently a part of the large NEOM project (for a planned tech and business hub), will require 4 GW of renewable power-generation capacity. Presently, it is not clear which company will be tasked with producing such an enormous amount of power, nor whether it will be generated by a solar plant, which would have to be the largest in the world, or by some other technology not disclosed in the original announcement.[34]

For the KSA, as with other regional oil exporters, focusing on CCUS makes sense. If the KSA can leverage its dominance in hydrocarbons to become a leader in CCUS and the related technologies, it will be able to increase the competitiveness of its crude sales worldwide by reducing the carbon intensity of its products. Equally importantly, it also will be able to earn money from implementing these CCUS technologies globally, helping offset potential losses in demand for the nation's hydrocarbon.

The Saudi government continued and expanded its campaign in November 2020 with the introduction of a G-20 resolution on the circular carbon economy and a speech by the king promoting it, along with the four Rs. This official push from the highest level implies that the promotion and implementation of the circular carbon economy is likely to proceed at full speed. It is likely to be led by the Ministry of Energy and implemented by Saudi Aramco and an affiliate, Saudi Arabian Basic Industries Corporation (SABIC). The company already has a program at its Hawiyah gas plant, which captures roughly 800,000 tons of carbon per year. The captured carbon is then piped 85 kilometers (km) to the Uthmaniyah oil field and injected into the oil reservoir, not only sequestering CO_2 but also helping to maintain the pressure in the reservoir and enhance oil recovery.[35]

33 Andrew Roscoe, "Saudi Arabia Sets New 58.7 GW Renewable Energy Target for 2030," *MEED: Middle East Business Intelligence*, January 10, 2019, https://www.meed.com/saudi-arabia-renewable-energy-target/.

34 Jean-François Seznec and Samer Mosis, "The ACWA Power–Air Products Joint Venture for Green Hydrogen: A New Saudi Energy Policy?" *EnergySource*, Atlantic Council, https://www.atlanticcouncil.org/blogs/energysource/the-acwa-power-air-products-joint-venture-for-green-hydrogen-a-new-saudi-energy-policy/.

35 "Carbon Capture, Utilization and Storage," Saudi Aramco (website), accessed December 1, 2020, https://www.aramco.com/en/making-a-difference/planet/carbon-capture-utilization-and-storage#; the translation to tons is computed by the authors at 1 kg of CO_2 = 19.295 standard cubic feet.

The circular carbon economy's influence on state policy should not be underestimated, given it has formal backing by the highest levels of Saudi leadership. Even the aged king has accepted it and promoted it to his G-20 colleagues, and therefore to the rest of the world. It is not quite clear which Saudi institution will truly spearhead the four Rs in the KSA, but certainly efforts to reduce and remove carbon will have to be handled by Saudi Aramco, the Saudi Electricity Company, and REPDO. Subsequently, reusing the carbon as a feedstock in the process of making chemicals and fertilizers, along with injecting carbon into oil and gas fields to maintain pressure, all of which will likely be handled by Saudi Aramco and SABIC. The large amounts of CO_2 emitted by the country's 90 GW of electricity production and water desalination, as well as that produced by the large chemical plants and refineries, will need to be captured and all passed on to Saudi Aramco for injection in mature oil fields like Uthmaniya or Ghawar, or reused in chemicals by SABIC. Education to ensure domestic technology and knowledge build-out will be critical to these efforts and would benefit from coordinated government support and policy priority. This effort could benefit from and lean heavily on existing domestic research organizations such as the King Abdullah Petroleum Studies and Research Center. Only time will tell whether this major effort will actually bear fruit, but it does give the KSA a strong start in maintaining the primacy of its hydrocarbon exports through implementation of circular carbon economy concepts.

There is some degree of inconsistency in Saudi plans for the energy transition. As of December, the king was speaking publicly about the circular carbon economy and CCUS, and the latter could only be led by Saudi Aramco. By early 2021, however, the crown prince was defunding Aramco by forcing it and its SABIC affiliate to invest $1.3 trillion in other industries by 2030, directly or via the Public Investment Fund.[36] This amount of $68.4 billion per year is above and beyond the 50 percent income tax it pays to the state and the 98.5 percent of the $75 billion per year in dividends, which is more than Aramco's cash flow, already forcing it to borrow from international markets. The implication is that Saudi Aramco and SABIC could be forced to cancel most of their capital expenditures, including CCUS, or the circular carbon economy in general.

