BOOK REVIEWS

The Shale Dilemma: A Global Perspective on Fracking and Shale Development edited by Shanti Gamper-Rabindran. (University of Pittsburgh Press, 2018). 416 pages, Hardcover, ISBN-10: 0822945134, ISBN-13: 978-0822945130.

This book provides a set of comprehensive explanations and answers to questions that are in the mind of most people dealing with energy matters today. Shale gas production—is it really an energy revolution or does it announce an environmental catastrophe? For a country that possesses shale gas resources, is it worthwhile to develop such resources or is it better, for a great number of economic and environmental reasons to leave it in the ground?

The general literature tends to frame shale as bringing economic benefits but potentially bringing also environmental costs. The Shale Dilemma delves into this question more closely and argues that whether shale production brings net economic benefits and whether it spurs economic development that benefit society broadly are not foregone conclusions, when appropriate policies are not in place to achieve these goals.

As documented in the US chapter, shale brings enormous economic benefits, but it also brings economic costs. The shale industry faces a boom-bust cycle and when this boom-bust is not well managed, local economies risk experiencing a long-run reduction in economic productivity. A number of local governments, having borrowed heavily during the boom period, face heavy debt in the bust period that they find difficult to service at a time of reduced tax base. The US chapter also indicates the economics of shale raises distributional issues. Shale provided enormous benefits: energy resources, government revenue from taxes, jobs, to name a few. Owners of mineral rights gain royalty income and consumers enjoy cheaper gas. (US production is a large enough share of the segmented North American market to depress gas prices for consumers; the same would not likely be the case in Europe). On the contrary, owners of the surface and neighbors of shale operations experience negative spillovers from shale production without receiving the benefits of royalty incomes.

The world faces the urgent challenge of addressing climate change. Hence, how shale development would affect the climate is a key question for readers. Shale gas has been seen as more climate friendly than coal, as it emits less carbon dioxide than coal per energy unit. However, as noted in the US chapter, methane leakage from the chain of production and distribution of natural gas and weak regulations to control methane emissions undercuts the ability of shale gas to reduce overall greenhouse gas emissions. Moreover, shale gas production, when it adds to the overall fossil fuel combustion, rather than serve as a substitute to coal, would increase net greenhouse gas emissions. US coal displaced by shale gas was combusted in Europe.

The Shale Dilemma presents an excellent case study of the complexity of energy decisions involving short-term economic benefits and the long-term public interest. The introductory chapter lays out this complexity. The book takes a global comparative approach, taking into account three sets of countries: those with commercial production, those in an exploratory stage, and those not pursuing shale development. The book is very well-organized. Each chapter contains an exhaustive list of references, meaning that all significant sources of information on the subject have been used by the authors.

Answers to the Shale Dilemma differ widely across countries and even within some countries. Most states within the US have pursued shale extraction while only two states, New York and Maryland, have enacted moratoria. England has pursued shale, while Northern Ireland, Scotland and Wales have not. France and Germany have totally prohibited fracking. The elaboration of the national answer on whether to pursue shale is challenging because of the difficulty of weighing benefits against cost and the difficulty in weighing the interests of those who benefits from shale and

those who bear the costs. Moreover, many economic and environmental issues are mired in a great number of uncertainties. Companies, new entrants, environmental organizations, and citizens have exerted political pressure, championing their view points.

Chapters 2 and 3 deal with the United States, the leader in the shale gas experiment, which has disrupted the US energy markets and impacts the world energy dynamics. The US experience, presented in some detail, provides lessons for countries pursuing shale. Some of the medium term and long-term benefits and costs are still unfolding. Part of the uncertainty concerning shale's overall impacts is inherent to the industry—economic benefits are often early during the boom but economic costs are only revealed during the bust phase. Another part of the uncertainty is policy-driven. Policy failure to require baseline data collection and to monitor health and environmental impacts have contributed to the inability to fully evaluate the extent of environmental impacts.

