## BOOK REVIEWS

***Superpower: One man's quest to transform American energy*****,** Russell Gold (Simon & Schuster, 2019). 319 pages, ISBN 978-1-5011-6358-6.

Any supporter of renewable energy—politician or investor, activist or technocrat—is likely to identify with solar panels, wind turbines, and geothermal stations. The development of such power generation sources dominates the discussion around addressing both climate change and the energy transition, and these technologies are rightfully considered essential to any supply-side planning for the decarbonization of the electricity system. Equally important, however, to any transition towards greater renewable energy penetration will be the introduction of transmission systems that can move power from places where it is generated to the places where it is needed.

An engaging popular book draws attention to the critical importance of transmission while providing guidance for those dreaming of a new generation of clean technology deployment. Russell Gold, the veteran energy reporter at the *Wall Street Journal*, brings us the story of Michael Skelly, an entrepreneurial renewable energy developer who successfully helped build a multi-billion dollar wind energy company. Parlaying that success into Clean Line Energy, Skelly focused on large-scale transmission projects; "Superpower" is the story of the outcomes of that remarkable goal.

The world of wires does not always receive the airtime it deserves, perhaps because transmission pylons do not emotionally spur an individual the way a field of rotating wind turbine blades or a central power tower for concentrating solar thermal power does. This lack of emotional resonance has a dangerous downside, for without adequate transmission capacity that is capable of moving large power flows, there will be no renewable energy revolution.

Skelly's Clean Line business proposition was based on the simple fact that the best renewable generation sites (such as windy open spaces or sunny arid environments) are often far from load centers. Skelly and his team endeavored to unlock this potential by building numerous high voltage direct current (HVDC) lines that bring power from outstanding generation sites to the places where it was needed. HVDC (which stands in contrast to common alternating current (AC) transmission) brought a pair of added bonuses. These projects would require neither a substantial rise in power costs; indeed, it would likely make power cheaper by connecting inexpensive renewable generation to high-value load centers. Nor would the projects require the implementation of novel or untested technologies. Detailed empirical work by MacDonald et al. (2016) provides evidence of this feasibility. On the surface, such a potent combination seems destined for a successful implementation. Who could refuse such an ostensibly favorable arrangement?

Gold weaves a sympathetic portrait of this attempt to realize the dream of building cross-state HVDC transmission lines. Skelly was more prescient than most, and he built his team with credible and intelligent staff. Gold describes Skelly's capacity to tap into renewable energy's ability to capture the imaginations of young people, as Skelly was able to poach young idealists from top firms.

Of course, while an intricate network of elegant HVDC lines is technically possible and economically viable, the main takeaway of this exquisite narrative is to be cautious when an enterprising initiative bumps into social and political barriers. Skelly is a big-picture thinker and a fascinating individual, combining the cleverness of a Harvard MBA graduate with a strong work ethic and a commendable social responsibility bent. However, his undeniable strengths brought a double-edged sword of weaknesses, such as a proclivity for a lack of attention to details and a willingness to see the best in people. He seemed to underestimate the scale of opposition—even from utilities who might otherwise support cleaner sources of power in their electricity supply mix. In some cases, optimism may have compromised success; for instance, Clean Line held community

meetings earlier in the process than required and gave too much information, which led to problems down the road.

A strong point is that the book does an excellent job of outlining the critical hurdle posed by the presence of vocal citizen opposition. Readers are given an in-depth profile of Julie Morton—a native Arkansas resident (or "Arkie", to use a local term), who went to considerable lengths to ensure that a line is not built through that state. Morton's well-organized and mobilization-oriented dissent proves to have surprisingly hefty weight despite its rural origins, as she was able to spur her senators to support her views in Washington.

In sum, Gold depicts Michael Skelly as a man ahead of his time. While he had the vision and the drive to potentially effect massive change, better models may have been available, and at least superficially, it is unfortunate they were not utilized. For example, Clack et al. (2017) offers an alternative that Gold details, which would involve numerous lines being built within–rather than between–states. Each line would allow the individual owning state to serve as a conduit for their own renewables-generated power, and each state could share in the benefits of their line, bringing benefits to the citizenry generally and interested parties (e.g. sustainable energy pioneers) specifically. This solution is less optimal, to be sure, than interstate lines, but more likely to be realized.