This inconsistency exemplifies how the lack of unified vision and technical leadership on the energy transition is an impediment to the development of cleaner energy in Saudi Arabia and the region broadly. The Saudi institutions active in renewables like PIF, NEOM, REPDO, and ACWA Power and Projects Co. have produced high-quality public relations videos, events, and brochures to entice the world, but not yet established large production. For its part, Saudi Aramco has used its extensive public relations experience to "walk the talk" by going through extensive disclosures, providing detailed audited statements quarterly using international standards, hosting quarterly conferences with analysts from all over the world, and actually implementing CCUS. Yet, the public relations events and videos released by the likes of NEOM alone do not provide the world, and thus potential investors, with the necessary details on what will happen in the future.

The direct role of the highest levels of the KSA in the success of the circular carbon economy as a concept—including the development of a circular carbon economy national program—gives further weight to the notion that other initiatives aimed at improving Saudi Arabia's position within the global energy transition would be aided significantly by a centralized strategy or additional support from a strong singular institution. Many of the aforementioned transition initiatives, whether that be Aramco, NEOM, or ACWA, leverage the relative advantages Riyadh has in renewables potential, available capital, or energy expertise in their own unique way, but fail to capture the value-added to be gained from working in a more coordinated fashion together. The next section explores some of the key institutions that are working toward decarbonizing the energy sector in Saudi Arabia.

SAUDI ARAMCO

Aramco has an extensive research department, which over the years has focused on upstream and exploration research. However, for the past ten years, it has developed advanced studies of carbon capture in vehicles, in order to minimize CO_2 emissions from the combustion engine.[37] It also is working to expand the CCUS technologies used in the carbon capture and reinjection plant al al-Hawiyah. Along with this, Aramco, in collaboration with SABIC, has developed a proprietary technology and catalysts to take crude oil and transform it directly into chemicals. This development is leading to a $20 billion project of 400,000 b/d, which will lead to an increased efficiency of between 15 percent and 50 percent of the crude and natural gas used to make the same chemicals. Thus, it appears that Saudi Aramco and its new affiliate are using their own advanced research to improve efficiency, i.e., provide the KSA with more goods and income on less crude oil. The oil giant is thus at the forefront of the KSA's present emphasis on the circular carbon economy and could in turn play a central role in leading the economic and policy shift during this transition period. That said, Aramco is far from the only player with this ability presently.

36 Ghaida Ghantous and Saeed Azhar, "Saudi Arabia Announces $1.3 Trillion Private Sector Investment Push Led by Aramco, SABIC," Reuters, March 20, 2021, https://www.reuters.com/article/saudi-economy-int-idUSKBN2BM2L7.

37 "Transport Technologies: Mobile Carbon Capture," Aramco (website), accessed May 26, 2021, https://www.aramco.com/betterfuture-mcc/?utm_source=Display-Teads&utm_medium=display&utm_campaign=US_wave1-5_inf_native&utm_content=mcc.

ACWA

ACWA Power and Projects was started as a private venture in 2004 by a consortium of merchant families who felt that there was a great worldwide market potential, especially in Asia and in the Middle East, to design, finance, and build power and water plants. ACWA built very large plants fueled by natural gas, heavy fuel oil, and light crude in Saudi Arabia that cogenerated power and desalinated water. It is increasingly focused on engineering and developing solar plants. The company has built an excellent reputation over the years and holds a portfolio of fifty-eight projects with a capital value of $59.9 billion, production capacity of 37.7 GW of power, and 5.8 million cubic meters per day of desalinated water. It has eleven conventional (i.e., fuel-oil powered) projects in Saudi Arabia and a wide slate of power projects in eleven different countries from Vietnam to Morocco. The vast majority of ACWA's investments and projects—85 percent—are in non-renewable energy and water plants, but its portfolio is growing rapidly in solar and wind, collectively holding a gross renewable generating capacity of 4.6 GW, according to the company's latest annual reports.[38]

ACWA's success has drawn the attention of notable investors. In 2019, the PIF, the sovereign wealth fund of Saudi Arabia, took a 27 percent ownership stake in the company and more recently, in 2020, PIF announced it would increase its stake to 50 percent. The 2019 stake had made PIF the largest shareholder of the company. By increasing this stake to 50 percent, the investment fund now de facto controls the company. This level of ownership takes ACWA from being privately owned to state owned. This could bode well for ACWA in the sense that many of its power and water projects and proposals will now have access to larger financial means. PIF presently has over $350 billion in assets and is a key investor in numerous projects worldwide aimed at diversifying away from the KSA's dependence on hydrocarbons. Along with PIF, ACWA has a solid base of shareholders including eight well-known trading families, the Saudi Pension Fund, SANABIL (part of the PIF), and the International Finance Corporation (a member of the World Bank Group).