These chapters note that pollution related to shale operations, including to air, water, land as well as methane leaks have been documented in the US. However, without comprehensive data collection, monitoring and analysis, how frequent these incidents are relative to the total production cannot be fully accessed. Consequently, policies to ensure internalization of costs cannot be effectively designed. A key lesson for countries contemplating shale and for countries that are in the early stage of shale exploration and production is to put in place effective monitoring and responsive regulations to avert long-term cost. Another key lesson is to enact policies early during the boom to guard against adverse long run economic impacts. For example, many state governments in the United States have not raised the amount of performance bonds posted for shale wells, thus they risk repeating the problem already faced by taxpayers from previous conventional oil and gas booms. Taxpayers risk bearing the burden of paying for the capping of wells that are no longer in production and for rehabilitating environmental damages.

The chapters highlight the uneven distributions of benefits and costs from shale production, and thus the intense political battles on how to share the benefits of shale and how to limit its potential costs.

The US case shows how important and diverse are the political battles over authorizations, regulation, collection and disclosure of information, and taxation. Rent sharing is a key issue between companies, local authorities, state governments, and the federal government. A number of local governments, perceiving net costs, have attempted (many unsuccessfully) to restrict or ban shale operations, while state governments, that tend to be supportive of shale, have preempted local governments attempts to restrict shale.

The seven following chapters (4 to 10) address case studies of various countries: UK, Poland, France, Germany, Argentina, China, South Africa. All chapters, conducted using a common analytical framework, reveal the dilemma of shale—it can bring economics and environmental benefits (e.g. cleaner air when gas is combusted instead of coal), but it can also bring economic and environmental costs, especially when policies to mitigate costs and to distribute benefits and costs are not in place. Each chapter was written by researchers that have an academic recognition and actual experiences interacting with the energy industry and policy community. A number of them have been actively participating in the national debates discussing the benefits and limits of shale gas development. Authors have served or participated on the UK Climate Change Committee, the German Advisory Council on the Environment, the French energy transition debates, the South African study on scientific readiness for shale, to name a few.

The concluding chapter draws comparative lessons on the decision-making process across countries. The United States has long pursued domestic oil and gas production as a strategy to secure energy, and shale has proceeded as an extension of the existing onshore oil and gas industry. On the contrary, shale is perceived in Europe as a new industry subject to review prior to its expansion. The case studies from France and Germany reveal how the longer-term energy strategy of these countries—while not fully resolving these countries' energy challenges—created the political space for a discourse on whether pursuing shale is the optimal option to pursue. Likewise, in the UK, its

longer-term energy strategy of diversification, despite declining North Sea production, created the political space to consider both positive and negative aspects of shale. In all three countries, strong participation of local communities and environmental groups—their concerns on local and global environmental impacts and their preferences for shifting towards non-fossil energy sources—served as a counter to the view of industry, which highlighted financial rewards from developing shale. Ultimately, in the UK, local communities did not succeed in stopping fracking, though the latest seismic incident in autumn 2018 may well serve to dampened progress.

The concluding chapter also reveals the common thread of shale exploration in China and Argentina and prospective shale exploration in South Africa—weaknesses in the regulatory regimes to internalize potential health and environmental costs. This chapter recommends practical steps on how these countries can build on ongoing reforms to improve shale governance. Internalization of the environmental costs is critical as local communities who live around shale operations are the ones bearing the costs, but these communities generally have less political voice and are less likely to benefit directly from the higher skilled, better paying jobs that tend to go to nonlocal labor.

Finally, the concluding chapter urges informed analysis in decisions regarding investments into shale exploration and infrastructure to support shale, particularly when public resources are used. Shale has brought unpredicted large successes, as seen in some US shale basins. However, shale has also dashed expectations. The cases of Poland and even the Monterrey Shale in the United States cautions that the financial feasibility of shale is speculative, regardless of the amounts of promising physical reserves, until substantial exploration takes place.

