# Chapter 5
# The Geopolitical Implications of a Clean Energy Future from the Perspective of the United States

**Varun Sivaram and Sagatom Saha**

## 5.1 Introduction

Energy has historically shaped geopolitics, the effect of geography on international politics. As a result, energy has shaped U.S. foreign policy. Since WWII, America has presided over the international order as its principal superpower. The United States has waged wars to thwart those who would disrupt the free flow of oil, built alliances to ensure its supply, and led institutions and coalitions in hopes of preventing nuclear proliferation while abiding peaceful use of nuclear energy.

Sometime this century, an energy transition is likely to take place, replacing with clean energy sources the fossil fuels that serve more than 80% of humanity's energy needs today (World Bank 2014). That transition could happen for many reasons. Countries around the world may decide to seriously confront climate change, various clean energy technologies could become much more affordable, and countries may be enticed by the energy security that accompanies domestically produced clean energy.

Even after this transition, energy is likely to continue shape global geopolitics, albeit in very different ways. This new energy landscape could see the United States lose its privileged position at the center of it all. In some ways, this might benefit America. For example, if it is less dependent on fossil fuels in the future, the United States may be able to retrench from the Middle East, saving both blood and treasure.

But the United States also has plenty to lose from shifts in the energy landscape. If Russia leaves the United States behind as a leading exporter of nuclear power,

V. Sivaram (✉) · S. Saha
Council on Foreign Relations, New York, USA
e-mail: vsivaram@cfr.org

S. Saha
e-mail: sagatom.saha@gmail.com



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it could expand its coterie of client states in the developing world, eroding U.S. diplomatic leverage. And if countries around the world race to protect infant industries to capture a share of the growing clean energy economic pie, then the international trade regime that has brought America postwar prosperity could crumble.

The energy choices the United States makes will determine whether it can retain its central geopolitical role. By investing in energy innovation, the United States can command the advanced energy industries of the future, enhancing its energy security, amassing soft power, and shaping the future international order. And by leading worldwide action to confront climate change and commercialize clean energy technologies, the United States can build global goodwill that spills over to advance U.S. interests in other international fora.

This chapter explores five aspects of the global transition to clean energy, imagining hypothetical but plausible ways the world might unfold through 2050. The next section provides some theoretical background and explains the approach to selecting these five focus areas, into which subsequent sections dive. Finally, the chapter concludes with a discussion and set of recommendations to U.S. policymakers.

## 5.2 Theory and Approach

Theories of international relations are helpful in explaining many geopolitical aspects of energy in today's fossil-fuel-dominated world. These same theoretical tools are likely to be useful in helping to predict the geopolitics of a hypothetical future in which clean energy is much more prevalent. The literature comprises a wide range of theories, but to illustrate the explanatory power of the theoretical literature, it suffices to select two sufficiently different theories that are successful in explaining aspects of today's geopolitics of energy.

First, realism is a school of thought that posits a backdrop of international anarchy and holds that the state is the most important unit of analysis to understand international relations. The ultimate goal of a state is its own self-preservation, and to achieve it, a state will seek to maintain an advantageous balance of power in comparison with other states (Morgenthau 1993). Power comes in many flavors, including military strength, economic output, and diplomatic alliances (Mearsheimer 2001).

Realism succeeds in explaining many aspects of state behavior in relation to energy. For example, for over a half-century, the United States has expended considerable military resources to promote regional stability in the Middle East and secure international sea lanes to ensure the reliable production and safe passage of American fossil fuel imports. Because energy is vital to U.S. military and economic power, the United States is willing to invest heavily in securing its supply. Elsewhere, Russia has employed its domestic natural gas resource endowment to improve the balance of power among it and its neighbors, throttling or expanding the flow of gas to achieve its military, economic, and diplomatic goals (Yergin 1991).

Second, liberalism is a school of thought that differs sharply from realism but successfully explains some aspects of the geopolitics of energy where realism might fall short. Liberal theorists contend that the state is not necessarily the only, or even best, analytical unit to understand every aspect of international relations. Rather, other entities, like international institutions, can shape the behavior of states and choices (Moravcsik 1992). In addition to institutions, international norms can also influence states. Together, institutions and norms can facilitate mutually beneficial outcomes among states that would not materialize in the strictly anarchic setting, populated by purely self-interested states, that realists posit (Keohane and Martin 1995).

There is strong evidence to suggest that liberalism has explanatory power in some areas of the geopolitics of energy. For example, states cooperate under the auspices of the International Energy Agency to hold fossil-fuel reserves in anticipation of a global supply shock. And states also cooperate through the International Atomic Energy Agency, often voluntarily allowing external officials to inspect domestic facilities, to promote collective nuclear security.