Recently, ACWA has established a subsidiary called ACWA Power RenewCo, which controls its concentrated solar power (CSP), PV, and wind assets across the United Arab Emirates, South Africa, Jordan, Egypt, and Morocco, yielding an aggregate power capacity of 1,668 MW.[39] It is notable that, shortly after the establishment of this subsidiary, ACWA sold a 49 percent equity share in this affiliate to the Silk Road Fund, a Chinese state-owned investment fund. Given that PIF and ACWA are very reticent about their finances, it is unknown how much was paid by the Silk Road Fund, but it is likely to be a very substantial sum of money. Considering that the previous large contracts for ACWA's renewables projects in Dubai, Jordan, and Morocco were awarded to Chinese companies, one can expect that ACWA will now pass many, if not all, its renewables contracts to Chinese firms. In other words, while ACWA obtains the contracts, the actual construction and procurement will go to China. What this effectively means is that, while ACWA may be a major energy developer, its role in renewables development may have become just that of a financier, a dynamic that does not bode well for knowledge or manufacturing transfer to the KSA.

NEOM

NEOM, the company that is developing the famous 85 square kilometer "robot" city planned in Northern Saudi Arabia, is becoming increasingly involved in solar development. NEOM signed a contract with Air Products, a US-based company, to build the largest green hydrogen plant in the world. According to the press release issued by Air Products, the electrolysis plant will be powered by 4 GW of renewable energy.[40] While REPDO and Air Products are the main energy-sector partners for the project, it is not clear yet who will build the massive renewable requirement, which is nearly ten times bigger than Saudi Arabia's existing solar capacity. It is unlikely that 4 GW could be provided through PV technologies by 2025, as intended by the project developers. If this objective proves difficult to meet, Saudi Aramco could provide carbon-based electricity. However, this would negate the all-renewable status of NEOM, unless this traditional power generation could be linked to CCUS, wherein the carbon would be reinjected for enhanced oil recovery and field pressure maintenance. However, there are no existing oil fields near NEOM, thus requiring transportation infrastructure, which—unless the carbon was sufficient to take advantage of economies of scale—would be expensive due to the implied carbon transportation costs.

KING ABDALLAH CENTER FOR ATOMIC AND RENEWABLE ENERGY (K. A. CARE)

Saudi Arabia's King Abdallah Center for Atomic and Renewable Energy (K. A. CARE) is the core institution behind Saudi Arabia's efforts to build two nuclear reactors to produce electricity. Although the KSA has discussed civil nuclear cooperation with potential vendors such as the

38 ACWA Power, *Accelerated Transformation: ACWA Power Annual Report 2019*, ACWA Power (website) https://acwapower.com/media/341119/annual-report-2019.pdf.

39 ACWA Power, "ACWA Power and Silk Road Fund Announce the Completion of Partnership over ACWA Power Renewable Energy Holding LTD," ACWA Power (website), May 10, 2020, https://www.acwapower.com/news/acwa-power-and-silk-road-fund-announce-the-completion-of-partnership-over-acwa-power-renewable-energy-holding-ltd/.

40 "Air Products, ACWA Power, and NEOM Sign Agreement for $5 Billion Production Facility in NEOM Powered by Renewable Energy for Production and Export of Green Hydrogen to Global Markets," Air Products (website), July 7, 2020, https://www.airproducts.com/news-center/2020/07/0707-air-products-agreement-for-green-ammonia-production-facility-for-export-to-hydrogen-market.

United States, China, and the Republic of Korea, no substantive development plans have been contracted yet. Media sources have reported that the KSA has large reserves of uranium that are being surveyed by a Chinese company, although Riyadh denies that there is a uranium ore facility in Saudi Arabia.[41] It also will likely want to control the technology and reprocessing that goes into the development of nuclear material. This may prove to be problematic since some of these aspirations could go against the terms that the United States might require in a Section 123 agreement for peaceful cooperation, under the US Atomic Energy Act of 1954, which would be necessary for US-to-Saudi nuclear technology transfer.[42]

PIF

From a purely financial perspective, Saudi's primary sovereign wealth fund, PIF, could play an even greater role than it already is in leading the energy transition. PIF is responsible for providing 70 percent of the incremental capacity in Saudi Arabia's plan to expand renewable capacity from less than 1 GW today to over 27 GW by 2024 and over 58 GW by 2030.[43] PIF has stated this will be done through direct negotiations in order to fast-track localization and development of "giga-scale" projects.[44] In many ways, this is exactly what the KSA should be aspiring to do. However, the issue lies in the fact that PIF may not hold as significant in-house energy expertise as is available at Saudi Aramco, SABIC, Saudi Electricity Company (SEC), Mawarid (the state water-desalination company), and ACWA, in which PIF holds a majority stake and may provide the technical expertise PIF has been lacking.

