TENNENBAUM PROGRAM FOR FACT-BASED POLICY

US Energy Security

How We Got Here and Where We Are Headed

Daniel Yergin

Nine US presidents in a row—from Richard Nixon through Barack Obama and Donald Trump—used their State of the Union addresses to proclaim, in one way or another, "energy independence" as a national goal for the United States. But Joe Biden's 2024 State of the Union address was different. There was no mention of energy independence. He did, however, pledge to create a Climate Corps of sixty thousand young people "patterned after the Peace Corps."

That contrast tells much about how the energy position of the United States has changed. What for decades had seemed highly improbable has happened: The United States, after decades of wanting, is actually "energy independent" in terms of physical supply. Moreover, the United States is once again the world's largest producer of oil and natural gas. No nation has ever produced as much on a daily basis as the United States today. It is also the world's second-largest producer of electricity from solar and wind. All this adds up to energy security—but only up to a point.

"Energy security" means the availability of reliable and reasonably priced energy. That is a position bolstered by diversification of sources, resilience in the face of disruptions, steady supply chains, well-functioning markets, and continued technological advance. And, by those measures, US energy security is much improved. Partly because of the attainment of energy independence and the confidence that came with it, as well as the intense focus on climate, attention has shifted away from energy security to a focus on reducing emissions and a transition away from hydrocarbons.

But there are limits to what "energy independence" means. Physical oil supply is only part of the picture. Oil prices are determined on the world market. Moreover, global events, geopolitical conflict, unanticipated increases in electricity demand, and concerns about extreme weather—all these have recently pushed energy security back on the agenda. And energy security now applies not only in terms of oil and gas and electricity, but also minerals and manufacturing dependence and cybersecurity. In addition, the complexity of an energy transition has become increasingly clear.

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This essay will explore the significance of the United States' regaining the energy independence that it had lost three-quarters of a century before, the essential role of the "shale revolution" in that recovery, and the impact on global politics. It will also examine how the climate issue is changing the national energy agenda and policy around the topic of "energy transition," as well as prospects going forward with a new presidential administration and beyond—and how all of this relates to energy security.

THE IMPORTER

The United States had historically been the world's largest oil producer, providing six out of every seven barrels of oil used by the Allies in World War II. In 1946, the first tanker carrying Middle East oil arrived in Philadelphia's harbor. In the next few years, postwar demand started to outrun domestic production, putting the United States on its way to being a net importer. "Net" means the final balance between total imports and total exports—the key measure of reliance. (At any given point of time, some oil and oil products may be exported because of quality or location or refinery configuration, while others are imported.) By the beginning of the 1970s, imports were accelerating, and the United States was becoming increasingly dependent on foreign oil at a time when global demand was burgeoning.

The development of America's shale oil and gas has proved momentous both in transforming the energy position of the United States and in its geopolitical impact. But it was not something that could have been imagined at the time of the 1973 Oil Embargo, which introduced the modern age of energy. The embargo was the response of the Arab oil exporters to US resupply of weapons to Israel, which was at risk of defeat from the onslaught of a surprise attack by Egypt and Syria. By that time, the world economy had become heavily dependent on oil supplies from the Middle East. The embargo triggered a fourfold increase in the price of oil, a deep global recession, and panic in consuming countries. In the United States, the panic was all too visible in long gasoline lines, in which angry motorists fought for limited supplies, as well as in the rationing of access to gasoline to motorists depending on whether the license on their cars ended in an odd or even number.

Subsequently, however, it became clear that the shortages and high prices also resulted from the federal government's efforts to control the energy markets through regulations and price controls, which undermined investment and prevented the market from responding flexibly. The consequences were costly and destructive—a lesson to be heeded when the drive for such government control returns.

The crisis proved to be a political shock as well as an economic one. For, at that time, most Americans, even if they thought about it at all, did not know that the United States had become the world's largest oil importer, despite warnings over the preceding two years about tightening markets and a coming energy crisis.[1]

The crisis transformed oil and natural gas and, more broadly, energy overall into both high politics and contentious politics. A drive began to develop new oil resources to diversify away from dependence on the Organization of Petroleum Exporting Countries (OPEC). But

that effort in the United States, for oil as well as natural gas, was hampered by the complex and burdensome system of federal regulation and price controls.

The 1973 crisis was followed by another in 1979, with the revolution that toppled the Shah in Iran disrupting supplies from that country and further doubling oil prices. Under Presidents Jimmy Carter and Ronald Reagan, the system of price controls was progressively dismantled. Coal for generating electricity was promoted as national policy in order to push out oil from electric generation, and new nuclear power plants were built.

Yet energy independence seemed only more unattainable. In 1973, the United States was importing a third of its oil. By 2008, it was almost 60 percent.

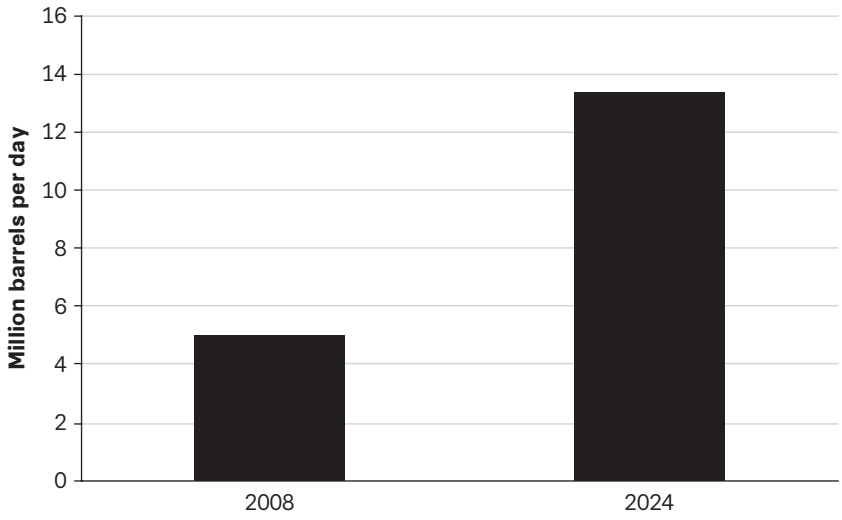
But then came the shale revolution.

SHALE AND ENERGY INDEPENDENCE

Shale was not an overnight revolution. The textbooks said such production from very dense rock formations was commercially not possible. But after three decades of research, experimentation, and technological advances—and in the face of continuing skepticism—in the late 1990s and early 2000s it was proved possible. Until then almost all oil and gas wells were vertical—they went straight down. But the advent of computer-assisted horizontal drilling meant that a well could go down a mile or two vertically into the earth, well below the water table, and then make a gradual ninety-degree turn and run another two miles or more horizontally, exposing much more rock. The second advance was hydraulic fracturing—in which a mixture composed mostly of water with sand and a small amount of chemicals and guar (which is also used in ice cream and yogurt) is injected under pressure through that horizontal pipe. This process breaks down the dense rock sufficiently to allow oil and gas to flow into the well and up to the surface. The entire process became better known as "fracking." These advances were augmented by the development of 3D seismic imaging, which provided much greater understanding of the subsurface geology. The development of shale was facilitated by an entrepreneurial culture in the domestic US oil and gas industry as well as private ownership of mineral rights.

