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THE NEW MAP

ENERGY, CLIMATE, AND THE CLASH OF NATIONS

DANIEL YERGIN

WINNER OF THE PULITZER PRIZE

PENGUIN BOOKS

The New Map

Named 'Energy Writer of the Year' by the American Energy Society

'There are many stories in this wonderful book, all of them directed at the transformation of the global map of power and wealth that has happened in the 21st century . . . capacious and well-written . . . We are in a disordered period of rising tensions, but, then again, we usually are. Human competence races ahead, but wisdom remains as rare a commodity as it ever was' Bryan Appleyard, Sun*day Times*

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‘*The New Map* earned energy’s highest literary prize for its ambitious survey and realistic assessment of energy and how it shapes all of human affairs. It is also an exceptional literary triumph in its narrative and in the quality of writing that we have come to expect from Dan Yergin’ The American Energy Society, in awarding Daniel Yergin ‘Energy Writer of the Year’

ABOUT THE AUTHOR

Daniel Yergin is one of the most influential voices on energy, international politics and economics in the world. He is the vice chairman of IHS Markit and a recipient of the United States Energy Award for ‘lifelong achievements in energy and the promotion of international understanding’ and was named ‘Energy Writer of the Year’ by The American Energy Society in 2020. Yergin is the author of *The Quest* and received the Pulitzer Prize for *The Prize: The Epic Quest for Oil, Money and Power*, which became a number one bestseller and was made into an acclaimed eight-hour PBS/BBC series.

DANIEL YERGIN

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To Angela, Rebecca, Alex, and Jessica

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Introduction

This book is about the new global map that is being shaped by dramatic shifts in geopolitics and energy. It is also about where this map is taking us. Geopolitics focuses on the shifting balance and rising tensions among nations. Energy reflects far-reaching alterations in global supply and flows, driven in major part by the remarkable change in the energy position of the United States, and by the growing global role of renewables and the new politics of climate.

Different kinds of power are in play. One is the power of nations that is shaped by economics, military capabilities, and geography; by grand strategy and calculated ambition; by suspicion and fear; and by the contingent and the unexpected. The other is the power that comes from oil and gas and coal, from wind and solar, and from splitting atoms, and the power that comes from policies that seek to reorder the world's energy system and move toward net zero carbon in the name of climate.

This is no simple map to follow, for it is dynamic, constantly changing. It has been made even more complicated by the coronavirus that swept out of China and across the planet in 2020, bringing grief and vast human suffering and disarray. It also shut down the world economy, disrupted commerce both local and global, destroyed jobs and businesses and impoverished many, plunged the world economy into the deepest recession since the Great Depression, added enormously to public debt, accentuated the tensions among countries, and created vast turmoil in global energy markets.

This book seeks to illuminate and explain this new map. How the shale revolution has changed America's position in the world. How and why new cold wars are developing between the United States on one hand, and Russia and China on the other, and energy's role in them. How swiftly—and potentially perilously—the overall relationship between the United States and China is changing from "engagement" to "strategic rivalry" and what begins to look like an emerging cold war. How unsteady are the foundations of a Middle East that still supplies a third of the world's total petroleum and a significant amount of natural gas. How the familiar ecosystem of oil and autos, which has held for more than a century, is now being challenged by a new mobility revolution. How climate concerns are reshaping the map of energy, and how the much-discussed "energy transition" from fossil fuels to renewables may actually play out. And how has the coronavirus changed the energy markets and the future roles of the Big Three—the United States, Saudi Arabia, and Russia—which now dominate world oil.

"AMERICA'S NEW MAP" TELLS THE STORY OF THE UNANTICIpated shale revolution that is transforming America's place in the world, upending world energy markets, and resetting global geopolitics. Together, shale oil and shale gas have proven to be the biggest energy innovations so far in the twenty-first century. Wind and solar are both innovations of the 1970s and 1980s, though they came into their own only over the last decade. The United States has surged ahead of Russia and Saudi Arabia to become the world's number one producer of both oil and gas, and is now one of the world's major exporters of both.

Though targeted for bans by some politicians, the shale revolution has fueled America's economic growth, enhancing its trade position, generating investment and job creation, and lowering utility bills for millions of consumers. The supply chains supporting shale reach all across the United States, into virtually every state, creating jobs even in New York state, which prohibits shale development within its borders, owing to environmental opposition.

Starting with the energy crises of the 1970s, Americans became accustomed to thinking the country was vulnerable because of U.S. dependence on imported sources. But the geopolitical consequences for the United States, now that it is almost self-sufficient, are apparent in new dimensions of influence, increased energy security, and greater flexibility in foreign policy. Yet there are limits to this newfound self-assurance, for energy remains a globally-interconnected industry and these consequences are still only part of the overall nexus of relations among nations. Moreover, shale was already in search of its next "revolution" when coronavirus sent it spinning into a new crisis.

"RUSSIA'S MAP" IS ABOUT THE TINDER CREATED BY THE IN-teraction of energy flows, geopolitical competition, and the continuing contention over the unsettled borders that resulted from the collapse of the Soviet Union three decades ago—and from Vladimir Putin's drive to restore Russia as a Great Power. Russia may be an "energy superpower," but it is also economically dependent on oil and gas exports. Today, as in Soviet times, those exports are stoking fierce debate about the possible political leverage over Europe that may come in their wake. Yet, any potential leverage has been dissipated by changes in both the European and global gas markets.

The consequences of the abrupt transformation of the Soviet Union into fifteen independent countries remain uncertain, nowhere more so than between Russia and Ukraine, where conflict over natural gas has been central. Following the 2014 Russian annexation of Crimea, the struggle moved to the battlefield in southeastern Ukraine. In the strange way that history works, that war—and, specifically, the matter of U.S. weapons to resist Russian tanks—triggered the impeachment of Donald Trump by the House of Representatives, followed by his acquittal by the Senate.

U.S.-Russian relations have sunk to a level of hostility not seen since Soviet days in the early 1980s. At the same time, Russia has "returned" to the Middle East and is "pivoting to the east," to China. Moscow and Beijing are united in asserting "absolute sovereignty" and their opposition to what they decry as American "hegemony." There are also practical considerations to their burgeoning relationship: China needs energy, and Russia needs markets.

"CHINA'S MAP" IS ROOTED BOTH IN WHAT IT CALLS THE "CENtury of Humiliation" and in its tremendous gains in global economic and military power over the last two decades, and by the energy needs of what will become the world's largest economy (and, by some measure, already is). China is expanding its reach in all dimensions: geographically, militarily, economically, technologically, and politically. The "workshop of the world," it now seeks to move up the value chain and become the global leader in the new industries of this century. China is also asserting its own map for almost the entirety of the South China Sea, the most critical oceanic trade route in the world, and now the sharpest point of strategic confrontation with the United States. Energy is an important part of that claim.

China's Belt and Road Initiative is designed to redraw the economic map of Asia and Eurasia and beyond, putting what was once the "Middle Kingdom" in the middle of a reordered global economy. The initiative seeks to assure that China will have markets for its goods and access to the energy and raw materials that it needs. But to what degree is the Belt and Road mainly an economic project, or, as critics assert, a geopolitical project aimed at creating a new Chinese order in world politics?

The "WTO consensus" that goes back to the beginning of this century has broken down. Criticism of China is one thing that unites divided Democrats and Republicans in the United States, and the national security establishments in both countries increasingly focus on the other as the future adversary. Yet the two countries are more integrated economically and more interdependent than many recognize, as the 2020 coronavirus outbreak unhappily demonstrated; and they are mutually dependent on global prosperity. But that reality counts for less as calls grow louder for "decoupling" between the world's two largest economies, accompanied by growing mistrust, which has been amplified by the coronavirus crisis, one of the lasting consequences of which will be greater tension between the two countries.