There are lessons for energy economists here. First, renewable energy resources should not be looked at in isolation. They are part of a broader system framework–generation, transmission, distribution, and other energy services–that is mutually interdependent for resource optimization. Second, incremental tinkering is not viable for a decarbonization-oriented supply-side electricity response strategy–the difficulties of implementing renewables require aggressive coordinated action from business, government, and communities. Gold has done a good job of covering these issues, and this book should be read by anyone interested in renewable energy trajectories.

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***The Economics of Renewable Energy in the Gulf*,** edited by Hisham Akhonbay (Routledge Taylor and Francis Group, 2019), 246 pages, ISBN: 978-1-138-35190-5 hardback, 978-0-429-43497-6 ebook, 9780367584955 paperback.

When we think of the Gulf Cooperation Council (GCC), renewable energy does not immediately come to mind. The six countries that comprise the GCC—Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE)—situated in one of the oiliest regions of the world—have enhanced their fortunes with and are still heavily dependent on petroleum. Yet all have stated goals for an increase in renewable energy as chronicled in this edited volume. The reasons arise from many of their shared challenges and environments. Their lands are arid with relatively high population growth rates and large potential for wind and solar energy. In some cases, they have relatively high unemployment rates for nationals especially for entry-level youth. They have high levels of non-nationals in the labor force (exceeding 40% in all 6 countries), and a high share of na-

tionals employed in government jobs. The legacy practice of subsidizing water and energy have led to high use and increasing financial burdens for their governments. Keeping their economies healthy while diverting oil and gas from domestic use to the export market coupled with a desire to diversify their economies, provide new job opportunities and meet their climate policy commitments are some of the drivers of their push towards renewables.

This book was prepared by the King Abdullah Petroleum Studies and Research Center (KAPSARC) in Saudi Arabia. Of the 26 authors represented in the 11 chapter almost a third are affiliated with KAPSARC, a little more than a third are other regional experts affiliated with universities, research institutes, or government organizations within GCC countries with the remainder from other non-regional research organizations and universities including the Oxford Institute of Energy Studies and the United Nation Development Program. The book provides a nice overview of many aspects of GCC country's current situation and dependence on fossil fuels along with renewable aspirations, accomplishments, and hurdles to be met.

Hisham Akhonbay and Marilyn Smith set the stage in their short introductory chapter highlighting the solar and wind energy potential in the GCC, the need for the transition to renewables, and renewable targets by country. They include the requisite chapter-by-chapter synopsis. The topics can be grouped under some major themes—the current energy situation and its unsustainability, how to realize the renewable potential of the region, new policy frameworks needed, the need for integration within national energy systems and across the region, and additional potential benefits from new job creation and regional sharing of research and development.

In chapter 2, David Wogan, Imtenan Al-Mubarak, Abdullah Al-Badi, and Shreekar Pradhan lay further groundwork for the remaining chapters with their overview of current energy supply and demand in the GCC by country. They highlight the link between electricity generation and water production, the barrier of low hydrocarbon prices to renewable saturation, and the need for an integrated grid for electricity trade. They give historical energy consumption by country, recent energy consumption and $CO_2$ emissions by country and sector, and electricity generation and water desalinization by country, technology, and fuel use. They include oil, natural gas, and water production, consumption and regional trade along with fossil, wind and solar resources by country. They wind the chapter up with accomplished and targeted energy price reform, and renewable targets.