PIF finances NEOM and is thus controlling its foray into green hydrogen and ammonia, a project that will require 4 GW of green electricity. However, as mentioned above, it is not clear whether the power will come from what would be the largest solar plant in the world—more than ten times KSA's current total operational solar capacity—or from a hydrocarbon plant supplied by Saudi Aramco, but equipped with hugely expensive recapture and reinject features. In any case, plans for the power production for this project have not yet been made public.

PIF's actions in the development of renewables—especially its controlling stake in ACWA—raise questions as to the true nature of PIF's renewables strategy. First, ACWA, which had been controlled by well-known families from the private sector, is now a de facto state-owned firm, which has not created an effective precedent for involving more of the private sector in the renewables industry. Second, since ACWA and PIF sold a 49 percent stake in ACWA's renewables assets to the Silk Road Fund, Saudi Arabia's efforts to become a major supplier of goods and technology to the industry worldwide may be hampered. Furthermore, there have been a number of announcements about ACWA going public. Undoubtedly, the Tadawul stock market in Riyadh would be very receptive to shares issued by ACWA, which has an excellent reputation in the KSA. Should the company go public, it would increase the value of PIF's share in the company. This would allow PIF to raise substantial funds if it decided to sell its participation to the public, just as was done in selling SABIC stock to Saudi Aramco. Hence, on the one hand, the notion of PIF buying and controlling ACWA could be interpreted as providing ACWA with the means to become one of the leading developers of renewables in Asia and Africa, as well as in the Middle East. However, on the other hand, PIF is very opaque, so its strategy with regards to renewables could just as well be a public relations effort to increase the value of its stake in ACWA and thus maximize its financial gain, rather than increase its knowledge of renewables.

A major advantage for ACWA to go public is that, if it does, it will be forced to become financially transparent due to Tadawul regulations. Even though ACWA mentions how much power and water it is responsible for, as well as how much cash it generates, it is less than clear about how its investments are structured, what the ownership of the assets looks like, and most importantly, the actual profitability of the company. Achieving transparency will help ACWA cement independence from state support, allowing it to focus on renewables in its joint venture with the Chinese and contribute more to the transition from hydrocarbons in the KSA and wherever else it is active.

41 MEE Staff, "Saudi Arabia Constructs Facility for Extracting Uranium Yellowcake: Report," *Middle East Eye*, August 5, 2020, https://www.middleeasteye.net/news/saudi-arabia-nuclear-programme-china-yellowcake-uranium.

42 National Nuclear Security Administration, "123 Agreements for Peaceful Cooperation," US Department of Energy (website), https://www.energy.gov/nnsa/123-agreements-peaceful-cooperation.

43 "Saudi Solar Gains Momentum, but Hydrocarbons Still Dominate Project Pipeline" *MEES*, April 17, 2020, https://www.mees.com/2020/4/17/power-water/saudi-solar-gains-momentum-but-hydrocarbons-still-dominate-project-pipeline/92a491c0-80c4-11ea-880c-2d54266d9593.

44 Jamie Ingram "Saudi Solar: Key 2 GW Plant Faces Covid-19 Delays," *MEES*, July 24, 2020, https://www.mees.com/2020/7/24/power-water/saudi-solar-key-2gw-plant-faces-covid-19-delays/062d3040-cdb5-11ea-8950-2b003529ef75.

The Energy Transition in the UAE: Balancing Competing Interests

Compared to Saudi Arabia, the UAE's strategy toward the energy transition is relatively more focused; however, due to the federal structure of the country, there are diverging strategies in the key emirates of Abu Dhabi and Dubai. While Abu Dhabi has had considerable success establishing expertise in clean energy deployment, Dubai is bringing online the region's first coal-fired power plant, putting energy security ahead of carbon reduction. At the same time, although the recent solar gains across the emirates have been notable, it is still not enough to put a dent in the reliance on natural gas in the UAE's power generation. This dependence on natural gas in the power stack—combined with the geopolitically difficult fact that the UAE still relies of natural gas imports from Qatar to meet roughly one-fifth of its domestic natural gas demand—underlines the large push by the country to diversify its energy system, not only into solar, but also into nuclear, tight shale gas reservoirs, and even new coal capacity.