THE MIDDLE EAST'S GEOGRAPHIC BOUNDARIES WERE CONtinually redrawn throughout antiquity, with the rise and fall of so many empires. Though the Ottoman Turkish Empire ruled for six centuries, its borders were often shifting. The map of the modern Middle East was laid down during and after the First World War, in the vacuum resulting from the collapse of the Ottomans and yet based on the provincial lines left behind by the Ottomans. The maps have been challenged ever since—by pan-Arab nationalism and political Islam, by opposition to the state of Israel, and then by jihadists such as ISIS, who want to replace the very idea of a "nation-state" with a caliphate. One of the biggest challenges in the region today comes from the rivalry between Sunni Saudi Arabia and Shia Iran for preeminence, now made more complex by Turkey's new bid for that role, reclaiming a lineage going back to the

Ottomans. But also defining for the region are the four-decade confrontation between the United States and Iran and the prevalence of weak governance in many countries.

The Middle East has been shaped, of course, not only by the maps of frontiers but by different kinds of maps—of geology, of oil and gas wells, of pipelines and tanker routes. The oil and gas, and the revenues and riches and power that flow from them, remain central to the identity of the region. Yet the oil price collapse that began in 2014 has fed into a new debate about the future of oil. Not much more than a decade ago, the world worried about "peak oil," the idea that oil supplies would run out. The focus has shifted to "peak demand": how long consumption of oil will continue to grow and when it will begin to decline. Will oil lose its value and importance in the decades to come? The demand collapse for oil in 2020 has further fueled the urgency for oil exporters to diversify and modernize their economies, which Abu Dhabi had begun in 2007 with its Vision 2030, and which Saudi Arabia is now trying to do in double time.

If there is one major factor leading to the idea that demand, not supply, is the future constraint, it is related to the junction of climate policies and technology. The one market that seemed to be guaranteed for oil for a very long time was transportation and, specifically, the automobile. No longer, not on the "Roadmap" to the future. For oil now faces a sudden challenge from the New Triad: the electric car, which uses no oil; "mobility as a service," ride-hailing and ride-sharing; and cars that drive themselves. The result could be a contest for dominance in a new trillion-dollar industry: "Auto-Tech."

THE DEBATE OVER HOW RAPIDLY THE WORLD CAN AND MUST adjust to a changing climate, and how much it will cost, is unlikely to be resolved in this decade. But the endeavor will take on greater urgency as public opinion becomes more aroused and new policies seek to implement "net zero carbon." All this takes us to the "Energy Transition": the shift from the world of today, which depends on oil, natural gas, and coal for more than 80 percent of its energy—just as it did thirty years ago—to a world that increasingly operates on renewables. The Paris Agreement of 2015 galvanized the march toward a lower carbon future. Indeed, in terms of energy and climate, there are two distinct eras: "Before Paris" and "After Paris." Yet, while energy transition has become a pervasive theme all around the world, disagreement rages, both within countries and among them, on the nature of the transition: how it unfolds, how long it takes, and who pays. "Energy transition" certainly means something very different to a developing country such as India, where hundreds of millions of impoverished people do not have access to commercial energy, than to Germany or the Netherlands.

Solar and wind have become the chosen vehicles for "decarbonizing" electricity. Once "alternatives," they are now mainstream. Yet, as their share of generation grows larger, they confront the challenge of "intermittency." They can flood the grid with electricity when the sun shines and the wind blows, but then almost disappear when the day is cloudy or there is only a murmuring breeze. This points to major technological challenges: to maintain grid stability and find ways to store electricity at large scale for periods longer than a few hours.

"Climate" will be a profound determinant of the new map of energy. Here I build on the story I began in *The Quest*. In that book, I explored how "climate" went from being a subject of interest to a handful of scientists in mid-nineteenth century Europe, who feared the advent of another Ice Age that would obliterate civilization, to the consensus about warming that would bring 195 countries together in Paris in 2015 to forge a climate compact that has become the global benchmark. The focus in the pages of this book is on how the momentum of climate policies—powered by research and observation, by climate models, and by political mobilization and regulatory power, social activism, financial institutions, and deepening anxiety—will transform the energy system. "Net zero carbon" will be one of the great challenges of the decades ahead, not just politically but also in how people live their lives and in the costs of achieving it.

My first book, *Shattered Peace*, is about the origins of the Soviet-American Cold War. Now in these pages, readers will find the origins of new cold wars. *The Prize* is a sprawling canvas about geopolitics and oil over almost a century and a half, and that certainly is part of the narrative of *The New Map*. *The Commanding Heights*, which I coauthored, was about the world after the Cold War and the new age of globalization. Now the fragmenting of globalization becomes part of this story.

For the coronavirus has fueled a retreat that had already begun from globalization and from the international institutions and cooperation that have underpinned it. In 2008–2009, international collaboration was key to conquering the financial contagion. A dozen years later, such cooperation at the governmental and international level in fighting the contagion of the virus was notable by its absence. What had been talk of "decoupling" had turned into a rolling back of the supply chains that have been a foundation of a $90 trillion global economy. More broadly, borders go up, nationalism and protectionism rise, and the generally free movement of people becomes less free. One consequence of the global economic misery from the pandemic of 2020 could be greater prevalence of fragile and failed states, which would create new security challenges that, at some point, would reach beyond their borders. Yet governments would be hampered in responding to domestic and international needs, whether around security or health or energy and climate, by the huge debt and fiscal armor they have assumed in battling to preserve their economies.

But the journey on the road to the future had commenced well before the coronavirus crisis, not only with renewables and electric vehicles, but also with the shale revolution that has transformed the energy position of the United States, shaken global markets, and changed America's role in the world.

And it is on that road where we now begin.

AMERICA'S NEW MAP

Chapter 1

THE GAS MAN

If you want to get to the beginning of the shale revolution, pick up Interstate 35E out of Dallas and head north forty miles and then take the turnoff for the tiny town of Ponder. Pass the feed store, the white water tower, the sign for the Cowboy Church, and the donut store that's closed down. Another four miles and you're in Dish, Texas, population about 400. You end up at a wire mesh fence around a small tangle of pipes with a built-in stepladder. You're there—the SH Griffin #4 natural gas well. The sign on the fence tells the date—DRILLED IN 1998.

That was not exactly a great time to be drilling a well. Oil and gas prices had cratered with the Asian financial crisis and the ensuing global economic panic. But SH Griffin #4 would change things more than anyone could have imagined at the time.

The well was drilled mainly with standard technology, but also with experimentation and ingenuity, despite considerable skepticism. The small band of believers working on the well were convinced that somehow you could extract natural gas from dense shale rock in a way that was commercially viable—something that the petroleum engineering textbooks said was impossible. More than anyone else, the unshakable conviction belonged to one man, their boss—George P. Mitchell. He had been a true believer for a long time.

To grasp the intensity of that conviction, you have to understand that the road to SH Griffin #4 really begins much longer ago, in a tiny village in Greece's Peloponnesian peninsula.

In 1901, an illiterate twenty-year-old shepherd named Savvas Paraskevopoulos decided that his only ticket out of a life of poverty was to emigrate to the United States. By the time he ended up in Galveston, Texas, he had been rechristened Mike Mitchell. He eventually opened a laundry and shoeshine shop that just barely supported his family. His son George enrolled at Texas A&M University, where he studied geology and the relatively new discipline of petroleum engineering. George was poor, and this was the time of the Great Depression. To pay his way through school, he sold candy and embossed stationery to the other students, waited on their tables, and did tailoring on their clothes. He also captained the tennis team and came top in his class.

After World War II, Mitchell did not want to work for anyone else. With a couple of partners, he opened an office as a consulting geologist atop a Houston drugstore. By the 1970s, he had built a sizable oil and gas company, though with ups and downs along the way. But he had an unusual proclivity. He favored natural gas over oil.