In summary, the book is rooted in a serious commitment to science and social science analysis and it applies a common framework for a rich comparative analysis. To my knowledge, it is the only contribution which, while taking seriously the benefits from shale, covers equally seriously the problematic aspects of shale gas development and explains how diverse countries have come to divergent decisions on whether and how to pursue shale. Grappling with the shale dilemma—its potential benefits but its potential costs and the uncertainties on whether and to what extent public policies would be enacted to distribute benefits and limits costs—is a message underscored from start to end in this informative volume.

Jean-Marie Chevalier
Professor, University of Paris-Dauphine

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Note to reader: We inadvertently published the wrong version of the review for the following book in the last print issue of *The Energy Journal, vol 40, issue 1, page 247*. We have corrected the online version. For the print version, we ask that you refer to the correct version printed below. I apologize to the publisher, authors, and EJ readers for our mistake. Carol Dahl, Senior Book Review Editor.

Handbook of Energy Politics edited by Jennifer Considine and Keun-Wook Paik. (Edward Elgar, 2018), 528 pages, ISBN: 9781784712297.

The editors of this volume take Mel Conant's definition of geopolitics—"geo" for location and "politics" for the decisions of governments. Starting from his prospective as a tribute and memorial is a nice touch. Mel, one of those to whom the volume is dedicated, was an icon in energy economics and geopolitics. His consulting firm for decades studied and advised many on the economic, political and security aspects of oil and gas. He was founder and editor of the monthly periodical *Geopolitics of Energy* from 1979-1995.

The forward contains two short Conant articles that are cause for thought and reflection. One published shortly after the Iranian revolution in 1979, first indicates an earlier time when the

world was flush with oil. American oil policy was largely determined by meetings between oil producers and Washington policymakers to protect the US oil industry from cheap foreign imports. With US production peaking, the Arab oil embargo, and the Iranian revolution, cries of protection from cheap oil imports became a scramble for access to foreign imports. Gone were the feelings of abundance. Conant likens U.S. energy policy at the time to a high stake "gigantic floating crap game" and notes the geopolitical struggles within the US. Oil producers wanted the high market prices for oil, coal producers wanted to protect and promote coal, the farm belt wanted gasohol, solar projects appealed to the Sunbelt, New England thought low oil prices a good thing and wouldn't mind subsidies for wood stoves either.

The other Conant article written in the mid-nineteen nineties after the fall of the Soviet Union and the first Gulf War paints a picture of oil scarcity and insecurity. It outlines key issues in oil markets at the time: US policy failure to curb oil consumption and a dependence on unstable Gulf states for oil imports, dwindling supplies of oil in Southeast Asia, increasing competition for production from the Arabian/Persian Gulf, Russia's lagging oil and gas industry, and the prescience that regional trouble spots such as Iraq or Yemen might provide future arenas of conflict to threaten oil supplies.

Although the editors argue that little has changed in US energy and environmental policy since Conant's 1979 article, I would argue that feelings of oil shortage and insecurity are dramatically muted. Producers heavily dependent on oil are unlikely to use it as a political weapon; rapid technical change has make hydrocarbons relatively abundant at a moment of weakening oil markets; U.S. natural gas has put dramatic stress on global coal markets; rapid decreases in solar and wind power costs coupled with digital technology and a Chinese push towards electric vehicles suggest a transportation path that could put more stress on oil markets sooner than I would have predicted a few years ago. Despite a relative feeling of fossil fuel abundance, climate policy and technical change may bring peak oil closer but from the demand not the supply side. Gas still looks like a good bet. I would agree that struggles over oil and gas will not cease as buyers, sellers, and policy makers continue to dance with each to their own tunes but the dance may be slower.