In chapter 3, Amro M. Elshurafa and Walid Matar continue the look into the economic potential for solar power. They model deployments of solar power for two cases: distributed solar photovoltaics (PV) in the residential sector (which consumes about half of all electricity in GCC countries) and utility scale generation using solar PV or concentrating solar thermal (CST) generation. Although their analysis is for Saudi Arabia, the authors indicate that the situation is likely to be the same for other GCC countries. For residential PV, they compare cost for two options—purchase from the grid or obtaining power from both solar PV and the grid. They develop a frontier showing what grid price is needed for it to be economical to switch to deploying solar at various consumption levels. They conclude that electricity grid prices would need to rise from the current price (around $0.04 per kWh) to $0.12 for solar residential to be competitive. Their assessment of solar penetration into grid utilities is more opaque. The model cited is the KAPSARC energy model, which appears to include the major energy using sectors of the economy including electricity, water desalinization, cement, petrochemicals, and refining. The electricity sector's objective is to pick capacity expansion by technology from 2015 to 2032 to minimize total power system cost to satisfy projected electricity consumption allowing solar PV and CST as potential sources under various policy options. To understand the structure of their model, one would need to go read the model documentation, which I leave to the more ambitious reader. The most interesting take away from their results is when price increases make solar attractive, a combination of solar PV and CST with storage is the best option.

In chapter 4, Maha Alsabbagh and Odel Al Jayyoush look to the European Union (EU) for guidance in developing renewable energy policy. As the EU is arguably the most successful

regional organization in deploying renewable energy, the authors consider the Union's policies in seven categories. They are mandatory targets, legal and literary frameworks, research development and innovation, regulatory measures such as feed in tariffs and tradable certificates, voluntary measures, public participation and acceptance, and evaluating policies in terms of economic efficiency, sustainability, and energy security. I appreciated the author's summaries of European practice in these categories, their comparison of GCC policy in the same categories, and their recommendations based on their summary work. Their main policy conclusions for the GCC are to set mandatory targets with local choice on implementation; research development and innovation should focus on application rather than basic research; regulatory and voluntary measures are best coupled to support renewables; public participation and acceptance of the policies is essential; collective action across the whole region is likely to yield the best results.

In chapter 5, Karen Young outlines financial and other barriers to investment in renewables in the current period of low oil prices and fiscal constraints. Although the author identifies a number of renewable energy products that are planned and underway, government revenue needs for other required spending may divert funds away from such projects, while legal, financial and ownership structures that will facilitate sharing of risk across partners in large infrastructure investments are at present rather limited. Institutional inertia and the ever-present problem of electricity and water price subsidies disincentivize investment in renewables as well. She notes that all countries are in the process of price subsidy reform and are providing new mechanisms for public private partnerships (PPPs) to encourage participation of the private sector and cites examples of renewable PPPs across the region. While bonds called sukuks may provide a funding source that meets the Islamic criteria for no payments of interest. She notes cases of pushback for some of the reforms and outlines a brief case history of the UAE, which has seen the most success in moves towards solar energy.

In chapter 6, Stephen Gitonga and Walid Ali continue with the topic of risk. With the International Energy Agency (IEA) estimating that it will take $13.5 trillion to meet the nationally determined contributions (NDCs) from the COP21 Paris Agreement, the authors argue that the almost $1 trillion dollars controlled by the private sector will need to be tapped. However, less than 1% of this is currently invested in sustainable energy. Incentivizing these investors to invest in renewable energy projects, especially in developing countries, where the costs and risks tend to be higher, can be difficult. The authors, who are both employed by the United Nations Development Program (UNDP), argue that an important ingredient to shift these incentives is to reduce risk for such projects, and they outline the UNDP's new program De-risking Renewable Energy Investment (DREI). This program has four stages (1) identify barriers and risks, (2) assess current policy in light of these risks and select the appropriate policy instruments to reduce these risks, (3) calculate levelized costs of investment for projects, and (4) assess policies including sensitivity analysis based on four metrics "the investment leverage ratio, savings leverage ratio, end-user affordability, and carbon abatement". The de-risking policies considered fall into three categories: (1) de-risking policy including building government institutional and labor force capacity that supports renewables, long term targets, and designing a well-functioning power market, (2) de-risking finance by transferring some risk from the private to the public sector including loan guarantees, insurance for political risk, and public private co-investment, and (3) compensating the private sector for taking on the risk including feed in tariffs, tax credits, and carbon offsets. Although the DREI program has not been applied to the GCC, they indicate cases where it has been applied, interest these cases have generated and argue DREI could be applied in the GCC to good advantage. These countries already have renewable targets, have started on renewable trajectories, have some de-risking policies already in place, and have good credit ratings but do not yet have the amount of private market participation desired. By de-risking and scaling up investment, these countries might become hubs for low carbon investment, and could develop energy clusters and centers of excellence that could supply expertise within the GCC as well as for the export market.