Around 1972, he came across *The Limits to Growth*, a book by an environmental group, the Club of Rome. It predicted that a soon-to-be overpopulated world would run out of natural resources. Intrigued, he became increasingly interested in environmental issues. Natural gas became for him not only a business but also a cause, for it was cleaner than burning coal. Sometimes he would call up people and berate them if he thought that they had said something nice about coal.

Fueled by his new environmental ethos, he launched a totally different business—creating a wooded, landscaped, forty-four-square-mile master-planned community north of Houston called The Woodlands. Its slogan was "the livable forest." (Today it has a population over one hundred thousand.) Mitchell involved himself in the decision making down to the details of the flower beds and trees and populating it with wild turkeys (until one got shot).[1]

Yet he could hardly ignore his energy business. He had a big problem. Mitchell Energy was contracted to provide 10 percent of Chicago's natural gas. But the reserves of gas in the ground to support that contract were running down. Mitchell Energy needed to do something. That is when Mitchell stumbled across a possible solution.

In 1981, he read the draft of a journal article by one of his geologists. The article offered a hypothesis that ran counter to what was taught in geology and petroleum engineering classes. It suggested that commercial gas could be extracted deep underground from very dense rock—denser than concrete. This was the source rock, the "kitchen" in which organic material was "cooked" for several million years and transformed into oil or gas. According to the textbooks, the oil and gas then migrated into reservoirs, from which it could be extracted.

It was thought at the time that oil and gas might still remain in the shale but could not be produced on a commercial basis because they could not flow through the dense rock. The draft article disagreed. Mitchell, beset by worries about the contract for Chicago, became convinced that here might be the road to his company's salvation. There had to be a way to prove the received wisdom wrong.

The test area would be the Barnett Shale, named for a farmer who had come out to the area by wagon train in the mid-nineteenth century—five thousand square miles in extent, a mile or more underground, sprawling out beneath the Dallas/Fort Worth Airport and under the ranches and small towns of North Texas. Year after year, the Mitchell team toiled away to break the shale code. Their goal was to open up tiny pathways in the dense shale so gas could flow through the rock and into the well. To do that, they applied hydraulic fracturing, later much better known as "fracking," which uses cocktails of water, sand, gel, and some chemicals injected under high pressure into rocks that would break open tiny pores and liberate the gas. Hydraulic fracturing is a technology that had been developed in the late 1940s and has been commonly used in conventional oil and gas drilling ever since.

But here the fracking was being applied not to a conventional reservoir but to the shale itself. Yet time was passing, and much money was being spent, with no commercial results. Criticism mounted inside the company. But when people dared to suggest to Mitchell that his idea would not work, that it was only a "science experiment," he would say, "This is what we're going to do." And since he controlled the company, Mitchell Energy went on fracking in the Barnett, but still with no good result.

By the mid-1990s, the company's financial position was precarious. Natural gas prices were low. Mitchell Energy cut its spending and slashed its workforce. The company sold The Woodlands for $543 million. When the announcement was passed to him for review, Mitchell jotted, "OK but sad." He later said, "I hated to sell it." But he had no choice. The company needed the money. But Mitchell would not bend on shale. One thing that characterized him, as his granddaughter once said, was "stubbornness." If he had doubts, he kept them to himself.[2]

BY 1998, THE COMPANY HAD SPENT A LOT OF MONEY ON THE Barnett—as much as a quarter billion dollars. When analysts did forecasts of America's future natural gas supplies, the Barnett did not even make the list. "All sorts of experienced, educated folks wanted to bail out of the Barnett," said Dan Steward, one of the believers at Mitchell. "They said we were throwing money away."[3]

Nick Steinsberger, a thirty-four-year-old Mitchell manager in the Barnett, was not among the skeptics. He was convinced that there had to be a technical solution to commercially produce from shale. Moreover, natural gas prices were low, and he was also trying to bring down the costs of drilling a well. To do that, he had to attack one of the biggest costs—that of guar.

Guar, mostly imported from India, is derived from the guar bean. It is used extensively in the food industry to assure consistency in cakes, pies, ice cream, breakfast cereals, and yogurt. But it has another major use—in fracking, in a Jell-O-like slosh that carries sand into the fractures to expand them. But guar and the related additives were expensive. At a baseball game in Dallas, Steinsberger ran into some other geologists who had successfully replaced much of the guar with water, but in another part of Texas and not in shale. In 1997, he experimented with their water recipe on a couple of shale wells, without success.

Steinsberger got approval for one final try. This was the SH Griffin #4 in Dish. The team was still using water to replace most of the guar, but this time they fed in the sand more slowly. By the spring of 1998, they had the answer. "The well," said Steinsberger, "was vastly superior to any other well that Mitchell had ever drilled." The code for shale had been broken.

The new technique needed a name. They didn't want to just call it "water fracking." That would have been too prosaic, even boring. So they called it "slick water fracturing."

The company quickly adapted the technique to its new wells in the Barnett. Production surged. Yet if it was going to develop shale on a large scale, Mitchell Energy needed a lot more capital, which it simply did not have. Reluctantly, George Mitchell started a process to sell the company. Personally, it was a difficult time for him. Although he could take great satisfaction that his intuition—and conviction—had been proved right after seventeen years, he was being treated for prostate cancer and his wife was slipping into Alzheimer's. There were no buyers. The sales process was called off, and the company went back to work.

OVER THE NEXT TWO YEARS, MITCHELL ENERGY'S GAS OUTput more than doubled. This caught the attention of Larry Nichols, CEO of Devon Energy, one of the companies that had passed on Mitchell Energy during the earlier sales process. Nichols challenged his own engineers: "Why was this happening? If fracking was not working, why was Mitchell's output up?" Devon's engineers realized that Mitchell Energy had indeed cracked the code. Nichols was not going to let the company get away a second time. In 2002, Devon bought Mitchell for $3.5 billion. "At that time," said Nichols, "absolutely no one believed that shale drilling worked—other than Mitchell and us."

But shale drilling needed another technology to be economic. This was horizontal drilling. It allowed operators to drill down vertically (today, as much as two miles) to what is called the "kick-off point," where the drill bit turns and moves horizontally through the shale. This exposes far more of the rock to the drill bit, thus leading to much greater recovery of gas (or oil). While there was experience with horizontal drilling, the technology did not become more prevalent until the late 1980s and early 1990s. This was the result of advances in measurement and sensing, directional drilling, seismic analysis, and in special motors that would do a remarkable thing—a mile or two underground, they would propel the drill bit forward once it had made its ninety-degree turn and started moving horizontally. And it required one other thing—extensive "trial and error." Devon was now positioned to try to meld horizontal drilling with fracking.[4]

IN THE HOT SUMMER OF 2003, A LARGE GROUP OF GOVERNment officials, engineers, experts, and executives from the natural gas industry were convening, 750 miles to the north, in a cavernous conference room at the Denver airport Marriott. The objective was to review the results of a major study on the future of U.S. natural gas. The conclusions were deeply pessimistic. After languishing for years, natural gas prices had suddenly moved up sharply. Demand was rising, especially in electric power. Yet despite a doubling in the number of active drilling rigs, the report said, the "sobering" fact was that "sustained high natural gas prices" were not bringing the expected increased supplies of natural gas. In short, the United States was running out of natural gas.

New technologies and "non-conventional" or "unconventional" gas, the study chairman told the group, would hardly have any impact. Shale gas did not even get a fleeting mention on the list.

A professor from the University of Texas shot up to object. He noted that this estimate for "non-conventional" was only about a third of another projection. "That's a hell of a big difference," he caustically commented. The chairman disagreed. The dissenting projection of larger potential supply, he said, was flat wrong.