RENEWABLES

A focus on growing renewables and nuclear power is part of the UAE's *Energy Strategy 2050*, which aims to increase the contribution of clean energy in the total energy mix from the current 25 percent to 50 percent by 2050, a core part of which will be nuclear power generation. The UAE still leads in the region's installed utility-scale solar capacity, with 2.3 GW in operation—which is nearly eight times that of Saudi Arabia—and nearly another 4 GW in advanced stages of development.

However, core to any transition in the UAE will be the strategy of Abu Dhabi, which not only produces the bulk of the UAE's hydrocarbon exports, but also holds the largest share of the country's electricity generation capacity and provides power to some of the smaller emirates. In 2018, Abu Dhabi merged the Abu Dhabi Water and Electricity Authority (ADWEA) and the Regulation and Supervision Bureau to establish the Department of Energy (DoE), which is a regulatory institution that also is mandated with organizing the emirate's energy transition policies. To ensure this focus on regulation and policy, operating assets were then spun off into Abu Dhabi Power (ADPower), which was integrated into TAQA (which, in turn, is owned by ADQ, a holding company closely aligned with Abu Dhabi's government).

One of key energy companies within the UAE is Masdar, which is Abu Dhabi's main developer. Masdar was established in 2006 "for Abu Dhabi to lead the way in developing scalable, cost-efficient, clean energy solutions by using its energy expertise and financial resources on a global basis."[45] One of Masdar's first assignments was to develop Masdar City in Abu Dhabi to showcase the emirate's commitment to sustainability, and especially sustainable real estate. It was to be a full city with transport pods taking inhabitants from their energy efficient houses to energy efficient offices, all using renewable power. Today, Masdar City is home to the International Renewable Energy Agency (IRENA), and it contains a large research center with areas for teaching, laboratories, and housing for researchers. Only small parts of the actual city have been built; over the last several years, however, Masdar has been repurposed as the UAE's primary developer of renewable technology both domestically and abroad.

Masdar is owned by Mubadala Investment Company, the second-largest SWF of Abu Dhabi, with total assets of over $230 billion. Mubadala was founded in 2002 and mandated with facilitating Abu Dhabi's diversification and efforts for broader economic transformation in the UAE. As of 2021, Mubadala has intensified its focus on technology, infrastructure, life sciences, renewables, and other clean technologies, a notable shift from its focus on long-term, capital-intensive projects during the first two decades of its existence.[46] Unlike most other regional SWFs, which are prone to secrecy, Mubadala produces audited financial statements, giving it great credibility with existing and potential joint-venture partners. Moreover, it often seeks controlling or at least board-level shares in the projects it enters, making its investment strategy relatively public by nature.

It is thus not surprising that, through the backing of Mubadala, Masdar is perceived as the most credible renewables developer and investor in the region, with a clear mandate and clear support from its leadership. Today, Masdar is present in more than thirty countries and its investments in renewable energy projects total nearly 11 GW gross, either

45 Jamie Ingram, "Masdar: The Mideast Renewable Pioneer," *MEES*, July 10, 2020, https://www.mees.com/2020/7/10/power-water/masdar-the-mideast-renewable-pioneer/3089b8c0-c2b3-11ea-a321-8742c9d28806.

46 Nicolas Parasie, "Abu Dhabi's $232 Billion Mubadala Wants to Take Crack at Top 10," *Bloomberg*, January 7, 2021, https://www.bloomberg.com/news/articles/2021-01-07/abu-dhabi-crisis-dealmaker-mubadala-to-crack-wealth-fund-top-10.

fully operational or in development globally.[47] In some of the projects it acts merely as a minority shareholder, especially in the large plants where US and European firms are the lead designers, like the projects in the United States, United Kingdom, Spain, and Morocco. However, on many smaller projects it is the developer and main investor alongside an additional minority partner. A good example here is EDF Renewables (a unit of France's EDF Group), with which Masdar has developed several highly successful projects including the very large 800 MW Noor Midelt Moroccan solar project, the Dumat al-Jandal project, which will be the first wind farm in Saudi Arabia, and the 800 MW, phase three project of Dubai's Mohammed Bin Rashid al-Maktoum (MBR) Solar Park.