For more insights on how the next exciting transition might be affected by geopolitics, let's turn to the papers in this volume. The book is divided into 5 sections. The first 2 sections on global supply and demand have a good representation of the geo part of geopolitics and span the globe with articles representing policy within Canada, Russia, India, China, Latin America, sub-Saharan Africa, the United States, and the international oil market. A large portion of them relate to oil and natural gas.

Part III is entitled the main influences in geopolitics. Three of the four articles deal primarily with oil and gas markets in a global perspective, first looking back and then to the future. Two see an abundant oil future. One argues oil will still dominate in 2050, another that American oil and gas from shale will have a major impact on reducing energy vulnerabilities. The third shadows the past and sees peak oil, other resources constraints, and global population growth on an unpleasant collusion course by 2050 without major policy initiatives. The last article looks at the development of oil and other resources from a producing country point of view and argues for slower staged development to avoid the resource curse problem with economic modeling to support their arguments.

Although geopolitics has often historically been strongly associated with oil, the winds do seem to be changing. In Part IV on technology, capital and financial markets, the editors are moving towards this brave new world. Only one of the articles relates to oil, that on oil trade and pricing in Asia. Another considers global experience in financing of green projects with a third looking at smart grids to coordinate all the new electricity generation options and policies to make that happen.

Part V finishes the volume with two articles on environmental climate policy. One considers policy risk with high profile examples of policy reversals toward low carbon energy, while the second considers climate agreements and the response of the three largest carbon emitters—China, United States, and the European Union.

The following discussion contains a bit more information by individual articles for the interested reader. In Part I, relating to global supply, Anna Vypovska, Laura Johnson, Dinara Millington and Allan Fogwill consider environmental permitting of natural gas and LNG projects in British Columbia, Canada. They outline potential environmental effects in the permitting process and consider provincial and federal law especially relating to indigenous peoples. Nina Poussenkova considers Russia's moves to gain leverage by diversifying oil and gas sales away from Europe towards the Indian and Chinese markets. I found the details on how these agreements evolved especially interesting.

Liu Xiaoli and Tian Lei outline problems from China's high carbon development strategy including inefficient exploitation and waste, serious air pollution, local ecological damage from coal mining, and international pressure relating to CO_2 emissions. They outline China's new development strategy for low carbon and green development with natural gas as a bridge. Douglas Reynolds considers the role of institutions and oil supply. He makes a comparison of property rights using Texas and Alaska examples along with a discussion of risk with international and national oil companies as examples. With Alberto Cisneros Lavalle's article, we move to the other side of the fence and consider risk from the producer's point of view. In this case, price crises are plunging not spiking prices and they include oil prices crashing in the mid 1980s, after the Asian crisis in the later part of the 1990s, and again after the subprime mortgage crisis in 2008. From these earlier examples, he concluded that the more recent price crisis beginning in the latter part of 2014 was likely to see price recovery in around 2 years. He then considered how these trends might affect Mexico's replacement of declining Cantarelle production, Venezuelan heavy oil production, Brazilian deep pre-salt reserve development, and Argentinian shale gas development.

In Part II, the focus shifts to global demand. Keun-Wook Paik continues the discussion of the Russian shift east to China, for the natural gas market. He outlines some of the commercial initiatives between companies in the two countries, reports Chinese natural gas supply and demand projections along with LNG import projects, and urges more overseas loans for gas to power away from the now majority of Chinese loans for coal. Se Hyun Ahn notes that a fast growing economy and an almost total dependence on energy imports makes S. Korean energy security a critical policy consideration. He outlines their current energy consumption patterns and policy initiatives. He is critical of Korean energy pricing, which he argues is too low with relative prices that do not reflect externalities, and does not believe the policy shift to nuclear and renewables has been a success. Nor does he think Korean energy diplomacy has been effective.