"Somebody is dead wrong here, aren't they?" retorted the professor.

Almost everybody in the room was convinced that it was the professor who was dead wrong and that the United States faced a permanent shortage of domestic natural gas. The main way to make up for the shortfall was to look overseas—to import liquefied natural gas (LNG). The United States would have to do something new in its history: increasingly depend on large imports of LNG from the Caribbean, West Africa, the Middle East, or Asia. The country, it was thought, was destined to become the world's largest importer of LNG, ever more dependent on global markets for its gas, as it already was for its oil.[5]

Yet that July 2003, while the natural gas study was being deliberated in the air-conditioned ballroom in Denver, Devon's crews were working away in almost-hundred-degree temperatures down in Texas, methodically drilling what eventually totaled fifty-five wells.

Larry Nichols, the Devon CEO, missed the Denver meeting because he was focused on Devon's drilling program. "As we drilled each well and as we saw the continuing production of the wells, we realized a little more each day that this was indeed a game changer," Nichols recalled. "There never was a single Eureka moment. There were lots of small Eureka moments as we gradually improved our technology."

By the end of that drilling program, they had the proof. Devon's engineers had successfully yoked together the two technologies—slick water fracturing with horizontal drilling—to liberate natural gas imprisoned in the shale. "The rest was history," Nichols would later say.[6]

IT WAS AS THOUGH A STARTING GUN HAD GONE OFF. NEWS OF the breakthrough set off a frenetic race among other companies to get their piece of that dense rock before anyone else.

These were not the very large companies whose logos are familiar at gas stations across the country. Those "majors" were still divesting from their on-land U.S. production because they thought it was a dead end. Instead, they were putting their money into the Gulf of Mexico's deep waters and into multibillion-dollar "megaprojects" around the world. As they saw it, the U.S. onshore was too picked over, too obviously in decline, to provide new resources of the scale they needed.

The onshore was left to the independents—companies focused on exploration and production, unburdened with gas stations or refineries, more entrepreneurial, faster-moving, and with the lower cost structures required to make money in the increasingly depleted onshore. "Independents" itself was a pretty broad term, ranging from companies with multibillion-dollar valuations down to small scrappy explorationists.

The race was to lease as much promising acreage as possible from ranchers and farmers and then begin the process of proving up the resource. All shales, it was soon learned, were not the same; some were more productive than others. One wanted to find the "sweet spots," the potentially most productive acreage, before anyone else. The advance men of this particular revolution were the thousands of "land men" who knocked on screen doors and left notes in rural mailboxes and got landowners to trade their heretofore worthless mineral rights in exchange for the possibility of future royalties—and maybe riches.

The independents carried the race to other shales in Louisiana and Arkansas, in Oklahoma, and then to what would prove to be the greatest shale gas play of all, the mighty Marcellus, a thick bedrock a mile or more underground that stretches beneath western New York down into Pennsylvania and Ohio and on into West Virginia. It also reaches into Canada. The Marcellus shale would turn out to be the second-largest gas province in the world—and possibly the largest. And another shale formation called the Utica lay below parts of the Marcellus. What particularly drove the independents to move as fast as possible was that great motivator known as price. "After decades of being cheap and plentiful," the *Wall Street Journal* reported, "U.S. natural gas is the most expensive in the industrialized world." High prices motivated a lot of experimentation, investment, and risk taking that would not have been undertaken at lower prices. It involved mastering a production profile that differed from that of conventional gas (and then oil). Initial output from a new well was high, but then declined much more rapidly than in a conventional well before leveling off. This created the need to continue drilling new wells in what came to be described as a manufacturing process.[7]

The year 2008 was the moment when the bell rang. That year, U.S. natural gas output went up instead of down, as had been the general expectation. That abruptly caught the attention of the majors, the big international companies. Some of the majors began to shift some of their investment back to the onshore United States. In some cases, they bought independents. And a number of international companies—from China, India, France, Italy, Norway, Australia, Korea—paid up to become partners of U.S. independents and provide them with the cash they needed to continue their frenetic advance.

With this new perspective, estimates of the U.S. gas resource base rose dramatically. By 2011, the Potential Gas Committee, which analyzes physical resources for the United States, projected recoverable gas resources 70 percent higher than it had a decade earlier. That year, President Barack Obama declared, "Recent innovations have given us the opportunity to tap larger reserves—perhaps a century's worth—in the shale under our feet."

The numbers have continued to go up. By 2019, the Potential Gas Committee's estimate for recoverable natural gas reserves was triple what it had been in 2002. Gas production was rising so fast that it became known as the "shale gale." As gas moved from shortage into oversupply, the inevitable happened: prices plummeted. The combination of abundant supply and low price changed the overall U.S. energy mix, with gas's share of total U.S. energy rising.[8]

The most decisive change was in the electric power sector. King Coal had long been the dominant source for electric power, a position that had been bolstered by government policies in the 1970s and 1980s, which promoted coal as a secure domestic source of energy and restricted the use of natural gas for electric generation (because at that time, too, the country was thought to be running out of gas). In the 1990s, before shale, gas never accounted for more than 17 percent of generation. But, with the arrival of shale, gas was highly competitive on price, and environmental opposition had made it virtually impossible to build a new coal-fired plant in the United States. As late as 2007, coal generated half of U.S. electricity. By 2019, it was down to 24 percent, and natural gas had risen to 38 percent. That was the main reason why U.S. carbon dioxide (CO_2) emissions dropped down to the levels of the early 1990s, despite a doubling in the U.S. economy.

Any thought of expensive LNG imports had been banished. The challenge was no longer how to eke out scarce new supplies, but rather how to find markets for the growing abundance of inexpensive natural gas. There was just so much of it.

Chapter 2

THE "DISCOVERY" OF SHALE OIL

One morning in 2007, Mark Papa was getting ready for a board meeting in Houston. He was CEO of EOG, one of the leading independents in the Barnett Shale. Looking at the slides of how much gas EOG alone had found in the Barnett, his mind wandered down a troubling path. The magnitude was changing, Papa thought to himself. As a company, EOG used to think in terms of "bcf"—billions of cubic feet—for its natural gas reserves. Now, with all its shale gas in the Barnett, it was talking about units a thousand times larger—"tcf"—trillions of cubic feet. And "tcf," until the Barnett, was usually reserved for something like measuring the total gas reserves of the United States, not those of a single company!

Other companies were finding similar amounts. Papa added up the numbers in his head. The result was alarming. "This is going to affect the natural gas market," he realized.

Papa had the slightly surprised look of a chemistry professor who had just realized he was late to teach his class. He had grown up outside Pittsburgh, and then, after coming across a brochure from an oil company, decided to study petroleum engineering at the University of Pittsburgh. "This will sound unscientific," he once said, "but most of the areas where petroleum is found are relatively warm. I like warm."

Over the course of his career, Papa had learned to keep an eye on the "macro"—the big picture. He had once worked for an oil economist who closely followed OPEC and the fluctuations in the oil market. "I learned that you'd better pay attention to supply and demand," said Papa. "I love the supply-demand mechanics, the ebb and flow."

Now, putting aside the slides he was reviewing, Papa visualized what the supply-demand mechanics were saying. "It was just absolutely obvious," he said. "Gas is a commodity, and the gas price was going to fall like a rock. And we would be heavily impacted."[1]

EOG had only three options. It could go international, but then it would be competing against the likes of Exxon and Shell and BP, and that would be very tough since EOG did not have the scale, resources, or experience. Or it could venture out into the deep water of the Gulf of Mexico. But it had no expertise there.

Or it could go where it did have some expertise—in shale—and see if it could extract oil from the dense rock as it did natural gas. But that would push Papa into a position similar to that faced by George Mitchell—climbing up a high wall of skepticism. "Industry dogma," in EOG's words, flatly asserted that shale rock was too dense, even with fracturing, for oil to flow. According to that dogma, oil molecules were much larger than gas molecules, and thus would not be able to fit through the tiny pores that fracking would create in the rock.