In Dubai, policies and projects related to the energy transition are generally handled by the Dubai Electricity and Water Company (DEWA). Its flagship project is the aforementioned MBR Solar Park, which for a period allowed Dubai to present itself as the solar leader in the region, until it was overtaken by ADPower's Sweihan project. The MBR Solar Park currently has three operational phases totaling 710 MW, but plans to reach 5 GW by 2030, with 1.2 GW of that incremental capacity already awarded and another 900 MW currently out to tender. Notably, the MBR Solar Park is the first project to be implemented using the independent power producer model in the Gulf. The size of MBR makes it a prime candidate for green hydrogen development, a fact that has not been missed by DEWA, which in February 2020 signed a memorandum of understanding with Siemens to build a pilot project of a solar-powered hydrogen facility at the solar park.

A focus on partnerships has made Masdar and, by proxy, Abu Dhabi, into leading innovators in the region. For example, a core component of phase three of MBR is to utilize robots to clean the solar panels without the need for water, and solar tracking technology to follow the path of the sun, both additions that make the solar infrastructure more efficient.[48] The international project-development and global-partnership growth is a realization of what Mubadala was established to do, that is, partner with experienced industry leaders, bringing together Mubadala's regional connections and capital with their partners' expertise in hopes of creating a mutually beneficial exchange. The potential political benefits of this strategy are significant and were recently demonstrated amid UAE's expanding relations with Israel: Masdar and EDF Renewables Israel agreed in January 2021 to establish a strategic partnership to promote opportunities in the field of renewable energy in Israel.

Presently, it appears Abu Dhabi is looking to replicate some of the financial and technical success Mubadala has had in its recently established ADQ. As mentioned above, this holding company is closely aligned with Abu Dhabi's government, and owns ADPower. ADQ thus has the potential to leverage ADPower's technical expertise across the broader portfolio it manages in the UAE amid the UAE's increasing rate of electrification. ADPower is not only a majority partner (with Marubeni and Jinko Solar) in the 1.18 GW Sweihan PV project in Abu Dhabi (the largest solar project in the broader region) but has also recently taken an ownership stake in Abu Dhabi National Energy Company (TAQA), which has extensive experience managing energy and water facilities across Europe, the Middle East, Africa, and India. As part of the deal, ADPower transferred the majority of its power and water generation, transmission, and distribution assets to TAQA. The merger took TAQA's gross electricity generating to 23 GW (up from 18.1 GW), primarily held in the UAE, but also through utilities in Saudi Arabia, Oman, Morocco, India, and Ghana.[49]

This consolidation of state utilities aligns with a broader effort in Abu Dhabi to streamline the energy sector, which has included the merger of other Abu Dhabi SWFs into Mubadala, the formation of DoE itself, and the privatization of government companies, with the most recent example being ADNOC's sale of a $10 billion stake in its domestic pipeline network. TAQA thus represents the latest in this process, with the company raising its foreign ownership ceiling to 49 percent, a step which will likely be followed by a large public share offering. Presently, only 1.4 percent of the company is freely traded on the Abi Dhabi Securities Exchange (ADX). Since the merger of ADPower and TAQA, the latter has become the most valuable company on Abu Dhabi's capital market, and the float will undoubtedly raise significant capital.

47 "Clean Energy," Masdar (website), accessed May 26, 2021, https://masdar.ae/en/masdar-clean-energy/overview.
48 Ingram, "Masdar: The Mideast Renewable Pioneer."
49 David Knott, "Taqa Hikes Foreign Ownership Limit to 49% Ahead of Offering," *MEES*, November 13, 2020, https://www.mees.com/2020/11/13/power-water/taqa-hikes-foreign-ownership-limit-to-49-ahead-of-offering/444a75b0-25c0-11eb-b806-4138e049f16d.

The Barakah Nuclear Energy Plant in the UAE began operations in 2020. This photograph is reprinted with permission from the Emirates Nuclear Energy Corporation.

NUCLEAR

In 2020, Abu Dhabi's Barakah Nuclear Energy Plant began generating power, with commercial operations commencing in early 2021, making it the first nuclear energy plant in the Arab world. When all four reactors are complete, Barakah will provide up to 25 percent of the UAE's power demand. While a schedule revision was announced in 2018 (which was minor compared to most other contemporary new nuclear projects), the great effort made by the state in establishing four nuclear reactors—with the first reactor having come online in 2020, another in the start-up process, and two in the final stages of construction and commissioning—shows the country's commitment and willingness to put political and extensive financial resources behind diversification of the domestic energy landscape.