Philip Andrews-Speed and Sufang Zhang provide a nice summary of the evolution of the Chinese electricity market. In the early years from 1949 to the late 1970, the central government played a major role with help from the Soviet Union until the rift. With Mao's death in 1976, Deng Xiaopeng led the country towards more liberal policies. More authority was delegated to state and local government, large state owned enterprises began to be corporatized, and energy prices were edged closer to markets. In electricity markets, the emphasis was on developing infrastructure to support economic growth, industrial development, and the reduction of poverty. Electricity generation capacity grew dramatically with air pollution a growing problem. The 1990s to the early 2000s saw more structural reforms with closer moves to market pricing and the international community. However, power shortages and increasing pollution have led to new agendas with a push towards nuclear and renewables and demand side management. They indicate some of the issues with these agenda items and argue that despite impressive progress and reforms, the Chinese power sector is still "stranded between the plan and the market."

In one of my favorite articles in the volume, Rene Roger Tissot takes us to sub-Saharan Africa (SSA). He outlines a history of failed industrialization from import substitution strategies. Given this region's endowments, natural resources could be a path to industrialization. However, this will require forward and backward linkages between the export industry and the local economy. He argues that local content policies to promote such linkages have not yet been particularly suc-

cessful and believes that promotion of small and medium size businesses is the key to better results for local content policies

In Part III relating to the main influences in geopolitics, Mamdouh Salameh's short piece looks back over a century and half of the rise of oil and believes that oil will continue to "fuel the global struggles for political and economic primacy" for some time to come. He feels that forecasting the end of oil is premature and that oil will continue to dominate through the twenty-first century. Colin J. Campbell's rambling account outlines some oil geology, puts the oil age in a human context starting with stones and flints, and high lights some features of the global oil age. Unlike Salameh, Campbell does not see a rosie 100 years of oil but rather his second half of the oil age will see half of current oil production fueling an even higher population by 2050. Riots and revolution will ensue without strong policies to curb energy consumption and population growth. His appendix on oil production projections by region is rather hard to follow.

Michael Lynch notes that new energy technologies for wind, solar, electric vehicles, shale oil and gas reserves, and advanced nuclear are likely to increase energy autonomy and security for most countries. He does not see large inroads of non-fossil technology in the next couple of decades but sees a significant shift in geopolitics with increases in U.S. oil and gas from shales. Paul Stevens and Jennifer Considine round out this part arguing that the resource curse problem for resource exporting countries can be diverted with slower staged development. They use an option theory model with a simple numerical example to argue that contrary to much popular opinion, waiting can have commercial value for companies. They also use a rank order tournament model to suggest how companies might allocate investment funds to minimize resource curse, corruption and other government failures in the producing country.

In Part IV on financial markets and technology, Hazel Henderson suggests the transition away from fossil fuels is unstoppable but argues that mainstream financial markets and utilities have lagged in financing this global change. She further argues that this is slowly changing with changes in socio-economic trends from all sides. International agreements call for sustainable development goals with calls to phase out fossil fuel subsidies and change accounting standards to take into account externalities. Cost savings have spurred some investments. Socially ethical investors have been leading the way and tracking of some of these investments can be followed at http:\\www.ethical markets.com/2017–green–transition–scoreboard/. Some funds have divested away from fossil fuels and new digitization in the financial sector such as peer to peer lending and others cited in the paper may further facilitate the transition.

Tilak Doshi chronicles the rise of non-OECD Asian global oil consumption and cites forecasts that this region is likely to have higher oil demand growth than the rest of the OECD through 2040. He outlines pricing contracts in commodity markets, discusses the pricing of Middle Eastern oil, the Asian premium, and the role of price benchmarking in the oil market. Luciano de Castro, Joisa Dutra and Vivian Figer have a very nice introduction to the economics of the smart grid. They define the smart grid, discuss benefits and drivers leading to and challenges associated with its adoption. They note that policy has not kept up with the technology but cite some interesting adaptions in case studies. Although the smart grid can facilitate distributed generation, jurisdictional challenges, cyber security and privacy remain unsolved problems.