That was not the only reason for skepticism. There was also the almost universal conviction that America's day as a petroleum producer was fast ebbing away. By 2007, U.S. oil production would be down to 5.1 million barrels per day, little more than half of what it had been at the beginning of the 1970s. Meanwhile, net oil imports had risen to almost 60 percent of consumption. Politicians may have promised "energy independence." But the real question seemed to be at what rate imports would continue to rise.

EOG needed to answer the specific question: Were oil molecules too big to flow through shale that had been fracked? They were clearly bigger than natural gas molecules. But how much bigger?

"Let's look it up," Papa announced. Surely, there had to be some research papers. Yet, strangely, the EOG team could find no research that quantified the size of an oil molecule.

They would have to do the research themselves. How large was a natural gas molecule, how large was an oil molecule, and how big before and after fracking would be the pore spaces—the tiny spaces or holes, invisible to the naked eye, in the rock? After investigating the matter with electron microscopes and a CT scan and thin slices of cores, they had the answer—an oil molecule was anywhere from slightly bigger than a gas molecule to seven times bigger. But, crucially, oil molecules of even that size could slide through the "throat" of the pore.

Papa called together his senior managers. "These guys were all geared up for finding gas," he said. "We had been successful beyond our wildest dreams." So it was a shock when Papa said that the price of gas was going to collapse and could be low for many years. He told the stunned managers that the company was going to stop looking for shale gas. Instead they should start searching for shale oil.

The room was silent. Papa braced for the pushback. There could have been a rebellion. They could have said, "Mark, you're out of your mind." But instead, they said, "Okay, Mark, we'll do that."

Yet Papa was in no hurry to advertise the change publicly. Not long afterward, he went to an investors' conference in New York City and listened as the other CEOs all talked about how much gas they had discovered—and how much more they would find. Papa thought to himself, "Those guys are ignoring Economics 101." For his part, he was deliberately vague in public about EOG's new thinking.

But inside EOG, it was different. "We went 180 degrees in the other direction, looking for oil," said Papa.

EOG ended up focused on the Eagle Ford Shale, which underlies South Texas. The Eagle Ford was regarded as the source rock—the "kitchen"—for other Texas oil fields, but it was considered to have little commercial potential of its own. Yet in their research, the EOG geologists came across seismic logs from very low-production wells called "strippers" that had been drilled decades ago. As they examined the logs, they became more and more excited. The production profiles of those old wells matched up with how shale wells performed—high initial production, then declining to steady production at a much lower level. The play, said Papa, "was begging for horizontal drilling." The geologists and petroleum engineers at EOG suddenly visualized something that could not have previously been imagined—120 miles of pure oil.

Papa sent out orders to lease as much land as possible, but also as quietly as possible. By the time they were done, EOG's land men had acquired half a million acres at $400 an acre. EOG thought it had acquired almost a billion barrels of oil. But as it began to drill, it found that it had greatly underestimated the reserves. Papa broke the news at an investment conference in 2010. "We believe horizontal oil from unconventional rock will be a North American industry game changer," he said. Once it became apparent what EOG had done, other companies rushed into the Eagle Ford. The land price shot up from EOG's $400 an acre to $53,000. By 2014, EOG had become the largest onshore crude oil producer in the United States.

Within a couple of years, it would become clear that Papa had understated shale oil. It was not only a North American game changer. It would be a global game changer.[2]

THEN THERE WAS NORTH DAKOTA. AFTER DECADES OF DRY holes across the state, oil had first been discovered in 1951 in the

Williston Basin by a company called Amerada, which later became part of Hess Corporation.

The resulting boom led to a *Time* magazine cover story that described the state as an “El Dorado” for future oil production. A monument dedicated in 1953 at the site of the Amerada discovery said it “opened a new era for North Dakota.” But it turned out that there was no El Dorado and no new era. Despite a lot of drilling, not much oil was found, and the boom petered out. Nevertheless, Amerada (and later Hess) stayed in the state, adding to its acreage. “We kept finding other geologic horizons, and that kept us at the table,” said John Hess, CEO of Hess. “We thought that changes in technology would enable us to get more oil out. We held on because we continued to believe in it. There’s an old theory in the oil business—if you have an oil province where you have multiple shots, that’s something you want to keep.”[3]

A few others also suspected that significant oil could be found in North Dakota. That included an Oklahoman named Harold Hamm. He was an oil man to his core. “The oil business grabbed my mind and my young imagination,” he said. “I wanted to find oil.”

Hamm had grown up dirt poor, one of thirteen children of an Oklahoma sharecropper. As a child, he would help his family pull cotton bolls. Because the harvesting season extended beyond the opening of the school year, he would often be months late joining his grade and would have to work hard to catch up. Instead of going to college, he went to work around oil fields. In the beginning, his main skills were his work ethic, his intelligence, and a fierce drive to succeed. He was, as he described himself years later, “a hungry young man.”

One of his jobs was hauling diesel and lubricating oil to drilling sites, which is how he met oil men. He talked to them about the business, and was tutored by them on how to read maps and logs and how to drill and complete wells. At age twenty-five, in 1971, he scraped together the money to acquire rights to an oil field that a company was selling off. He had a different view of its prospects. "I had been in the business for five years," he said, "and I had a very strong conviction." He hit oil. He was launched. He also recognized that he had to catch up. He spent his evenings poring over books on geology and geophysics and took courses when he could at a local college. "I didn't go for the degree, but for the education," he said. He sold his first company in 1982. He started a drilling company. He also had his failures, including drilling seventeen dry holes in a row. But he persevered and built up a company that he named Continental Resources.

In the mid-1980s, he started looking for oil in the Williston Basin that straddles Montana and North Dakota. Continental discovered two fields on the Montana side using horizontal drilling. In 2003, Continental started acquiring acreage on the North Dakota side of the basin.

The shale revolution in natural gas was just getting going. Could this technology be applied in North Dakota? At a depth of two miles, sandwiched between a number of other strata, was a formation called the Bakken, named for a local farmer, and just below it the Three Forks. Though technically categorized as "tight sands," these are similar to shale and are usually called shale. Until the shale revolution, they were skipped over—no value. "People thought you could never produce from the Bakken," said John Hess. But what was happening in the Barnett in Texas suggested otherwise.

The answer in terms of technology was horizontal drilling in the form of "stages." Rather than trying to frack the length of the entire horizontal well all at once, the drillers would do so in stages, learning and experimenting and adjusting to the specific rock as they went. Doing this in stages two miles underground along a two-mile horizontal track took more time and cost more. But it *could* work. And by 2009, it *was* working.

The Bakken took off. In 2004, North Dakota had produced a grand total of 85,000 barrels per day. By 2011, it had more than quadrupled to 419,000 barrels. North Dakota overtook California as the third largest oil-producing state in the country, and then Alaska as the second largest, behind only Texas. By 2014, North Dakota was producing 1.1 million barrels per day—a fourteen-fold increase from a decade earlier. It turned out that *Time* magazine was absolutely right in predicting an "El Dorado" in North Dakota; it had just been sixty years too early.[4]

The oil boom in North Dakota gave a great boost to the state's economy and to state government revenues. Economic growth surged and so did incomes. Farmers operating on the margin but who owned mineral rights had an infusion of money. During the post-2008 years of high unemployment in the United States, North Dakota had the lowest rate, and the out-of-work migrated into the state.