Recent success in bringing the nuclear reactor online comes about after over a decade of research, planning, and development. At the beginning of these efforts in 2008, the UAE engaged with the United States to conclude a peaceful nuclear cooperation agreement in accordance with Section 123 of the Atomic Energy Act. The UAE also agreed to forego enrichment and reprocessing of spent nuclear reactor fuel. The UAE's civil nuclear program enjoys broad international engagement, as well as oversight from its former International Advisory Board, which included representatives from the United States, the Republic of Korea, Japan, France, and the UK. Korea Electric Power Corporation (KEPCO) won the prime contract for the construction of the Barakah Nuclear Energy Plant and fuel for the plant comes from a mix of US, European, and Canadian companies. It is important to note that the UAE was, and still remains, the only Gulf state pledging not to engage in uranium fuel upgrading, highlighting one of the main questions Saudi Arabia faces regarding its strategy for developing nuclear capacity domestically.

COAL

Even with the UAE's dramatic progress on nuclear energy, the UAE's clean energy credentials are often brought into question due to Dubai's build-out of a massive 2.4 GW coal plant at a cost of over $3 billion.[50] The project will comprise four units of 600 MW each. ACWA Power of Saudi Arabia and China's Harbin Electricity, the developers of the project, connected the first of four 600 MW units in May 2020, with each of the remaining three to be brought online through 2023. When fully completed, the plant will be the largest of its kind in the broader region and the first coal plant in the Arab Gulf. Given its ability to generate power without intermittency, it will be able to produce more than all of UAE's solar capacity. Indeed, while the coal plant will both provide Dubai with a stability of supply not dependent on irradiation and reduce reliance on natural gas from Abu Dhabi and Qatar, it also undermines the UAE's image as the leading provider of renewables in the region.

The UAE's well-funded, diverse set of renewable energy pursuits have offered arguably more substantial progress in terms of a transition to a less hydrocarbons-focused economic model. That said, the UAE's challenges to ensure cohesion across its emirates have left the extent of this progress, in absolute terms, an open question. Significant capital coordination from Abu Dhabi to deploy renewables and export new technologies has been successful and, importantly, brought considerable credibility to these efforts, yet some of this progress is negated by investments in coal in Dubai. Coordinating these efforts is an important next step, in which Abu Dhabi's technological prowess and Dubai's financial market experience could offer mutually reinforcing efforts to further insulate the UAE from the potential market shocks of the energy transition.

50 "Dubai Builds First Coal Power Plant Despite Pledging Lowest Carbon Footprint in the World by 2050," *Independent*, October 22, 2020, https://www.independent.co.uk/news/world/dubai-coal-fired-power-plant-electricity-renewable-energy-carbon-footprint-b1222381.html.

Conclusion and Policy Recommendations

The Gulf is starting to align with a global energy transition. Indeed, the governments in the Arab Gulf states—especially in Saudi Arabia and the UAE—have recognized the importance of this evolution and are taking dramatic steps to preserve their positions as leaders of the global energy industry. The first of these steps is the establishment of a robust base of low-carbon energy production. This is already moving forward, with the KSA and the UAE establishing world-class solar PV and CSP projects, building wind farms, and, in the case of the UAE, building a civil nuclear energy program.

Accordingly, it is vital for Saudi Arabia and the UAE to develop their own technologies based on their own natural advantages and not rely on imported technologies, a process that will allow them, in time, to turn their own research and development into exportable revenue-generating technology, potentially becoming as dominant in renewables and CCUS as they are today in oil and gas. Looking further down the road, based on their present and future acquired knowledge of renewables and CCUS, Saudi Arabia and the UAE can develop a downstream economy away from crude oil and natural gas based on cheap electricity, like the establishment of a clean hydrogen economy. This process of acquisition and development is not new to the Gulf. It is very similar to SABIC's strategy to learn from abroad and develop its own technologies to become one of the largest and most advanced chemical companies in the world.