In Part V, we continue the exploration of low carbon technology. Geoffrey Wood notes that recent investment in renewable electricity generation capacity has been striking and has exceeded that for fossil fuels. Nevertheless, uncertainty over policy and its goals has likely been some hindrance in this market. He cites three high profile policy reversals to illustrate policy risk: Spain retroactively reduced solar subsidy commitments, Denmark replaced generous feed in tariffs with renewable obligations, and President Donald Trump spouts anti-renewable and pro-fossil energy rhetoric. The author also more generally discusses some of the policy fumbling within the U.K.

Lara Lázaro-Touza provides an overview of international climate policy. She discusses six areas that are driving these initiatives. The scientific consensus seems to indicate the dangers of cli-

mate change are increasing. The economics of waiting are likely to be quite expensive while current renewable costs have been falling. Some see increasing business opportunities for providing green goods and services, while many in the business community increasingly want a predictable regulatory system. Meanwhile international climate diplomacy marches on. She includes nice tables on timelines and milestones for international conference of the parties and poll results on international concerns including climate change. She also considers climate policy in the three largest emitters: China, the U.S., and the European Union.

The book has an index. I would have also appreciated a table with the numerous abbreviations as well as a bit more information on the author's background. Most of the book should be accessible to the general reader interested in the topics covered. A number of articles could be considered as supplementary material in academic courses relating to geopolitics, energy and environmental policy. As with any edited volume, different articles will appeal to different readers. For me, the most interesting were those that detailed negotiations and relations between Russia and China, the evolution of Chinese electricity policy, natural resource development in sub-Saharan Africa, green finance, and the smart grid followed by the articles on climate policy.

Professor Emeritus Carol Dahl
Colorado School of Mines

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Energy: A Human History by Richard Rhodes. (Simon & Schuster, 2018). 464 pages, ISBN 978-1-5011-0535-7.

As an accomplished popular science writer, Richard Rhodes brings his expertise to bear and provides an accessible but detailed history of energy use since about 1600. The volume is particularly strong as a history of technological improvements and innovation that have unlocked successive new sources of heat, power, light, and work. The accessible narrative is a feature, but make no mistake, it is underlain by considerable research. The fifty (50) page bibliography is one of the greatest resources for academic readers. By comprehensively collecting the pertinent history of many sources and uses of energy, the curious researcher seeking a narrative anecdote or a presentation hook will find ample primary and authoritative source material. This non-technical volume offers valuable and well-crafted background information for energy economists seeking to frame current research questions and policy issues. While the history is perhaps more "English-speaking" than "human," since many of the technological improvements occurred in Great Britain and the United States.

The narrative starts in Elizabethan England, where concern about a shortage of wood as a strategic energy supply was allayed by the wider adoption of coal. The book opens with a vignette about the high value of lumber as a construction material, which made its use as a fuel particularly dear and encouraged the use of coal as a substitute. Wood has the advantage of being easy to collect and burn, whereas coal must be mined and transported from its source, and also requires more fuss to ignite and manage. However, coal delivers greater energy density and a higher heat rate. In addition to this efficiency, using coal also allowed English forests to be saved for strategic uses without substitutes, like providing the essential material for the Royal Navy.

Even before it built a substantial market share, the easily accessible coal in England was mined out. Water flooded pits and drifts and made it impossible to affordably dig more coal. Enter

a string of sundry characters working to develop and apply new technologies in a way to dry out coal mines. Rhodes follows the intellectual thread from Denis Papin to Thomas Savery and finally Thomas Newcomen, whose coal-hungry beast of an engine was the first functional steam power. It allowed coal mine owners to pump fast enough to stay ahead of flooding water and to mine more and deeper coal. The engine was so inefficient, however, that it had to be located at a coal mine. That limited the application of the new engine even as it allowed more coal to be mined for heating needs.