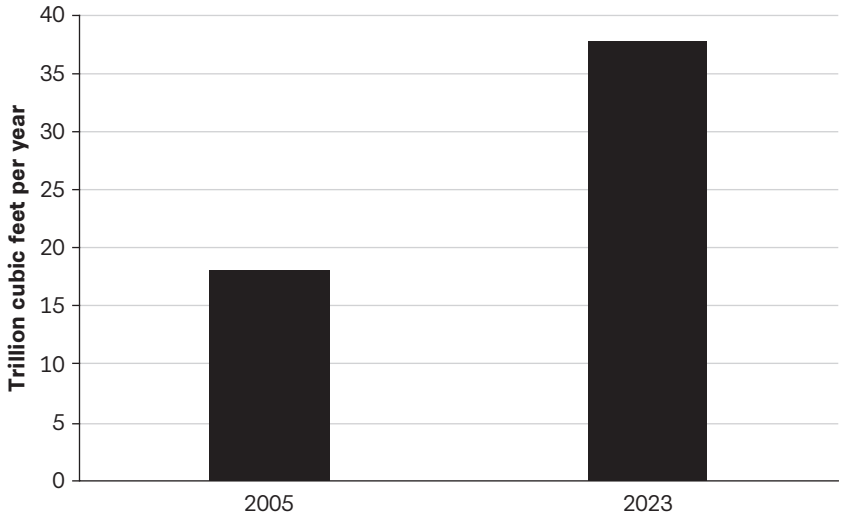
This new shale technology was first applied to natural gas. The impact of these technologies only became apparent around 2007 and 2008, when natural gas production began to increase. By the time of his 2011 State of the Union address, President Barack Obama could declare, "Recent innovations have given us the opportunity to tap larger reserves—perhaps a century's worth—in the shale under our feet."[2] By then shale technology was beginning to be applied to oil as well—with an impact far greater than most anyone would have imagined. Early criticism of the new shale technology on environmental grounds faded away as output grew. It became recognized that shale production is an industrial activity regulated at both the federal and state levels. The overall results are something that could not been contemplated earlier this century: US crude oil production has almost tripled, from 5 million barrels per day in 2008 to 13.4 in August 2024 (see figure 1). The United States today produces considerably more oil than the traditional leaders—Saudi Arabia and Russia. As for US natural gas

FIGURE 1 US crude oil production



Source: Data from US Energy Information Administration (EIA).

FIGURE 2 US natural gas production



Source: Data from US EIA.

production, it has more than doubled, from 18 trillion cubic feet in 2005 to 37.9 trillion in 2023 (see figure 2). This has made the United States the world's largest producer of natural gas, almost double that of Russia. Today, shale oil accounts for almost 70 percent of total US oil production and almost 80 percent of natural gas production. The top states include Texas, New Mexico, North Dakota, Pennsylvania, and Louisiana.

It was not, however, just a matter of output; it was also one of exports. Owing to the increasing volumes of shale gas, the United States was producing more natural gas than the domestic

market could absorb. The outlet became the export of liquefied natural gas (LNG), which began in 2016. This grew at such a rate that by 2023 the United States had become the world's largest exporter of LNG. While the volumes of shale oil also grew rapidly, they were not altogether well matched to the requirements of the US refining system, which turns crude oil into gasoline, diesel, jet fuel, and other products. By 2015, US oil production was more than 80 percent higher than it had been a decade earlier. Access to global markets was needed. A ban on the exports of crude, which had been implemented in the aftermath of the 1973 crisis, was lifted in 2015, and the United States became a major exporter of crude oil and what are called natural gas liquids.[3]

Altogether, the shale revolution has made the United States energy independent in physical terms for the first time since the late 1940s, and the impact has been enormous. The net oil import bill for the country in 2008 was $388 billion. By 2023, it had fallen to $4.7 billion—a 99 percent decline. (The fact that there was still a small charge reflected differing prices for different grades of oil.) Cumulatively, it has saved the United States trillions of dollars on its import bill, keeping dollars in the United States that would otherwise have been exported. It is responsible for millions of jobs, directly and indirectly. It has contributed significantly to federal and state treasuries. The availability and relatively low price of domestic natural gas has stimulated hundreds of billions of dollars of investment in new manufacturing facilities by both US and foreign companies.[4]

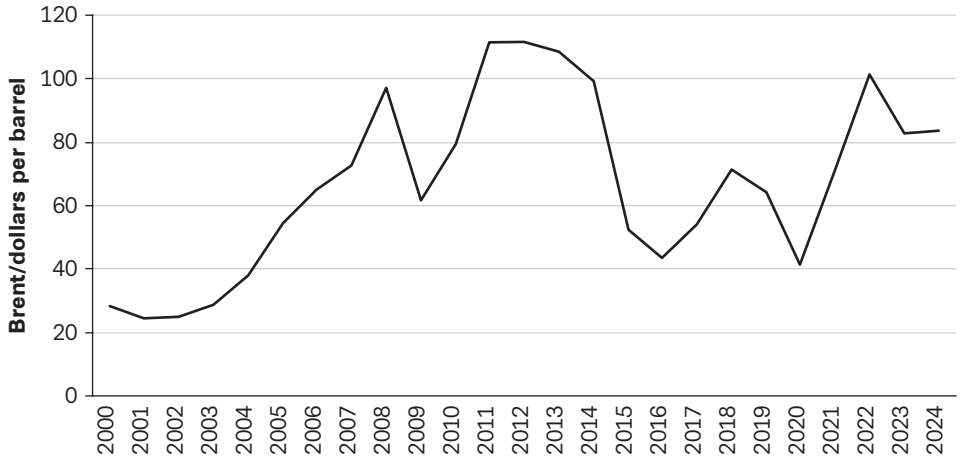
THE "SHALE GALE" AND GEOPOLITICS

The impact of the shale revolution is not just economic. Shale has proved geopolitically significant, bolstering America's position in the world.[5] The Obama administration was able to impose sanctions on Iranian oil exports in pursuit of restrictions on Iran's nuclear weapons program because growing US oil supplies exceeded the volumes of Iranian oil that would be kept off the world market by sanctions. In another example, US oil and gas exports to India have become an important part of an expanded relationship between the two countries.

But the biggest impact of the shale revolution, at least so far, came with Russia's invasion of Ukraine in 2022. Early on, Russian president Vladimir Putin saw that the development of shale gas would challenge the primacy of Russian gas exports into Europe—and Moscow's power. Russia financed environmental opposition to shale gas development in Eastern Europe. In 2013, at an international economic conference in St. Petersburg, at the mention of *slantsevy gaz*—shale gas—Putin erupted in fury, denouncing shale as "barbaric" and dangerous and environmentally destructive. It was clear that he saw the advent of shale as something that would strengthen the relative position of the United States. And, crucially, he viewed anything that might diminish the significance of Russian gas—or compete with it—as a direct threat to Russia's power. The Ukraine War would subsequently prove him right on both counts.[6]

In 2022, Putin sought to wield the "energy weapon"—cutting off Russian pipeline gas exports on which Europe relied heavily—with the aim of economically shattering the European coalition supporting Ukraine's resistance. But the weapon failed because Europe was able to replace the embargoed Russian pipeline gas with imported gas—additional supplies from

FIGURE 3 World crude oil prices



Source: Data from S&P Global Commodity Insights, compiled July 2, 2024. © 2024 S&P Global.