But the rapidity and scale of the boom created its own problems—a shortage of housing, and overcrowded roads, schools, hospitals, and even courts. Also, North Dakota was not sufficiently connected to pipelines, and that meant large volumes of oil had to move by rail in trains with as many as one hundred cars. The amount of oil transported by rail in the United States went from 50,000 barrels per day in 2010 to more than 1 million in 2014. That business was much welcomed by railroads, whose coal-hauling business was in decline.

One of the most unusual challenges in the Bakken turned out to be birds. The U.S. Department of Justice, acting on a complaint from the U.S. Fish and Wildlife Service, brought a criminal indictment against Continental and two other oil companies for the death of twenty-eight migratory birds. In Continental's case, the entire death toll totaled one bird, of a species known as Say's phoebe, which the Cornell University Lab of Ornithology describes as "common around people, often nesting on buildings." By comparison, according to the Fish and Wildlife Service, half a million birds a year are killed by wind farms, sixty million birds a year by cars, and one hundred million by flying into windows. A federal judge finally threw out the case in 2012, saying a conviction would criminalize many everyday activities, including trimming and cutting trees, harvesting crops, driving a car, and owning a cat (estimated to be responsible for up to 3.7 billion bird deaths a year in the United States).[5]

AFTER THE BAKKEN AND THE EAGLE FORD CAME THE PERMIAN—the biggest of all. The Permian Basin sprawls across seventy-five thousand square miles in West Texas down into southeastern New Mexico. Much of it is characterized as a "featureless high plain." It draws its name from rocks that are characteristic of the Permian geologic age, which ended with the "great extinction" that wiped out most living creatures about 250 million years ago. The name itself was derived from the Russian city of Perm, where in the nineteenth century a British geologist had identified rocks of that geologic era.

At the beginning of the twentieth century, the parched Permian region was dismissed as a "petroleum graveyard." In 1920, the Permian was said to have "little to recommend it . . . as a potential oil province."

The first successful well came in 1923 on lands the state had endowed to the University of Texas—the "Santa Rita 1," named for the "Patron Saint of the Impossible." But subsequent wells were disappointing.[6]

Then, in October 1926, on a lease that had almost expired, a discovery opened up the Permian as a great oil province. The Permian would also become one of America's most important assets during World War II, as its production literally doubled to meet the wartime need for fuel. After the war, the Permian boomed yet again. The region and its oil business became a magnet for young men seeking their chance, among them a Navy veteran and Yale university graduate, George H. W. Bush, who moved there with his wife, Barbara, and baby, George.

Every day, the independents were rolling the dice. "If I hit," Bush said at the time, there was money to be made. "If I didn't hit, it's my hard luck." In 1974, the basin—really a collection of several different giant oil fields—reached its peak, providing almost a quarter of total U.S. oil supplies.[7]

But thereafter output in the Permian began a precipitous decline, hitting a low point in 2007. The patron saint of the impossible was no longer there to help out, and many were the last rites said over the region. "The role of the Permian Basin as a major oil producing province thus appears to be past," wrote one geologist in 2006, and its future "can thus be only one of continuing decline."

Yet by then, rising oil prices were starting to stimulate renewed activity in the Permian. The number of drilling rigs increased, and by 2011 it was getting harder to find a free table at the Wall Street Bar and Grill, a favorite eatery for oil people in Midland. But the new drilling was still the traditional vertical wells.

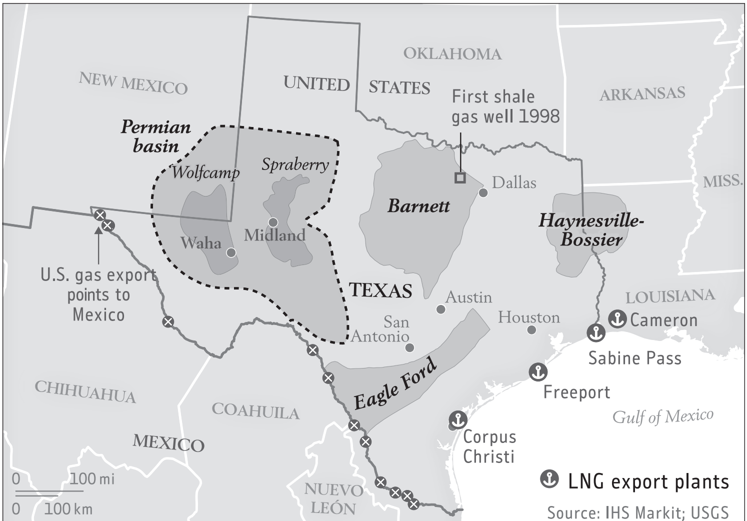
January 2011 marked the beginning of the "Arab Spring," which brought tumult to the Middle East and North Africa—and much uncertainty about that region's future. That same month, the title of a new report announced that the U.S. petroleum industry was changing—"The Shale Gale Goes Oily." The main case study was the Bakken. But it also called attention to a potential mega-shift—that "operators are taking a second look in their own backyard" in order to ascertain whether the new technologies could be applied in "existing fields" that were considered past their prime. The biggest backyard was the Permian Basin.[8]

In November 2011, the board members of Pioneer, a large independent, gathered in their conference room in Dallas to hear a three-hour presentation by the company's geologists. Pioneer's fortunes had mirrored the industry's. It had ventured into the deep waters of the Gulf of Mexico and internationally, developing projects in countries ranging from Argentina to Equatorial Guinea. In 2005, it decided to begin to sell off its international projects and come home. "The political arena and cost structure in our various assets outside of the lower forty-eight onshore in the United States were becoming too risky," said CEO Scott Sheffield. They could also see the success that other companies were having in the Barnett Shale. Better to plow money back into the United States, where contracts were generally observed and courts independent, than deal with foreign governments that could unilaterally change the terms under which a company operated.

For two years, Pioneer's geologists had studied the shales under Pioneer's nine hundred thousand acres in the Permian. Their conclusion was startling. Under it lay a potential bonanza—not just one layer of shale, but layer upon layer of tight rocks stacked on top of each other like pancakes a mile or two beneath the surface, whose oil could be made to flow in abundant volumes with hydraulic fracturing and horizontal drilling. "That," said Sheffield, "was the aha moment." Pioneer abruptly redirected its spending to that resource. In 2012, it drilled its first successful horizontal shale well in the Permian.[9]

Pioneer was only one of a host of companies that jumped on the new opportunity. Once again, the region was booming. The shortage now was not of oil, but of workers and housing and office space. Plans were made for a fifty-three-story office building in Midland that would be the tallest skyscraper between Houston and Los Angeles. Production skyrocketed. By 2014, Permian output zoomed from that low point of 850,000 barrels in 2007 to 2 million—almost 25 percent of total U.S. crude oil output.

Altogether, in a very short time the new technology transformed Texas, putting it on an extraordinary growth path. Between January 2009 and December 2014, the state's total crude oil output more than tripled. By this time, Texas was producing more oil than Mexico, and more than every OPEC country except Saudi Arabia and Iraq.



The New Shale Plays

Texas oil production increased five-fold in a decade and was larger than every country in OPEC except Saudi Arabia.

The unconventional revolution also transformed the map of oil resources. One area in the Permian—known as the Spraberry and Wolfcamp—was now deemed the second-largest oil field in the world, behind only Ghawar, Saudi Arabia's supergiant field. The Eagle Ford was ranked fifth, behind Burgan in Kuwait and another Saudi field, and ahead of the giant Samotlor field that is the foundation of Russia's oil might.

The United States was back, once again a major player in world oil.

Chapter 3

"IF YOU HAD TOLD ME TEN YEARS AGO": THE MANUFACTURING RENAISSANCE

St. James is a rural parish in Louisiana, on the banks of the Mississippi River. Its rich soil supports the sugarcane plantations that are the backbone of the local economy. It is known for the bonfires that are lit on Christmas Eve on the levees along the river, which, according to legend, are to welcome "Papa Noel," otherwise known as Santa Claus, and to help him avoid getting lost as he makes his way down the Mississippi bearing his satchel of gifts.