Sharp disputes have arisen between these two schools of thought and among others in the literature. This chapter does not take sides in those debates. Rather, recognizing that these various theories have had explanatory success to date, this chapter seeks out aspects of the shifting energy landscape that could have geopolitical significance under one or more theories of international relations. For example, in a future dominated by clean energy, realism holds that states will continue to pursue their interests and seek an advantageous balance of power. Therefore, this chapter will delve into the opportunities and risks posed by clean energy to the military, economic, and diplomatic strength of states. By contrast, because liberalism holds that institutions and norms will continue to matter, this chapter will also explore ways in which they might lead to mutually beneficial outcomes in a clean-energy future—or ways in which their erosion might compromise those outcomes.

In exploring these geopolitically significant implications of a clean-energy future, this chapter will focus on what America's place in the world might look like and how that would affect its prosperity and security at home. Collectively, the five themes explored below could affect America's energy, economic, and national security as well as its relationships with other countries and with international institutions.

The first aspect of a clean-energy future that this chapter examines is merely an extension of the current literature on energy and geopolitics (Kalicki and Goldwyn 2005). Today, energy security figures prominently in America's continued military presence in the Middle East, but in the future the United States might sharply curtail its consumption of oil, reducing its exposure to price volatility arising from global supply shocks. This could change the military, economic, and political calculus of maintaining a strong presence in the Middle East.

The implications of more or less exposure to Middle East oil are well described by the existing literature, so evaluating a clean energy future amounts to little more than applying existing analytical tools to a new set of assumptions. But this chapter subsequently aims to do more as it takes up four other aspects of a clean energy future. Rather than just study the geopolitics of the absence of fossil fuels, it aims to study the geopolitics of a sharply increased presence of clean energy.

Clean energy includes nuclear energy, much more of which will be needed alongside renewable energy for the world to reduce its emissions in a cost-effective and timely manner (Cao et al. 2016). But if the U.S. nuclear industry continues to stagnate, and countries like Russia and China continue to invest heavily in their industries, then America will sit on the sidelines of the race to capture emerging nuclear markets and win diplomatic leverage. The section on nuclear energy envisions such a future and assesses the damage to U.S. strategic interests.

There are many other geopolitical implications of the rise of clean energy. For example, in a hypothetical future characterized by substantial renewable energy, countries are likely to have upgraded their power grids to accommodate intermittent wind and solar power. As the section on the power grid envisions, the United States may in the future have both a bigger grid, connected to those of its North American neighbors, as well as a smarter grid connected to the internet. These raise questions about how America will cooperate with its neighbors and what cybersecurity threats it could face from newly digital critical infrastructure.

Trade in energy is another geopolitically loaded subject, and this would remain true in a clean energy future. As the section on trade describes, the U.S.-led international trade regime might face pressure if countries begin to consistently flout trade rules. But rapid growth of clean energy might compel countries to do just that, to avoid being left out of a new distribution of energy haves and have-nots. If so, America would find itself at the helm of eroding trade institutions.

The fifth and final aspect of a clean-energy future that this chapter examines is the opportunity for the United States to lead international cooperation on clean energy and climate change. It could do so through established institutions like the United Nations Framework Convention on Climate Change (UNFCCC) or even brand new ones. Yet under the Trump administration, the United States has retreated from, rather than demonstrated leadership in, international climate and clean energy institutions.

This list is not exhaustive. The five themes, however, were chosen because each of them relates to core U.S. strategic interests. Many of them are specific instances of the general expectations for interstate energy relations in a clean-energy future predicted in Chap. 1, which include: a change in leverage away from fossil-fuel producers; regionalization of energy markets; increased importance of distributed energy resources; and growing economic competition in the clean-energy value chain.

To examine each of these five geopolitically significant aspects of a clean-energy future, this chapter will take a three-step approach. First, it will introduce the present-day context, focusing on early signs of future trends toward increased clean energy prevalence. Second, it will postulate a hypothetical scenario for the world in

2050, in which clean energy does in fact rise sharply, in order to make inferences about geopolitics and U.S. foreign policy in such a future world. Nearly all data for these scenarios come from the International Energy Agency (IEA) or other public sources; in some cases, additional calculations and forecasts from the academic literature are used. The third step is then to enumerate the implications for America's place in the world and its prosperity and security at home.

The chapter will conclude by briefly discussing lessons learned and making recommendations to U.S. policymakers.

## 5.3 The Fading Geopolitics of Fossil Fuels: New Dynamics with Established Powers

America's relationship with the Persian Gulf could drastically change by 2050 as it adopts clean energy. The United States currently maintains a strong military presence in the region, in large part to prevent disruptions in global oil supplies. But the American economy could be far less exposed to oil shocks in the future if it reduces its oil demand and develops stronger buffers against supply disruption.

The United Kingdom's withdrawal from the Gulf during the Cold War provides a template for how America's drawdown might look. In such a scenario, America might substitute its permanent presence for a lighter footprint and redirect its naval power elsewhere to address more pressing security concerns. Yet regional instability might deter a full U.S. withdrawal.