Norway but the bulk in the form of LNG. About 40 percent of those LNG imports were processed in the United States from shale gas. On the consumption side, European demand went down in response to high prices, conservation efforts, and reduced industrial activity. But, without that LNG, the European coalition supporting Ukraine could well have collapsed under the dire economic pressure of a lack of energy and sky-rocketing prices. So significant was that supply that President Biden promised Europeans in 2022 to substantially increase US LNG exports to Europe. As the Ukraine War progressed, the geopolitical significance of LNG became evident: US LNG had become part of the expanded arsenal of the NATO alliance. Altogether, shale oil and gas have strengthened the strategic position of the United States and its alliance partners. Without US shale gas and the ability to process it into LNG, the Russian cutoff to Europe would have been catastrophic in its impact.

That last points to a further impact of the Russian invasion of Ukraine—the return of energy security as a major concern. It had certainly slipped off the table for the United States owing to the speed and scale of the shale revolution, as well as the increased concentration on climate. The "energy independence" that nine presidents had called for had eventually turned out not to be a chimera but rather a fact. As the "shale gale" erased net imports, the country could now take energy independence for granted and move on to other topics. For both the United States and many other countries around the world, the collapse in demand and plummeting oil prices that came with the COVID-19 pandemic further turned attention away from energy security (see figure 3).

But the Russian invasion abruptly made energy security a priority once again. The Biden administration, alarmed by spiking prices and shortfalls, pushed the US oil industry to increase production. In 2023, the Western Hemisphere exceeded the Middle East in oil production; and virtually all the growth in world supply came from the Western Hemisphere—not only the United States, but also Canada, Brazil, and Guyana. This "Western Hemisphere surge" became a bulwark of stability in the face of the wars in Ukraine and the Middle East, which in the past would have sent prices up.[7]

THE SCALE OF THE US ENERGY SYSTEM

The "energy transition" has become the organizing topic for energy and environmental discussions around the world. It is meant to describe the shift to a new energy system that no longer depends upon hydrocarbons, and it is often posited in terms of reaching net zero in terms of greenhouse gases (GHGs) by 2050—or by 2060 or 2070 for some countries.[8]

In order to understand the challenge of an energy transition and what it means for the United States, it is important to grasp the scale of the US energy system. The global energy system is in fact remarkably global—with production and consumption linked by trade and transport across the planet. Of course, the United States is a very big and complex part of that system, although its trading links have changed dramatically over the last two decades—as we will see shortly.

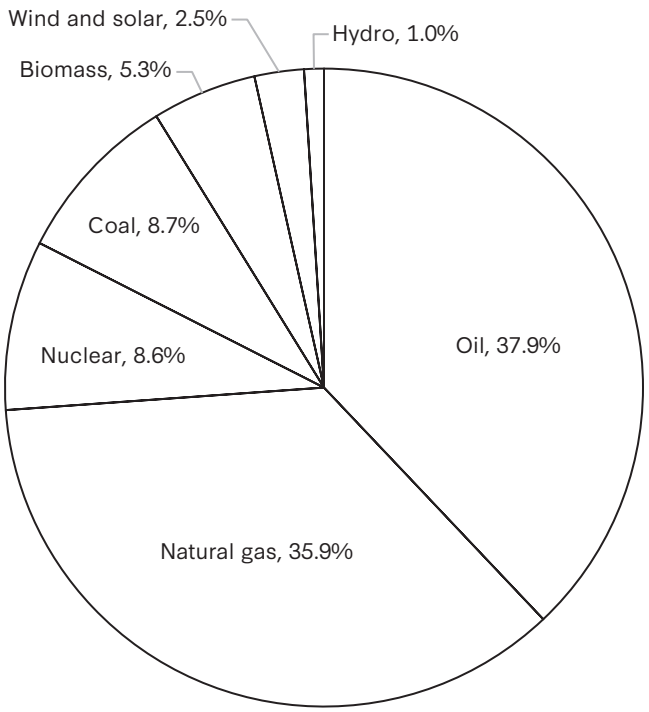
The United States was formerly the biggest energy consumer in the world. But no longer. That title now belongs to China. The United States represents 16 percent of total world energy consumption and China 26 percent, meaning that China uses almost 70 percent more energy than the United States. But in terms of GDP, the positions are reversed: the United States is about 25 percent of world GDP and China 18 percent. China's larger consumption reflects the fact it has a much bigger base of heavy industry, and its population is four times greater than the United States. One other striking difference: although it has a strong domestic petroleum industry, China imports almost 75 percent of its oil, while the United States on a net basis imports none. That is something very apparent to Beijing.[9]

The "energy mix"—the distribution of energy sources on which the US economy runs—demonstrates the continuing predominance of "hydrocarbons"—the all-inclusive term for oil, natural gas, and coal. In 2022, hydrocarbons accounted for 81 percent of US energy demand. In 2023, that dependence declined by 0.4 percent to 80.6 percent. Breaking that down finds oil and natural gas almost neck and neck—oil at 37.9 percent and gas at 35.9 percent. Coal has dropped to 8.7 percent as natural gas has upended its use in electric generation. Nuclear is 8.6 percent, and biomass, which includes ethanol, is 5.3 percent. Hydro and solar are about even—at about 1 percent each, while wind is 1.5 percent (see figure 4).[10]

If we look at electricity alone, the picture is different: natural gas fuels 43 percent of generation; coal, 16.2; and nuclear, 18.6 percent. Conventional hydropower is 5.7 percent (see figure 5).[11]

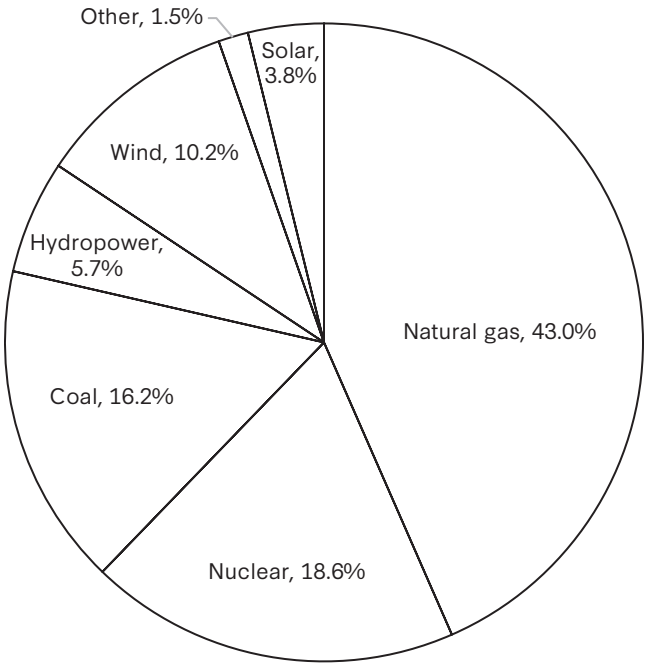
Wind and solar were negligible a decade and a half ago. But then, with costs coming down and international supply chains developing, and bolstered by government incentives and mandates, they began what has proved to be rapid growth. At this point, wind is almost three times greater than solar—10.2 percent of total electricity generation versus 3.9 percent for solar. But solar is growing at a faster clip. Between 2015 and 2023, while installed wind capacity doubled, solar installation grew almost eightfold, and that rapid rate is expected to continue, with a doubling from current levels by 2027.[12] Much smaller are biomass, at 1.1 percent, and geothermal, at 0.4 percent.

FIGURE 4 US energy mix 2023



Source: US EIA, *Monthly Energy Review*, July 2024.

FIGURE 5 US electricity by source 2023



Source: US EIA, *Monthly Energy Review*, July 2024.