The initial engine was serviceable and better than the alternative of flooded mines, but the very limited application led clever minds to apply themselves to improve the efficiency and broaden the use of steam power. James Watt, in cahoots with his business partner Matthew Boulton, provided a more efficient and useful engine by increasing the effective pressure and efficiency. Coal demand increased with the more versatile engine that could be located anywhere. Soon George Stephenson and Richard Trevithick were working to make mobile steam engines, revolutionizing transportation by unlocking chemical energy for power. Railroads and then steamships were born and revolutionized transportation.

The second section of the book recounts the quest for light, which involved competition between fuels rather than the struggle to improve technical efficiency of a single class of technology. Archibald Cochrane provided an initial demonstration, then William Murdoch and Phillippe Lebon (separately) figured out how to extract a reliable fuel for lighting and crafted functional if cumbersome systems for artificial light.

Gas light derived from coal competed with whale oil and turpentine. Rhodes takes time to describe the industries that grew up around these liquid fuels competing with coal gas. The American Civil War interrupted both—the trade in turpentine was affected by the blockade of the Confederate states, while the American whaling fleet was all but eliminated by privateers as they pursued their dwindling prey in the far reaches of the Bering Sea.

A timely technological innovation in drilling allowed kerosene derived from petroleum and provided an opportunity for a more dense fossil fuel—petroleum—to supplant coal gas, whale oil, and turpentine. Petroleum had been known for millennia, but the exploitation of natural seeps and pits did not allow for a sufficient volume of lighting fuel to be brought to market. The portability and high quality light from kerosene justified drilling for and refining crude oil, and even discarding useless byproducts like natural gas and gasoline. While this provided a timely succor for imperiled whales, Rhodes astutely recognizes the identical economic mechanism of first possession that governed the collection of illumination fuels.

Rhodes then turns to the technology of electricity, which allows for translation, transmission, and application of a wide variety of types of energy for heat, power, light, and work. Starting with the fundamental scientific discoveries of Benjamin Franklin, Luigi Galvani, Alessandro Volta, Hans Christian Oersted, and Michael Faraday, the attention quickly follows to the technologists like William Stanley, George Westinghouse, and Thomas Edison who helped rapidly electrify the coal-fired and gas-lit late 19th century. Electricity allowed for other sources of energy to be exploited more easily. The hydroelectric generation at Niagara Falls was the first large-scale project of its kind, evolving beyond the traditional millrace and allowing the power of falling water to be applied beyond the riverbank.

All of the technological progress to this point allows for a first digression on the opportunity costs of energy transitions, first about guano and horse manure, then about the effects of smoke.

The third section addresses successive energy transitions and the future of energy. The first chapter discusses the work of Charles Kettering and the chemist Thomas Midgely in developing useful gasoline. Early automobiles used steam, internal combustion using both gasoline and alcohol, and electric power. Only when gasoline, with its higher energy density and versatility, was improved to the point that it could outcompete the alternatives, thereby securing fortunes for Ford and General Motors, among others, was the petroleum-centric path of transportation energy cemented. The eventual addition of lead to motor gasoline to improve performance is well-addressed.

Rhodes won a Pulitzer Prize for The Making of the Atom Bomb, so it is no surprise that he has a lot to say about nuclear weapons and nuclear power. But this section of the book rambles and is inferior to the earlier technological progress stories. The narrative tries to strike out in other important directions like petroleum supply and transportation, growing environmental costs, increasing renewable electric generation technologies, but it always loops back to another story about nuclear power or nuclear technology. Whether that is the choices for civilian and military nuclear, or the perils of nuclear accidents and waste, or the government control and regulation of nuclear technologies and the resulting confused incentives, the clean narrative flow of the earlier sections breaks down and leads the reader in circles. The stories are both interesting and compelling but lack direction and takeaways for the future.

Taken as a non-technical supplement that may be valuable to researchers, this book is a both useful and enjoyable reference.

Timothy Fitzgerald
Texas Tech University