On an autumn Friday night in 2015, a different kind of ceremony was held in the local high school, this one to warmly welcome to the parish a new guest, who was carrying in his satchel a present of sorts—a large-scale investment in the parish, of a kind that had never before been seen. This visitor was Wang Jinshu, the chairman of Yuhuang Chemical Company, which is headquartered halfway around the world, in Shandong Province, China.

Wang had come to initiate the $1.9 billion first phase for a chemical facility that Yuhuang was building in St. James. Yuhuang had purchased not only thirteen hundred acres of sugarcane but also the adjacent high school in which the ceremony was being held, enabling the parish to build a new, more modern high school. Over time, the project would mean a lot of new jobs in St. James Parish and more income.

What brought Yuhuang to the parish was inexpensive natural gas. It was more economic for the company to take advantage of a pipeline that brought in shale gas, make the chemicals in Louisiana, and ship them to China, than to build a similar facility in China. A Yuhuang executive cited many reasons for the project—from the need for its product to the "beneficial" impact on U.S.-China relations and its alignment with the policies of Chinese president Xi Jinping. But the basis of it all was more down-to-earth—a twenty-year contract for inexpensive natural gas.[1]

In 2019, with the project 60 percent completed and a second phase planned but amid the U.S.-China trade war, Yuhuang prudently brought in a U.S. company as a joint-venture partner. But what had unfolded that night four years earlier, in 2015, in the high school in St. James Parish, was part of a much bigger story—America's manufacturing revival and its increased competitiveness in the world economy.

WITH THE UNCONVENTIONAL REVOLUTION, AMERICA'S ENergy position looked very different from what had been expected just a few years earlier. U.S. natural gas production was growing dramatically. The same was true for oil. Imports of oil were rapidly declining, as was the money that the United States spent on importing oil—all of which was reducing the U.S. trade deficit. Yet the impact of the shale revolution on the American economy went even further.

In 2014, Ben Bernanke, just retired as chairman of the Federal Reserve, described the unconventional revolution as "one of the most beneficial developments, if not the most beneficial development" in the American economy since the 2008–2009 financial crisis. This impact was amplified by the nature of the economic flows. The surge in economic activity stimulated by shale gas and oil, combined with the steep decline in imports, sent the benefits reverberating through supply chains and financial links right across the U.S. economy. This was very different from money flowing out of the country to support development elsewhere or ending up in the sovereign wealth funds of exporting countries. This domestic circulation of money would greatly multiply the impact.

Between the end of the Great Recession, in June 2009, and 2019, net fixed investment in the oil and gas extraction sector represented more than two-thirds of total U.S. net industrial investment. In another measure, between 2009 and 2019, the increases in oil and gas have accounted for 40 percent of the cumulative growth in U.S. industrial production.

In practical terms, that means money flowing into paychecks throughout the country. By 2019, the unconventional revolution was already supporting over 2.8 million jobs.* There were jobs in and around oil and gas fields, manufacturing jobs in the Midwest making equipment and trucks and pipes, jobs in California writing software and managing data, and jobs generated by increased income and spending, like real estate agents and car dealers. What is striking is that, owing to the linkages, the economic impact was felt across virtually all states. This was true even in New York state, where environmental activists and politicians succeeded in getting the state to ban hydraulic fracturing and prevent a new natural gas pipeline that would have carried inexpensive natural gas from the Marcellus in Pennsylvania to gas-short New England. The lack of new pipelines resulted in a prohibition in 2019 on gas hookups for new housing and small businesses in Westchester County, just north of New York City. Yet even New York registered over forty thousand jobs that were supporting shale activity in other states.[2]

* Altogether, before the COVID-19 shutdown of the economy, the entire oil and gas industry was responsible for 12.3 million jobs in the United States.

All of this incremental economic activity generates a lot of federal and state revenues, estimated to be $1.6 trillion between 2012 and 2025.

SHALE HAS GENERATED NOT ONLY REVENUES BUT ALSO ENVIronmental controversy and opposition as it grew. As with most major industrial activities, environmental issues around shale need to be properly managed. In the early years of the shale revolution, the controversy was particularly focused on water contamination, either from the fracking process itself or the disposal of wastewater that comes out of the well. A decade later, as Daniel Raimi observes in his book *The Fracking Debate*, water contamination has proved not to be the systemic problem that some feared. To begin with, the fracturing itself takes place several thousand feet below freshwater aquifers. There was also the view that shale was a "wild west" activity. But shale production, as with the rest of the oil and gas business, is highly regulated, in this case primarily at the state level. Some states needed time to ramp up their regulatory apparatus as shale development became significant in their area. Earthquakes were another concern, particularly after swarms were felt in Oklahoma. Follow-on studies attributed these quakes not to drilling but rather to disposing of wastewater in inappropriate locations, causing slippage of rock formations and thus quakes. With new regulation of where wastewater could be disposed and at what pressure, the number of earthquakes fell sharply. Much has been learned about managing the impacts on rural communities, including noise and the number of trucks on local roads, while at the same time meeting those communities' needs for jobs and new sources of income.

The most significant question today concerns "fugitive" methane emissions—basically, natural gas leaking from equipment or pipelines—which is not limited to shale. The Environmental Defense Fund was among those at the forefront in directing attention to methane as a significant greenhouse gas. Reducing those emissions is now a priority for both regulators and industry and a particular focus of the thirteen-company Oil and Gas Climate Initiative. Moreover, the International Energy Agency notes, "Methane is a valuable product and in many cases can be sold if it is captured."[3]

THE EFFECTS OF THE SHALE REVOLUTION ON THE TRADE POsition of the United States are striking. Using 2007 as the baseline comparison, the U.S. trade deficit in 2019 was $309 billion lower than it would have been if there had been no shale revolution. Without shale, the United States would have continued to be the world's largest oil importer. It also would have become a large importer of LNG, competing for supplies with China, Japan, and other countries, adding greatly to the trade deficit.[4]

The shale revolution also dramatically improved the competitive position of the United States in the world economy. For years, industrial investment flowed out of the United States to countries that were lower-cost because of lower labor costs. But the tide turned. Over $200 billion is being spent on new and expanded U.S. chemical-related facilities.[5] Tens of billions of dollars more are going into steel fabrication and other manufacturing and processing plants, as well as refining and infrastructure. The primary reason is the abundance of low-cost natural gas. It is used both as a fuel and as a raw material for making chemicals. It also helps lower the cost of generating electricity.

For years, investment by the chemical company Dow had been outward bound, primarily to the Middle East, in the quest for access to cheap natural gas as a raw material for its products. But the advent of inexpensive gas in the United States pulled it back home. The company has since committed billions to expanding or building new petrochemical facilities in the United States. Announcing a $4 billion expansion in Texas in 2012, Andrew Liveris, Dow's then–chief executive, said in

2012, "Things change. We pivoted very fast." He added, "If you had told me ten years ago I'd be standing up on this podium making this announcement, I would not have believed you."

But it's not only U.S. companies. European manufacturers are escaping the burden of Europe's high energy costs to invest in the United States. In announcing a $700 million investment in Corpus Christi, Texas, the CEO of an Austrian steel manufacturer explained at the time that the low U.S. gas price compared to Europe "is the big economic advantage." The migrants include fertilizer companies from Australia and plastics companies from Taiwan. After decades of U.S. companies setting up factories in China, Chinese manufacturing companies were starting up new manufacturing facilities in the United States, of which Shandong Yuhuang, in the sugarcane region of Louisiana, is a case in point.