To be useful, energy has to be delivered to consumers, and that requires a huge deployment of infrastructure that is both reliable and affordable. To give some idea of the nationwide system, there are over 450,000 miles of bulk electric power transmission lines; 230,000 miles of liquids pipelines; 411,000 miles of gas transmission and gathering pipes; 140,000 stations and stores selling gasoline; and 12,500 utility-scale power plants that generate electricity. Over 72,000 wind turbines are operating in the United States, and by one estimate 225 million solar panels are spread across the country in solar parks or on rooftops.

Since 1980, US energy consumption has grown by about 25 percent. Over the same time, however, overall GDP in inflation-adjusted dollars has tripled. What this means is that the United States has become a more efficient consumer of energy. It uses less than half as much energy per unit of GDP as it did in 1980. This reflects both greater improvements in the use of energy—think LED lights in place of incandescent bulbs—and also in the way the economy has changed. In the 1980s, no one talked about "Tech" as a sector, as companies like Google and Amazon did not even exist. Traditional energy-intensive manufacturing, such as steel, loomed larger then as a share of the economy than it does today. A striking contrast is with China: overall industrial output accounts for 18 percent of GDP for the United States compared to 40 percent for China.[13]

Where the change is most evident, however, is in terms of transportation and oil. Between 1980 and 2023, US oil consumption grew by something less than 20 percent—from 17 million barrels per day to 20.2—although population has grown by almost 50 percent and the number of cars and light trucks on the road has more than doubled. The main reason for comparably minor growth in oil consumption is automobile fuel efficiency standards. They were imposed by the federal government in 1975, two years after the 1973 Oil Embargo. At that time, the average car got fourteen miles to the gallon. Today, it gets twenty-five miles to the gallon—an 80 percent improvement.

It is one thing to continue to improve miles per gallon of automobiles. It is quite another thing to eliminate the "gallons" altogether. That is the ambition of some for the energy transition. In the International Energy Agency's "net zero by 2050" scenario, oil and natural gas demand in 2050 will still be significant although much smaller—one-quarter of what it is today. But the oil will be used for other purposes, since 94 percent of the world's car fleet is projected in that particular scenario to be electric.[14]

"THE ULTIMATE THREAT TO HUMANITY"

Democratic presidential administrations have increasingly focused on climate and carbon. Especially after the 2015 Paris Agreement, energy transition became an organizing principle for energy policies. The objective is to eliminate emissions of carbon dioxide, methane, and other greenhouse gases, transition away from oil and natural gas, and phase out coal from the US economy—and also achieve similar objectives on a global basis in collaboration with other countries. To accomplish this on an accelerated basis has been the focus of the Biden administration.

One of President Biden's first acts on his first day in the White House in 2021 was to sign an executive order reinstating US participation in the Paris Agreement, by which 195 countries (including the United States at the time of signing) had agreed to voluntarily work to prevent temperatures from increasing by 2 degrees centigrade above pre-industrial levels and, preferably, no more than 1.5 degrees. This target emerged from the work of the Intergovernmental Panel on Climate Change (IPCC), sponsored by the United Nations.

Rejoining the Paris Agreement was meant to demonstrate an immediate break from the Trump administration, which had adopted "energy dominance" as its organizing theme. In 2017, President Trump had withdrawn the United States from the Paris Agreement because, he said, it "disadvantages the United States to the exclusive benefit of other countries," allowing China to "increase their emissions" and India to "double their coal production."[15]

For Biden, in sharp contrast to Trump, climate is an overriding issue—an "existential threat to all of us," he has said, and "the ultimate threat to humanity."[16] The Biden administration sought to embed climate considerations in actions across the administration in a "whole of government" approach. A senior climate advisor was assigned to Cabinet officers to ensure that climate considerations are reflected in decisions and actions. The Department of Defense declared climate change a "national security risk." The administration called for a "carbon free" electric generation system by 2035 and for half the new cars sold in the United States to be electric by 2030. It has imposed new restrictions and regulations on oil and gas production, and it has rolled out tougher emission-reduction standards on conventional gasoline-powered cars, inevitably driving up their future price and thus, it is thought, speeding the shift to electric vehicles (EVs) on the part of both consumers and automakers.

"THE BIG CARROT": THE INFLATION REDUCTION ACT

The centerpiece of the Biden administration's climate policy is the 2022 Inflation Reduction Act (IRA). Following on the Bipartisan Infrastructure Law and the CHIPS and Science Act, the IRA is the third part of the administration's industrial policy trifecta—what Jake Sullivan, Biden's national security advisor, called "a modern industrial and innovation strategy."[17] The IRA is monumental in its scale and breadth and also in its costs. The provisions are both a roadmap to and an outline for a full energy transition. The Biden administration describes it as "a transformative law"[18] and "the most significant climate legislation in U.S. history, offering funding, programs and incentives to accelerate the transition to a clean energy economy."[19] At its signing ceremony, President Biden declared it "one of the most significant laws in our nation's history" and the "most aggressive action, ever, ever, ever to confront the climate crisis and increase our energy security."[20]

In addition to climate, the legislation has another major focus: China—that is, competing with China and reducing dependence on Chinese-dominated supply chains. It is also aimed, in the words of Energy Secretary Jennifer Granholm, at powering a "manufacturing revival" in the United States and increasing the share of "products made in America."[21]

The IRA is sometimes described as "agnostic" in that it is neither prescriptive nor narrowly focused. It seeks to stimulate a wide range of technologies, manufacturing, and markets; and it aims at molecules as well as electrons, providing opportunities not only for renewable developers and technology companies but also incumbent energy companies.

This approach differs markedly from what companies describe as the detailed and highly prescriptive regulatory approach of the European Union (EU). The scale and approach of the IRA—using the federal balance sheet to promote a domestic transition policy through incentives—has disconcerted the EU and various European governments, which have been accustomed to seeing themselves at the forefront on climate policy, well ahead of the United States.

The discomfort among European governments has increased as European-based companies, along with Asian companies, have pursued major new investment opportunities in the United States, drawn by the magnetic power of the IRA incentives—what Energy Secretary Granholm has called "massive carrots."[22] Altogether, it is estimated that more than $300 billion of private sector capital has been allocated and actually financed in response to the IRA.[23]

For the Japanese, long accustomed to criticism from Washington for implementing "industrial policy," the US initiatives have engendered some surprise, for the IRA along with the Bipartisan Infrastructure Bill and the CHIPS and Science Act are seen as industrial policy on a very large scale. But, in these policies, the Japanese also see a significant opportunity to shift to Japan parts of what now constitute China-US supply chains.

It should be noted that the IRA is not just about climate. Other elements include, in the words of the White House, "making health care more affordable" (i.e., reducing drug costs in various ways) and "strengthening enforcement against wealthy tax cheats and increasing recoveries from delinquent millionaires" (i.e., $80 billion for the Internal Revenue Service).[24]

But the IRA is mostly about climate and energy, and there is a lot to it. The provisions are so extensive that explicating them would take up a substantial part of this essay. But here are some of the headline points:

- Expanded investment tax credits for wind and solar. Unlike the previous tax credits, which needed to be renewed every two years, these tax credit provisions are long term and will be impactful for decades.

- Similar credits for a wide range of technologies from carbon capture and direct air capture to battery storage and biofuels, sustainable aviation fuel, and landfill gas.

- A major commitment to develop a "green hydrogen" industry, as well as a hydrogen market—partially as a replacement for natural gas—with tax credits and the establishment of hydrogen hubs.