At the same time, the Arab Gulf states will want to maintain the value of their assets in the ground. To achieve this, Saudi Arabia and, to a lesser extent, the UAE are actively pushing the concept of the circular carbon economy. The two countries are focusing on CCUS, with both operating CCUS facilities and planning further CCUS expansion. Admittedly, the industry has struggled to demonstrate the cost-competitiveness of CCUS and, thus, the circular carbon economy implies very large investments in recapture and reinjections as well as developing technologies that can reduce the costs over a period in which demand for fossil fuels remains economically conducive. Of course, there exists significant room for cost efficiencies, something that regional national oil companies could champion. This is especially true given the Gulf's vast underground storage potential in old oil fields and access to substantial local capital. Further, the region has an excellent cadre of engineers and managers who can drive this research forward. Taking on the challenge of making CCUS commercially viable would thus amplify Gulf exporters' market positioning and global leadership given the increased focus on the technology globally.

To emerge as regional leaders of the energy transition, Saudi Arabia and the UAE will first need to establish a clearer sense of their domestic energy priorities. Saudi Arabia must be more transparent regarding which government and quasi-government organizations are leading its energy transition, and where the power to make change truly lies. The UAE has demonstrated that it is fully committed to the energy transition at the highest levels, but each of the emirates must work in concert with one another to ensure that the country is meeting its clean energy goals. If Saudi Arabia and the UAE can demonstrate greater organization in their respective energy sectors, then they will attract foreign investors and achieve the knowledge transfer and market exposure needed to be successful.

With these factors in mind, policy makers and business leaders across Saudi Arabia and the UAE should consider the following broad guidelines:

- **Promote greater transparency in government agencies**: Saudi Arabia and the UAE should ensure that the respective governmental organizations—such as the PIF, ACWA, and Masdar—that play leadership roles in the energy transition increase their levels of financial transparency.

- **Provide consistency in the planning of the transition**: Regional leadership should show consistent support for transition efforts. In Saudi Arabia, this means support from the country's leadership for Saudi Aramco and SABIC's technologies in CCUS, crude-to-chemicals, and the circular carbon economy. For the UAE, this means staying the course with ADPower and ensuring that it has the bandwidth to extend its expertise to broader portions of ADQ.

- **Strengthen the private sector**: Saudi Arabia and the UAE should invest in the private sector, in addition to their investments in state-owned companies; both countries should limit the extent to which private firms can be taken over by state entities; and both countries should actively help their respective private sectors acquire foreign technology companies, with a priority put on knowledge and skills transfer.

- **Invest in education**: The countries should help universities and existing state entities—like Saudi Aramco or SABIC research—and commercialize locally developed technologies.

- **Invest in existing clean energy technologies and in clean energy innovation**: Both countries should set a

goal of making CCUS commercially viable; emphasize local content requirements in all renewables and circular carbon economy projects, much like Saudi Aramco has done with the in-kingdom total value-add program; and encourage national oil companies—like ADNOC and Saudi Aramco—to match the goals set by many IOCs of getting to zero net emissions by a target date.

While forecasts for a sustained, albeit shrinking, role for oil and gas in the global energy mix provide some support for the traditional hydrocarbon-focused economic structure of the Arab Gulf states, the ongoing energy transition will force all countries to adjust the form and function of their respective energy exports. In this sense, Saudi Arabia and the UAE must find opportunities where they can create a competitive advantage in decarbonizing and, equally importantly, help others decarbonize. These actions will not be cheap or easy, but they are necessary. This paper has outlined some of the advantages that Saudi Arabia and the UAE hold in achieving these goals. To sufficiently leverage these comparative advantages, further work is necessary, all of which will be dependent on strong and transparent institutional leadership and structure. While the building blocks for this are in place, getting across the finish line will take determined policy formation.

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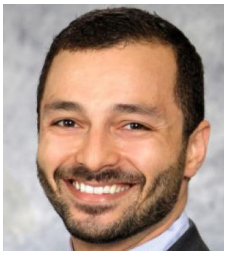
Dr. Jean-François Seznec is a nonresident senior fellow with the Atlantic Council Global Energy Center. He is also an adjunct professor at the McDonough School of Business at Georgetown University and at Johns Hopkins' School of Advanced International Studies. He teaches classes on finance, energy, and politics in the Persian Gulf. He holds a Master of International Affairs degree from Columbia University (1973), and an MA and PhD from Yale University (1994). He has published and lectured extensively on chemical and energy-based industries in the Gulf, and their importance in world trade. He is interviewed regularly on national and international TV, radio, and newspapers. Dr. Seznec has twenty-five years of experience in international banking and finance, of which ten years were spent in the Middle East. Dr. Seznec is managing partner of the Lafayette Group, a US-based consulting and investment company. His research centers on the influence of the Arab-Persian Gulf, as well as political and social variables on the financial and oil markets in the region.



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