In chapter 7, Rahmatallah Poudineh, Anupama Sen, and Bassam Fattouh reiterate and add to the policy discussion on how to promote renewables in resource rich countries. They broaden their discussion a bit beyond the GCC to include countries in the Middle East and North Africa with renewable targets. They note that although the transition to renewable has begun, this area of the world lags behind the rest of the world. They enumerate reasons for the transition including fiscal and environmental sustainability, the pressure the shale revolution has put on oil prices and revenues, and the falling cost and huge renewable potential with half or more of the land area suitable for solar and wind power. Subsidies are again noted as a major barrier to renewable entry. Although measurement of subsidies is not straight forward, the authors believe that with their removal, renewables already might be cost competitive in these countries. However, they acknowledge that historical precedents and the structure of these economies with their dependence on energy intensive sectors make subsidy removal quite difficult. In light of this difficulty, they acknowledge that subsidies to renewables maybe required. These subsidies may target production in the form of feed in tariffs or premiums or energy auctions ($/MWh) or they may be investment oriented in the form of grants or auctions based on capacity ($/MW). They recommend six criteria for choosing supports schemes—compatibility with the electricity sector, market oriented if possible, compatible with project scale, ability to reduce economic risk, compatibility with countries' institutions, and compatible with fiscal constraints. Of the policies mentioned, they tend to favor auctions for energy given that most electricity markets have not been liberalized in these regions coupled with fiscal constraints. Meanwhile governments can continue to phase out subsidies when possible, continue to interconnect and integrate renewables into their grids, and reduce the following risks whenever feasible—political, policy, regulatory, technological, currency, liquidity, and buyer default. Such risk policies could include insurance, guarantees, currency risk hedging, and the extension of local currency credit.

In chapter 8, Steve Griffiths and Daniah Orkouki extend the policy discussion to more completely consider climate policy. They place support policies in 3 general categories: fiscal incentives, public financing, and regulation. The 1st two of these may support any portion of renewable's lifecycle including research, development, demonstration, and deployment. The regulations they consider are feed in tariffs or premiums, tendering or auctions, tradable renewable certificates, and net metering. They add to this usual roster more specific carbon price climate policies—carbon taxes and tradable permits—and briefly summarize how many countries have implemented these policies and how the funds are used including green funding, general funds, or revenue recycling. They reiterate the reasons for energy price subsidy reform, summarize the existing renewable targets, and have an interesting table with a variety of policies demonstrating that outside of the UAE, policies in the other GCC countries to back up their renewable targets are quite sparse. Further, they note that with the exception of Oman none of the countries have any carbon reduction targets. In recommending policies, they note that low energy prices preclude the success of net metering or the distributed installation of solar water heating. They discuss the drawbacks of FITs and conclude that auctions are a preferred policy at this time. Reviewing a number of auctioning schemes they conclude that 1st price sealed bid auctions may be preferred for the region. Although a carbon tax is probably politically infeasible in the region, they suggest considering a regional carbon emission trading program using lessons learned from the EU, China, and other places.

In chapter 9, Moiz Bohra, Nasreddine El-Dehaibi, Antonio Sanfilippo, and Marwan Khraisheh state the aim of their paper as estimating "the cost savings that could be achieved by replacing oil and gas for electricity generation and for transport with solar energy." They use a nonlinear programming model with an objective function consisting of three saving components: subsidy returns from reduced oil and gas use, reduced carbon tax costs for a hypothetically imposed carbon tax, and reduced cost of putting in new gas fired power plants. These savings appear to be per MWh of new PV, but it is not clear to me why the denominator is adopted PV in the first component, and targeted PV in the second two components. The endogenous variables are oil and gas price subsi-