- A new tax credit for "zero-emission nuclear power production" to support existing nuclear electricity generation in the face of competitive pressures, as well as "clean electricity" tax credits that would benefit new nuclear projects.

- $200 billion in new authority for grants and loans—the latter for technologies deemed ready to scale but lacking the track record to pull in private sector investment.

- Interdependent incentives to create de novo an entire supply chain for EVs, from minerals and components to manufacturing to consumer (e.g., tax incentives for new vehicles keyed to a rising share of domestic- or free trade–sourced minerals), all of this aimed at reducing dependence on China, spurring domestic manufacturing of EVs, and, of essential importance, spurring consumers to buy them.

- Parallel support for solar manufacturing, with the same aim of reducing dependence on China, which currently supplies 90 percent of solar wafers and 70 percent of the world's solar panels.

Then there are the octane-boosters. The tax incentives for projects can be further augmented if those projects pay "prevailing wages" (i.e., union labor) or meet such "environmental justice" objectives as targeting minority or poor communities or Indian lands. If all the add-ons are met, the investment tax credits could, in some circumstances, cover a significant part of the cost of a project. Moreover, the IRA seeks to stimulate further investment by allowing tax credits to be traded and sold, with the aim of significantly widening the pools of capital going into energy transition investments.

There are many other provisions—funding for the US Postal Service to buy zero emission vehicles, funding for the Environmental Protection Agency (EPA) both to award labels for construction materials deemed lower in embodied emissions and to fund "environmental justice" grants. Altogether, according to one analysis, there are 90 separate funding provisions in the IRA.[25]

At the time of its launch, the cost of the IRA for the US government was estimated at about $369 billion over ten years. Subsequent estimates, according to the US Treasury, put the fiscal cost between $800 billion and $1.2 trillion dollars over the same period.[26] Some estimates range higher.

Climate and energy transition policy has also become trade policy. In addition, the IRA represents a new version of energy security policy, as it is aimed at reducing and/or eliminating dependence on foreign—that is, Chinese—supply chains. As China came out of its extended COVID-19 lockdown, its exports surged owing to what has been widely described as its "industrial overcapacity."[27] This has added significantly to the already considerable trade tensions between the China on one side and Europe and the United States on the other. For the Biden administration, concern continued to rise that cheaper imports from China would undermine "green energy supply chains" and the trillions of dollars of investment slated to go into it.

In 2024, the administration responded to the growth—and threat—of Chinese exports with steep tariff hikes in order to protect those industries along with the investment the administration was making in them. Tariffs on Chinese electric cars were increased to 100 percent, and to 25 percent on EV batteries and critical minerals. "I'm determined," the president said, "that the future of the electric vehicles will be made in America by union workers."[28]

The tariffs on Chinese solar panels were raised to 50 percent because, said the president, "the Chinese government is subsidizing excess capacity, they're flooding the market." China produces over half of the world's entire steel output. President Biden put a 25 percent tariff on steel and aluminum in order, he said, to protect, "the major investments" that "we're making . . . in clean American steel and aluminum" that emits "half as much carbon as steel made in China." He also announced a 50 percent tariff on semiconductors made in China to protect the domestic industry and the multibillion investment that Washington is making through the CHIPS and Science Act.[29]

But the effort to shield domestic industry will be challenged if Chinese manufacturing and assembly expand in Mexico under the umbrella of the United States-Mexico-Canada Agreement. However, renegotiation of that agreement is expected in 2026; and, in a charged political environment, Mexico will be faced with a choice between Chinese manufacturing in Mexico and access to the United States for 80 percent of its exports. It is noteworthy, however, that Chinese imports now constitute about 20 percent of total new car sales in Mexico.

REGULATIONS AND MANDATES

Of course, the steps toward energy transition are not only about incentives—"carrots." They also involve regulations, rulemaking, and mandates. But given the discretionary nature of regulations issued by one administration, their longevity may depend on the policies of the next administration. This uncertainty can undermine the confidence of investors.

THE KEYSTONE CASE STUDY

The risks and uncertainty that come with political variability are captured in the tortuous saga of the Keystone XL pipeline. The proposed $9-billion project was launched in 2008 as a northern extension to the existing Keystone pipeline system that carries Canadian oil to US refineries. It was designed to bring an additional 830,000 barrels of oil a day from the Canadian province of Alberta across the US border and down to Oklahoma.

In 2012, when gasoline prices hit $4 a gallon, President Barack Obama hit the road and flew to Cushing, Oklahoma, to bless the construction of the southern section of the Keystone system. "A company called TransCanada has applied to build a new pipeline that would speed oil from Cushing to state-of-the-art refineries down on the Gulf Coast," he said. "Today, I'm directing my administration to cut through the red tape, break through the bureaucratic hurdles, and make this project a priority to go ahead and get it done." He added, "My administration has approved dozens of new oil and gas pipelines over the last three years."[30]

The proposed new part of the northern part of the pipeline system, Keystone XL, would have added about one-half of 1 percent (0.5 percent) to the total length of the petroleum liquids pipeline system in the United States. But it proved to be an extraordinarily controversial one-half of 1 percent—with demonstrations and protests all along the proposed route and in Washington, DC, where many people were arrested, including a famous climate scientist who declared that the pipeline was the "fuse to the biggest carbon bomb on the planet."[31]

In 2015, after a seven-year review that filled eleven volumes, the Obama administration rejected the permit required to cross the Canadian-US border because an approval "would undercut the credibility and influence of the United States in urging other countries to put forth ambitious actions and implement efforts to combat climate change."[32]

But that decision did not stand all that long. Two years later, in January 2017, just four days after taking office, President Donald Trump reversed the decision and called for approval of Keystone XL to be provided in an "expedited manner" because it "would serve the national interest."[33] Then, almost exactly four years later, President Joe Biden, on his first day in office, revoked "the permit granted to the Keystone XL pipeline," explaining that it would not serve "the U.S. national interest."[34] Six months, later TC Energy—as TransCanada had been renamed—finally gave up, saying that it was winding down the project that it had announced thirteen years earlier.

AUTO EMISSIONS AND PERMITTING

Regulations continue to be a battlefield, especially as the Biden administration has rolled out scores of new administrative and regulatory actions related to climate and industry over the last few years. Automobiles are among the most contentious.

Auto emissions are regulated by the EPA and fuel efficiency standards by the National Highway Traffic and Safety Administration. In 2024, new standards were rolled out that would require much tougher reduction of tailpipe emissions for new vehicles—already down by 99 percent since the 1970s according to the EPA—and much greater fuel efficiency—65 miles per gallon by 2031 for passenger cars. These regulations would set further engineering challenges for automakers. As noted earlier, this would make traditional cars more costly, thus making EVs more competitive in terms of price and therefore more attractive to consumers. The end goal: accelerate the penetration of EVs in line with Biden administration goals, with the anticipated result that 68 percent of new vehicles would be EVs or plug-in hybrids by 2032.