Inexpensive energy was not the only reason, of course. But for many companies—American and foreign—abundant low-cost natural gas—and the expectation that it will last for a long time—is decisive. All this makes shale gas a key contributor to what has been called the "manufacturing renaissance" in the United States and to the increased competitiveness of the United States in the world economy.[6]

Chapter 4

THE NEW GAS EXPORTER

It took two phone calls in 2009 to convince Charif Souki to turn around the business he was trying to build. One was from the hard-charging CEO of independent Chesapeake, one of the companies at the forefront of shale gas development; the other, from one of the largest companies in the world, Shell. Both had the same question—could Souki transform the facility he was building to import LNG into a plant to export the growing supply of U.S. gas?

Souki was taken aback. He had bought into the consensus of the early 2000s about the gas shortage and had raised hundreds of millions of dollars and signed complex contracts on the premise that the United States would have to import very large amounts of LNG. The calls suggested that he had made a big very bad bet.

Souki, with his longish hair, double-breasted suits, and traces of an accent, did not exactly fit the profile of a wildcatter in the oil and gas patch. He had grown up in Beirut, where his father was the well-connected Middle East correspondent for *Newsweek*. Souki had begun his career working for an investment bank in the Arab world, honing his skills of persuasion. Returning to the United States, he became an investment adviser, then opened restaurants in Aspen, Colorado, and Los Angeles before ending up in Houston, where he put together a company to explore for natural gas. He named his company Cheniere—a Cajun word for the raised ground in a swamp.

Cheniere got nowhere as an exploration company. But it convinced Souki, like many others, that America was running short of natural gas, leading him to the audacious idea of importing LNG from around the world. Audacious was actually an understatement. Souki had been a restaurateur, he had no money but would need billions of dollars, and he was going to try to make deals with the world's largest oil and gas companies and with major exporting nations. Though short of money, he was not short of confidence. Still, he was a novice trying to break into a big global business that was already more than forty years old.[1]

IN FEBRUARY 1959, THE *JOURNAL OF COMMERCE*, IN A STORY headlined "Cargo Ship with Methane on High Seas," announced that a converted World War II freighter, renamed the *Methane Pioneer*, had set sail from Louisiana for England. It carried a cargo that had never before been shipped over the seas—liquefied natural gas—LNG. Liquefied natural gas is the product of a complex process that refrigerates natural gas to extreme cold, down to minus 260 degrees Fahrenheit, thus compressing it into a liquid. Since in its liquid form the gas takes up only one six-hundredth of the space that it would in its gaseous state, it can be pumped into tanks on refrigerated ships and transported across oceans and then "regasified"—turned back into gas—at the other end and pumped into a pipeline system in the receiving country.

The technology had been developed during World War I. But it was only after World War II that experiments began to liquefy gas in order to transport it. The real spur was the killer fog that enveloped London in 1952. Burning cleaner gas instead of coal to generate electricity would help alleviate pollution, and LNG could be the source of that gas. It took time to work out the designs and find the right materials for the tanks. By 1959, the *Methane Pioneer* was ready to sail. This shipment, the head of the new company said, "is the prelude to a new era when natural gas, previously wasted or shut in for want of accessible markets in many parts of the world, will be liquefied and transported by tanker to countries where gas is not naturally available." That was a pretty good description of what would unfold over the next several decades.[2]

Yet things did not go quite as expected. The major market for LNG in Britain and in Europe largely evaporated with the discovery of the huge Groningen natural gas field in the Netherlands and then additional gas in North Africa and in the seabed off the east coast of Britain.

The growth market for LNG turned out to be on the other side of the world, in the East Asian "economic miracle"—Japan, South Korea, and Taiwan. To lower their dependence on Mideast oil for generating electricity and increase energy security, and to reduce pollution, those countries entered into complex contracts for LNG from Indonesia, Malaysia, and the sultanate of Brunei. Also, a small LNG facility in Kenai, Alaska, would intermittently ship supplies to Japan.

This new LNG business required very large investments—eventually billions of dollars—to find and develop and pump the gas; to construct the plants that, at one end, would liquefy the gas and, at the other, regasify it; and to build the specially constructed tanker ships that would ply the thousands of miles of ocean in between. Given the amount of money, participants in the market required confidence about the long term. Thus a highly interconnected business model developed, in which the various partners would coinvest up and down the supply chain and gain predictability via twenty-year contracts. Molecules from a particular field in Indonesia or Brunei or Malaysia would end up in specific power plants in Japan, Korea, or Taiwan. There was no buying and selling along the way, no redirection, no middlemen. Prices were indexed to the price of oil. If oil went up, the LNG price would go up. If the oil price went down, the gas price would also go down.

It was on this basis that the LNG industry turned into a big business. For a number of years, it was largely Asia-bound. Then the emirate of Qatar transformed it into a global business. Qatar is a flat, sandy peninsula that projects out into the Persian Gulf from the eastern side of Saudi Arabia. For much of the twentieth century, it was a poor country, eking out a living from fishing and pearl diving. That started to change when modest oil production began in the late 1960s. But the rapid development of the North Field, offshore of Qatar, would transform its economic position and its global importance. The North Field is considered the world's largest gas field. Separated only by a demarcation line on the map is Iran's huge South Pars field.

Qatar and the companies it partnered with introduced ever-greater scale into every phase of the LNG operations, including tanker size. The objective was to be able to competitively ship gas anywhere in the world. By 2007, Qatar had overtaken Indonesia to become the world's largest supplier of LNG. It was poised to begin large exports to the United States to help allay the anticipated domestic shortage of gas that had so gripped the U.S. energy industry.

This was the global business into which Souki wanted to jump. He set out to build a regasification facility—or several of them. They would take the natural gas, which had been liquefied in Qatar or Trinidad or somewhere else, and turn it back into gaseous form so that it could be put into a pipeline and sent on to U.S. consumers.

For his new terminals, Souki identified sites on the U.S. Gulf Coast. But he was still missing something very important—money. Two dozen investors showed him the door with varying degrees of politeness and incredulity; only one yelled at him. But he did know someone who had capital, another unusual entrepreneur—Michael Smith.

Smith had originally moved to Colorado to study veterinary medicine. Instead, he had ended up dabbling in Colorado real estate. Then he heard about an oil discovery and invested $10,000 in some nearby oil leases. The company he built was eventually sold for $410 million. He then went right back into the energy business, this time offshore in the Gulf of Mexico. Souki's pitch coincided with his own thinking—that a gas shortage was coming. U.S. gas, and Smith's gas production in the Gulf of Mexico, was, as he later said, "falling flat on its face."[3]

Souki and Smith worked out a partnership. Smith took controlling interest in one of the proposed sites, Freeport, about seventy miles south of Houston. Souki pushed ahead on a project at Sabine Pass in Louisiana, on the border with Texas. Two international majors signed twenty-year contracts to use Cheniere's Sabine Pass facility to regasify their LNG shipped in from the other parts of the world. The financial markets were now taking Cheniere seriously. Its stock price rose twenty-five-fold and then split. Michael Smith brought in major investors for his Freeport facility. Construction began at both sites. By 2007, dozens more regasification projects were being proposed by other groups. In 2008, natural gas prices reached a high point of almost $9 per thousand cubic feet, providing further "proof" of a shortage and thus increased urgency to import LNG. Yet by 2008, skepticism was emerging about the financial strength of Cheniere, and its stock price was falling. Souki himself was becoming depressed about the prospects for his business as he kept reading and hearing about more new gas discoveries in the United States, which could mean less demand for LNG imports.

Then, in the spring of 2009, came the call to Souki from Aubrey McClendon, CEO of Chesapeake, who was at the forefront of the shale gag boom and had built up a huge inventory of drilling sites.

"Hey, can you guys do liquefaction at Sabine Pass?" asked McClendon.

"Why are you asking?" replied Souki.

McClendon became more explicit—could Cheniere build an export terminal for Chesapeake so that it could find markets outside the