dies, the carbon tax, and the split between replacing oil or gas. If the solar power is going to replace electric vehicles, it is assumed to be replacing oil, and if it is going to replace other electricity uses, it is assumed to be replacing natural gas. Parameters include the emissions of $CO_2$ from natural gas and oil as well as the conversion efficiencies of natural gas to electricity and from the oil in internal combustion vehicles to electric vehicles. Exogenous variables are oil and gas prices and the levelized fixed and capital costs of new gas fired generation. From sensitivity tests on oil and gas prices and subsidies, the oil gas split, the carbon tax, and the levelized cost of power, they conclude that solar PV makes sense in most of their oil and gas price scenarios. They also find among other results that replacing oil is a better choice, if oil is more than $90 per barrel, otherwise replacing natural gas is the more economical choice. I appreciate their quantification of the benefits of switching to solar from gas and find that part of the analysis fairly straight forward. However, despite repeated reading of the chapter. I am not yet very clear or comfortable with their modeling of the switch from oil. For as they acknowledge, they do not take into account any of the infrastructure or capital costs of such a transition. Further, their carbon taxes maxing out at $10 per tonne of $CO_2$ seem rather low compared to other estimates of damages that are floating about (See for example Nordhaus, 2017).

In chapter 10, Sylvain Côte considers renewable energy in the context of the GCC labor market. In these youthful societies with more than 40% of the population below 25 years old, the highly capital and fossil fuel intensive industries that have developed in the region are often not able to soak up all the new entrants to the labor market. GCC countries look to their renewables plans to generate jobs and improve the employment situation among nationals. The author considers the current labor situation in the GCC, outlines barriers to the potential for increased labor market employment in renewables amongst nationals and suggests enabling polices. He surveys the literature on total cradle to grave renewable job creation estimates as well as by skill set, by stage of deployment, and by renewable source. With considerably higher levels of unemployment for nationals under age 25 for all but Qatar, the size of the new labor pool is not so likely to be a constraint. However, cheaper non-nationals, the lack of needed skills amongst nationals, and national's cultural bias away from jobs that require vocational training towards government jobs that offer shorter working hours, job security, and higher pay are all barriers. These biases have led to educational systems that largely neglect vocational (far behind rates in the OECD and China) and inadequate numbers of national engineers and scientists in the region. His recommendation to deal with these issues include promotion of renewable jobs so that nationals know about them and will be attracted to them, and training to match up the skill sets with the renewable employment needs.

Omar Al-Ubaydli, Ghada Abdulla, Lama Yaseen round out the discussion in the last chapter by urging more coordination of efforts across the region to help the countries realize their goals of transitioning to knowledge economies. Such coordination can enhance their R&D capabilities for diversifying out of fossil fuels, allow them to better adapt renewable technology to their hot, arid, and dusty climates, and better integrate their energy systems for enhanced ability to manage renewables intermittency. They further argue that energy integration might speed the pace of overall economic integration in the region. Although the GCC has been a free trade area since 1983, a customs union since 2002, and a common market since 2008, implementation of these agreements has apparently been slow. After a review of the policies by country, the authors conclude that despite the similarities in the countries' long term goals and shared visions, joint renewable projects are not so common. Their recommendations for increased coordination on renewables focuses mostly at the government level and could start with meetings and committees to reduce research duplication and plan for joint research and projects. Such joint activities could reap economies of scale and provide for cross fertilization and collaboration on renewables as well as the larger energy systems.

I found this book to contain a nice overview of energy systems in the GCC, the motivations for and current targets for renewable adoption in the region, the barriers to adoption, and policies to lower these barriers. A nice touch is that each chapter except for the introduction begins with an abstract and a bulleted list of the most policy relevant insights. I appreciated some of the technical

tidbits scattered throughout (e.g. the loss in solar PV efficiency for increases in temperature and increased maintenance needs for net metering.). Although tables and graphs often provided helpful information, some were hard to read without a magnifying glass. The book for the most part should be accessible to the general reader and should be interesting to academics, policy makers, and investors interested in an introduction to renewable energy in the GCC as well as others interested in promoting renewable energy, especially in the developing world.

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