In January 2024, the Biden administration announced a "pause" on the granting of permits for new LNG export in order to study "potential cost increases" and, more centrally, to assess "the impact of greenhouse gas emissions." This came as a surprise to many, given the strategic role of US LNG, the large financial commitments already made to new projects, and the boost it would give to competing projects in other countries.[35]

Permitting has become a vexing issue across the energy spectrum. One thing on which both conventional energy and renewable companies agree is that the permitting system in the United States is dysfunctional. It is challenging new wind projects. It is stalling the development of new mines in the United States that can produce the minerals required for electrification and reduce dependence on China. Getting through the permitting process can take multiple years, adding significant costs, and then still be subject to further judicial challenges; sometimes it seems destined never to end. Altogether, according to S&P Global research, it can take nearly twenty-nine years to go from mineral discovery to production in the United States.[36] As US Senator Joe Manchin, chairman of the Senate Energy Committee, put it, "America's permitting process is broken, consumed by bureaucratic delays and endless litigation at every turn."[37]

The overriding legislation that covers environmental permitting is the National Environmental Policy Act (NEPA) of 1970. It requires "federal agencies to assess the environmental effects of their proposed actions prior to making decisions."[38]

In May 2024, the US Council on Environmental Quality published a new rulemaking—the so-called NEPA Phase 2—to "simplify and modernize" the federal environmental review process. Phase 2 is the response to a wide chorus of complaints about what sometimes seems the almost endless—and expensive—NEPA process. As it turns out, however, Phase 2 moves closer to a two-tier approach. For those projects deemed to reduce GHG emissions (e.g., renewable power projects or new electricity transmission lines), the review process is to be simplified and expedited. But, for conventional projects, the review process will be expanded and made more complex, requiring evaluation of direct and indirect impacts on emissions and climate, as well as community and environmental justice impacts. All this will further complicate and stretch out the review process. Moreover, a natural gas project would face a new test—having to prove that low-emitting alternatives (e.g., renewable power) could not just as readily meet the expected demand. The Biden administration's NEPA Phase 2 is encountering fierce congressional opposition and the charge that it "rides roughshod over the bipartisan, bicameral consensus on streamlining federal permits."[39]

One can identify many other areas where national energy policy is really national climate policy, ranging from offshore leasing to new natural gas–fired power projects to requirements regarding home furnaces. And litigation is usually the follow-on to the publication of the new regulations in the *Federal Register*. Many states are pursuing similar policies, including mandates requiring growing shares of renewables in electric generation. New York State has banned gas-fired stoves in new residential buildings under seven stories and, after 2027, in taller buildings. California has banned the sale of cars with internal combustion engines by 2035, which is just a decade away. That state also requires that 90 percent of its electricity come from renewables by that same year and is pledging a 94 percent drop in state oil consumption in twenty years. At the same time, California is contending with electricity prices that are the highest in the continental United States and more than double the national average.[40]

THE CHALLENGES

The IRA paints a picture of what the other side of a net zero energy transition would look like—a new system composed of renewable power, biofuels and sustainable aviation fuel, hydrogen, e-fuels, EVs, carbon capture and direct air capture, greater energy efficiency, and new materials. It is all meant to prepare a future that is highly electrified, be it transportation, buildings, or industrial processes.

But turning this picture into reality inevitably encounters real-world obstacles.

The Biden administration's goal is that half of new vehicles sold in the United States by 2030 should be EVs. "New energy vehicles," as Beijing calls them, have certainly taken off in China. Their progress has been propelled by mandates, regulations, and incentives—all of that underpinned by the government's alarm about depending on imports for 75 percent of its total oil supply and by the objective to be the dominant player in the world's EV supply chain. In the first half of 2024, a fierce price war among Chinese companies helped drive sales of new "new energy vehicles" toward 50 percent of total sales. In major European markets, the rate of adoption has slowed—in Germany slipping from 26 percent in fourth quarter 2023 to 18 percent in first quarter 2024 after subsidies were removed. Overall, EV sales in Europe are running at about 20 percent of total sales.[41]

It is a different story in the United States where, at least so far, EV penetration has been much slower—9.5 percent of new car sales most recently. That divides into 7.2 percent for battery-powered and 2.3 percent for plug-in hybrids. This rate of penetration is to the disappointment of automakers, who are investing billions of dollars in preparing for the EV surge, and an administration that wants them to make that investment. Yet auto dealers complain about EVs sitting on their lots unsold or only being sold at a loss. Some four thousand dealers signed on to a letter to the Biden administration asking it to "hit the brakes" on the aggressive push for EVs and protesting the tough new EPA emission standards that support the "electric vehicle mandate." Despite more generous incentives (some states top off the federal subsidies), many car buyers have range anxiety and worry about availability of charging—which is being deployed at a slower rate than anticipated—and are unpersuaded about the advantages of a full-battery EV over a gasoline-powered or hybrid car. There's also the matter of upfront costs and lower resale values.

Recent price cuts could bring in more buyers, as is happening in China. However, electric cars in the United States now seem to face an obstacle that was unanticipated. They have become caught up in what is widely described as the "culture wars" and what pollsters describe as the "politization of EVs." Their mandating is seen by some conservative voters as an embodiment of progressive policies and values. In the meantime, to the surprise of automakers, there is a renewed interest in what had seemed an "also-ran"—hybrids that combine electric motors with gasoline engines.

Renewable power is on a fast track for growth, as already noted above. At this point, it is anticipated that 70 to 80 percent of the new electricity generating capacity that will be added

in the United States in the years ahead will be renewables—wind and solar, increasingly backed up by battery storage. But that path is not as clear as it seemed a couple of years ago. Wind's advance has been hindered by what have been higher interest rates, supply chain bottlenecks, and rising costs, along with permitting delays, local opposition, and judicial challenges.[42] Much-anticipated wind projects offshore of the East Coast have been cancelled or postponed owing to sharp increases in costs—or renegotiated with higher subsidies. Suppliers of key components to the wind industry have been cautious in building up capacity for fear of boom-and-bust cycles. As an example, special cabling required for offshore wind that is ordered in 2024 probably cannot be delivered until 2028 at the earliest. Further complicating supply chains is the concern about potential political risks from using Chinese components and equipment and the worry that contracts for future delivery of equipment may be disrupted by new restrictions.

Another challenge is the need to assure affordable and available energy to the American public. In its first year in office, the Biden administration was unexpectedly faced with a global oil market that was tightening, owing to the post-COVID global rebound in demand, which in turn sent prices up. Just ten months after entering the White House, President Biden ordered a release from the Strategic Petroleum Reserve to put more supply into the market to address what he called "the problem of high gasoline prices" and was urging oil companies to increase production.[43]

This occurred four months before Russia's invasion of Ukraine, with the major disruptions in oil and gas supplies that followed. The administration subsequently orchestrated further releases from the Strategic Petroleum Reserve, which in total reduced the actual reserve by 45 percent. When Russia cut off natural gas pipeline supplies to much of Europe in Putin's drive to undermine support for Ukraine, the Europeans compensated for a major part of the loss with much-increased imports of LNG, of which, as noted, 40 percent came from the United States, processed from shale gas. In short, notwithstanding climate ambitions, the requirements of demand and security have meant a renewed emphasis on ensuring the adequacy of oil and gas supplies.

A new issue is emerging for the energy transition: ensuring the "reliability" of electricity supplies—"reliability" being a subset of energy security. The Biden administration's target is carbon-free electric generation by 2035. Achieving that would require squeezing out natural gas and coal, which together currently constitute 60 percent of generation.[44] Under that rubric, the only way that natural gas could stay in the system is with big advances in carbon capture on the part of gas producers and electricity generators.

That goal was predicated on the assumption that the future would resemble the past: over the last ten years, the nation's electricity demand has been almost flat, growing at just 0.35 percent per year. But the last year or so has brought the realization that demand is now on a track to grow much faster—S&P Global estimates almost 2 percent annually—taxing the current infrastructure. Between 2022 and 2023, PJM, which manages electricity transmission in the region stretching from Illinois to New Jersey and Maryland, doubled its long-term forecasts

for annual growth in electricity demand. One major utility in the southeast noted in April 2024 that its power demand was growing faster than forecast just seven months earlier. Many utilities are substantially increasing their forecasted need for new generating and transmission capacity.

Three factors have come together to fuel this coming but unanticipated ballooning of demand. One is the mounting "energy transition demand"—from EV charging and the overall push to electrification. The second is the impact from increased manufacturing resulting from the CHIPs and Science Act, the IRA, and other incentives, and from the reshoring of supply chains. But the most significant of all is the rapid growth of data centers and the cloud, crypto mining, and the rollout of artificial intelligence (AI). An AI search takes much more electricity than a conventional Google or Bing search. Data centers will become major factors in total US electricity usage, projected by the Electric Power Research Institute to grow from 4.6 percent total electricity to as much as 9.1 percent by 2030.[45] The number-one priority for siting a data center has become assured access to reliable twenty-four-hour power. As Bill Gates explained at CERAWeek, "Cloud companies . . . think about a data center" according to "its power requirements. . . . A long time ago we'd say, 'Oh, we have 20,000 CPUs—central processing units. Now we just say, 'This is a 300 megawatt data center.'"[46]

Meeting this surge will require a great deal of new investment. But implementing that will require success in running a complex gauntlet of permitting processes, supply chain bottlenecks, regulatory approvals, and challenges from consumer and environmental groups. It also means that natural gas could end up playing a much larger role in meeting demand growth and balancing the intermittency of wind and solar than had been contemplated when the IRA was passed and the 2035 carbon-free target for electricity was laid down. That unanticipated role for natural gas is reflected in the growing orders for natural gas turbines, as utilities hasten to prepare for surge in consumption that was not in their plans two years ago.

However, natural gas will face a growing competitive challenge from the integration of batteries into the electric power system and advances in battery chemistry—for batteries can store surplus electricity produced by solar and wind when the sun is shining and wind is blowing and then release that electricity when neither is operating. Widespread adoption of batteries would help turn "intermittent" supply from wind and solar into "firm" supply over the entire twenty-four hours.

But, overall, this growth in electricity demand comes with a major risk: any significant blackouts or disruption of electricity supplies will have massive impact on, and lasting reverberations for, energy policy.

The surge in electricity demand is providing further momentum for the revival of nuclear power. The IRA provides the aforementioned tax incentives to enable conventional nuclear power plants to remain competitive—and operating. The lives of existing nuclear power plants are being extended, but it is highly unlikely that any new large-sized conventional nuclear plants will be built because of the perennial experience of cost overruns and regulatory delays and

disruptions. The focus has now shifted to advanced designs and, in particular, small modular reactors. But deployment is probably not something that will happen before the 2030s. Fusion has attracted billions of dollars in venture funding, and companies and research institutions are working on scores of advanced nuclear reactor projects. One constraint that only recently is being addressed is a heavy dependence on Russia, which has 44 percent of world enrichment capacity and has been supplying a third of US imports of uranium fuel. Legislation passed in 2024 bans imports of Russian uranium beginning in 2028, but that leaves the question as to where to source uranium.

FROM "BIG OIL" TO "BIG SHOVELS"

A further challenge involves the new supply chains required for the energy transition—what I describe in *The New Map* as a shift from "Big Oil" to "Big Shovels." In other words: more mining and more minerals. The International Energy Agency has warned that the net zero 2050 target will "supercharge demand for critical minerals" as the world moves from a "fuel-intensive to a mineral-intensive energy system."[47] This prospect has raised alarm for the US government in that while "global demand for these critical minerals is set to skyrocket," the additional supply will fall far short of what is required "as the world transitions to a clean energy economy."[48]

But what is that risk? S&P Global has sought to quantify the requirements by focusing in on copper, the "metal of electrification." In order to meet climate and emission goals for 2050, its study concluded, world supply of copper would have to double by 2035.[49] That is extremely unlikely, owing to the fact that it can take twenty years on average globally to bring on a new Tier 1 mine. There are not only the technical, engineering, and logistical challenges for developing a mine. There are also the permitting and regulatory processes, compounded often by opposition from environmental, political, and local groups. What is true for copper also holds true for other minerals. Clearly, this spike in demand provides incentives to apply technology to wrest increased output from existing mines, despite declining ore qualities, as well as for innovation in new materials, new battery designs, substitution, and recycling. But all of that takes time to develop and get to scale.

But it's not just physical supply when it comes to minerals. It's also geopolitics—particularly rising tensions between the United States and China. Chinese state-owned companies are among the leaders in mining around the world. Even more than that, China dominates processing of minerals into metals. China, for instance, mines 90 percent of rare earth minerals and processes 60 to 70 percent of cobalt and lithium ore.[50] The United States has taken the lead in establishing a Minerals Security Partnership with thirteen other countries to "diversify supply chains," but that is challenging given lead times, investment needs, opposition to mining, complex and time-consuming permitting processes, and environmental challenges to the kind of industrial facilities that can turn ores into usable metals. In sum, how the growing demands of energy transition will match up with the limits of mineral supply will be a major test—and potentially a significant constraint.

REGULATION AND THE END OF THE CHEVRON DEFERENCE

For decades, energy and environmental regulation by federal agencies has been guided by "Chevron deference," a doctrine resulting from a 1984 Supreme Court decision that regulatory agencies have "precedence" in interpreting ambiguous or unclear federal legislation—or on which legislation is "silent." By one count, more than eighteen thousand court decisions have been based on Chevron deference in the four decades since.[51] While it had somewhat eroded over time, Chevron had remained the law of the land.

No longer. In a highly consequential decision—*Loper Bright v. Raimondo*—the Supreme Court ruled on June 28, 2024, in a 6 to 3 vote, that it is up to judges to decide what the law says, not regulators. Writing for the majority, Chief Justice John Roberts said that it is "the responsibility of the court to decide whether the law means what the agency says" and that courts are meant to "decide legal questions by applying their own judgment." Writing for the minority, Justice Elena Kagan declared that the decision "will cause a massive shock to the legal system" by giving judges, who lack technical expertise, "exclusive power over every open issue—no matter of how expertise-driven or policy-laden."[52]

The end of Chevron deference will inevitably mean a new legal order of litigation and with that more uncertainty. The authority of agencies to issue energy and environmental rules and regulations, as in other regulatory realms, will be subject to much more extensive review by numerous federal judges throughout the country. Regulators may no longer be able to require "climate impact" evaluations without explicit legislative authorization. Less well recognized is that the decision allows other experts to present their views on an equal basis, as in other litigation. In other words, the court would accord scientists from a university or a national laboratory the same "expert" status as those from the regulatory agency, which is now not the case. As one analysis concluded, "The end of Chevron deference implies a new era of volatility in the legal and regulatory landscape for US energy and climate policy. Everyone from projects developers and operators to investors and local stakeholders should prepare accordingly. . . . The ruling undermines [the Biden's administration's] sweeping regulatory efforts toward economy-wide decarbonization." The decision will inevitably have an impact on aspects of the IRA.[53] In another decision three days later, *Corner Post*, the Court further changed the landscape, opening the door to a litigation challenge well more than six years after promulgation of a regulatory action, which is now often taken as the limit.

THE NEXT ADMINISTRATION

The greatest uncertainty is looming—the outcome of the 2024 presidential election, as well as elections for the Senate and House of Representatives. The Democratic and Republican Parties, obviously, have dramatically opposed positions on environmental and energy issues.

However, the question is no longer what a second Biden administration would do but rather a first Harris administration. During her campaign for president in 2019, Kamala Harris was much in keeping with the progressive wing of the Democratic Party. She pledged both a "ban" on fracking and on new fossil fuel infrastructure, released a $10 trillion plan for net zero, and

promised to prosecute oil companies for their "accountability" on climate. She endorsed the Green New Deal and subsequently co-sponsored it as legislation. She also introduced a bill requiring an "equity" scoring on energy and environmental legislation, meant to parallel the Congressional Budget Office's scoring of spending costs of legislation.

Once she became Joe Biden's 2020 running mate, she shifted on shale. "Without any ambiguity, Joe is clear," she said during the 2020 campaign. "We will not ban fracking."[54] Four years in the White House reinforced the shift. As her 2024 race got underway, the Harris campaign sought to distance her from positions taken in 2020, notably now saying she "will not seek to ban fracking." In August 2024, she explained, "What I have seen is that we can grow and we can increase a thriving clean energy economy without banning fracking."[55] A prohibition on fracking, if actually implemented, would mean that the United States would be importing almost 80 percent of its natural gas and almost 70 percent of its oil and, as a result, competing with China to be the world's largest oil importer. The geopolitics are clear: no one would benefit more from a ban on fracking than Vladimir Putin, for it would press Europe back to importing Russian pipeline gas and push Japan to increase imports of Russian LNG. It was also clear that a prohibition would be poorly received in the swing state of Pennsylvania, which is benefiting economically from shale.

During the Biden administration, Harris has been characterized as a "climate diplomat." That is certainly the role she played at the COP 28 Conference in Dubai in December 2023. "We must treat the climate crisis as the existential crisis that it truly is," she said in Dubai. "The clock is no longer just ticking; it is banging." As president, she would certainly promote a "whole-of-government" doubling down on climate action, both domestically and internationally, with a stronger emphasis on "equity." A new departure is likely to be a focus on what one current Biden policymaker has called "the elephant in the room"—the emissions associated with world trade. The aim would be to rebuild the "current global trading system . . . to curb emissions" and revise "international economic systems, including trade—and harness them for climate action."[56] This points to what in Europe is called a "carbon border adjustment mechanism," essentially a carbon tariff.

On climate policy overall, what could not be achieved through Congress would be sought through more regulation and administrative action, although the end of Chevron deference could limit the administrations' ability to do so. Harris has indicated that implementing the IRA will be a central vehicle for meeting her administration's goals. And the IRA bears her signature as well as Biden's. When the IRA came to a vote in the Senate, it was a tie—50 to 50. As president of the Senate, Harris broke the tie, casting the deciding vote that made it a law. As she left the Senate floor, she declared, "This is a great day."[57]

For Donald Trump, that was not a great day. There would be no such continuity with a Trump victory in 2024. As the transition from Obama to Trump and then Trump to Biden brought abrupt changes in direction, so would be the case with a second Trump administration. Climate would no longer be the organizing principle of energy and environmental policy. While the Republican platform does not mention "climate," it does pledge to "unleash Energy Production from all sources, including nuclear," and promises to terminate "the Socialist

Green New Deal."[58] As Trump in 2017 and then Biden in 2021 each looked for high-visibility "first days" symbolic events, so would a new Trump administration. Trump has already indicated what one initiative would be: "I would end the Electric Vehicle Mandate on day one, thereby saving the US auto industry from complete obliteration," he said.[59] He has said he will once again withdraw the United States from the Paris Agreement. He's also likely to immediately revoke the "pause" on granting LNG licenses and to launch opposition to ESG investing and ESG corporate disclosures. A second Trump administration is very likely to do something it did not do in the first administration—review the US engagement with the International Energy Agency, which House Republicans have criticized for, they say, shifting away from its "core energy security mission towards radical climate policy advocacy."[60]

But what happens to the Biden administration's biggest signature legislation, the Inflation Reduction Act? The IRA, said Trump, "has nothing to do with inflation reduction" but "much more to do with the green new scam, which is what it really is."[61] Yet the IRA is a law and, unless repealed, will remain so. It is a Democratic law, in that no Republican member of the Senate or House of Representatives voted for it. How much of that partisan opposition would be offset by the subsequent implementation would be one of the open questions. Much of the money is going to "red states," and Republican governors have been supportive of those financial flows into their states. Moreover, the agnostic nature of the IRA means that a broad range of companies are engaged, and thus a wide range of workers, and it is drawing significant investment into the United States from non-US companies. The law, while remaining in place, could be amended or differently implemented in practice. There would be much flexibility on spending and discretion on how money is programmed or redirected or reduced, and on the application or continuation of various tax credits.

CONCLUSION: HOW FAST?

Over the last decade and a half, the United States has developed a much stronger position in terms of energy security. This is the result of multiple factors: the shale revolution, which has completely reversed the country's relationship to global oil and gas markets; the advances in wind and solar; greater efficiency in use of energy; and an innovation ecosystem that continues to open new doors.

But risks are certainly still there. The United States remains integrated into global markets and is vulnerable to disruptions and crises in those markets. Cyberthreats to energy infrastructure are a growing concern. Rising tension between the United States and China puts a spotlight on the concentration of minerals supply chains. The resilience and reliability of the electric power system has always been a primary concern. But the increasing electrification of the overall economy—central to the energy transition—means that resilience becomes an even greater priority. How quickly and to what extent and in what ways will America's energy system change? Wind and especially solar are being deployed at rapid rates. Yet, overall, as noted earlier, between 2022 and 2023 the share of hydrocarbons in total US energy declined by just four-tenths of 1 percent—from 81 percent to 80.6 percent. Given that the system is still over 80 percent based on hydrocarbons, one has to conclude that, despite the formidable engines of policy, this moment is still early in the transition.

The answers about the pacing and nature of change will emerge from the convergence of policy and public opinion, technology and innovation, finance and economics, the robustness and flexibility of supply chains—and geopolitics. The wide range of uncertainty can be indicated in just two of these elements. In terms of technology and innovation, how quickly will batteries improve both for cars and for electricity storage, how quickly will new data centers become less electricity-intensive than now anticipated, how quickly will the cost come down for the electrolyzers needed to make green hydrogen? In terms of geopolitics, will rising geopolitical tensions disrupt global supply chains for minerals and trigger unexpected cyber-induced disruption in electricity supplies?

In short, there is no clear-cut answer to the question of how quickly and in what ways America's energy system will change. As would be expected, there are many different perspectives. Yet one informed view was provided by Joe Biden in an unscripted comment that he added during his 2023 State of the Union address: "We're going to need oil at least for another decade . . . and beyond that," he said. A week later, for clarity's sake, he elaborated, "We're going to need oil for a long time, gas for a long time. It's not going to . . . go away."[62] But how long is long? That is up to time to tell.

NOTES

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2. Daniel Yergin, *The New Map: Energy, Climate and the Clash of Nations* (New York: Penguin, 2021), 12.

3. The ban on exporting refined products like gasoline and jet fuel had been lifted in 1981 with no fanfare. Yergin, *The New Map*, 53–55.

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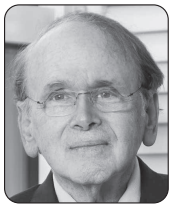

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