### *5.3.1 Context*

America has long considered the Persian Gulf central to its national interest. Driven by concerns over global oil supply, President Franklin D. Roosevelt declared "the defense of Saudi Arabia as vital to the defense of the United States" in 1943, authorizing U.S. military aid to the Kingdom (Klare 2013). As the region constituted most of the world's non-Soviet oil at the time, a large supply disruption in the Gulf would have been disastrous to the United States (Glaser and Kelanic 2017).

Such a disruption came to pass when the Organization of the Petroleum Exporting Countries (OPEC) set an embargo on oil in 1973 (DOS n.d.). The price of oil in the United States quadrupled, imposing daunting costs on consumers and the wider economy. Between 1973 and 1975, U.S. GDP plummeted 6% and unemployment doubled to 9% (Hayward 2015). The U.S. economy is still exposed to oil prices today. Though it is difficult to estimate the direct economic cost of oil dependency, economists suggest a 10% increase in oil prices shaves 0.4% from GDP. If prices were to double today, economic output would shrink by 3% or about $550 billion (Glaser and Kelanic 2017).

Echoing FDR's doctrine, President Carter, in a State of the Union address, proclaimed that "an attempt by any outside force to gain control of the Persian Gulf region will be regarded as an assault on the vital interests of the United States of America, and such an assault will be repelled by any means necessary, including military force." (Peters and Woolley n.d.a). He later created the Rapid Deployment Force, which would become U.S. Central Command (CENTCOM), America's unified U.S. military command responsible for the Middle East (Cordesman 1991).

Today, the U.S. military presence in the Gulf is still motivated by preventing both deliberate and unintended oil supply disruptions. The first mission is to ensure that countries in the region—in particular, Iran—cannot purposefully disrupt the flow of oil through the Strait of Hormuz. An extended closure would be devastating, blocking 20% of the world's oil supply (EIA 2012; Glaser and Kelanic 2017). The second mission is to backstop stability for major supplier-countries to guarantee steady production. Iraq's invasion of Kuwait alone cumulatively wiped 420 million barrels from world supply from 1990 to 1991 (Fattouh 2007). Either scenario—deliberate or unintended disruption to oil supply—would cause a surge in the price of oil, harming the U.S. economy.

To guard against these scenarios, the United States maintains roughly 35,000 troops in the Gulf, one-third of which are stationed in Kuwait (Katzman 2016). The remainder are positioned throughout the region in the United Arab Emirates, Oman, Bahrain, and Qatar. America's naval presence in the region is anchored by the Fifth Fleet, which patrols the Persian Gulf (Allen 2017). The fleet consists of several carrier strike groups, expeditionary strike groups, and a number of other ships and aircraft (Pike 2011a). The U.S. military also operates rotating Marine Expeditionary Units, brigade-size quick reaction forces for immediate crisis response (Pike 2011b).

It is difficult to attribute exactly how much the United States spends on protecting the flow of Gulf oil, given that many of these military assets also serve other purposes. However, experts estimate the cost at between 12 and 15% of the defense budget—roughly $90 billion dollars (Crane et al. 2009). Another assessment places U.S. defense spending attributable to oil imports at roughly $15 for each imported barrel (Hall 1992).

### *5.3.2 The End of Middle East Oil Dependence*

In the future, the United States may not be as nearly vulnerable to oil price shocks. To understand the resulting geopolitical shifts, this discussion explores how the United States might reshape its foreign policy if by 2050 it shielded itself from swings in Gulf oil supply. Such a scenario is plausible because in the coming decades, U.S. oil consumption could very well plunge while America and other countries could improve buffers to supply disruption.

#### 5.3.2.1 Decreased Domestic Demand

The lion's share of reduction in U.S. oil use would come from the transportation sector, which currently accounts for 70% of consumption (Glaser and Kelanic 2017). Oil demand from transportation has already been trending down for decades, so a drastic reduction is plausible. As one measure, U.S. petroleum consumption was lower in 2014 than in 1997 despite 50% economic growth in that period (EOP 2015). This reduction in the economy's petroleum dependence was largely because of higher fuel economy, though alternative fuels and electric vehicle (EV) adoption are playing an increasing role. Driven by lower technology costs and the need to combat climate change, all of these trends could accelerate through 2050.

First, substantial EV adoption would help the United States displace conventional vehicles. Though the U.S. is the second largest market for EVs, EV share of the U.S. vehicle market stands at a paltry 0.7%, suggesting significant room for future growth (IEA 2016a). Globally EVs are expected to account for 35% of new sales by 2040 (Randall 2016). In the United States, new sales could be as high as 50% by 2030 (Roelofsen 2016). Rapid global adoption of EVs could reduce oil consumption by 2 million barrels by 2028, creating oversupply equivalent to what triggered the 2014 oil price collapse (Randall 2016). Other developments like persistent increases in fuel economy for conventional vehicles would also decrease U.S. oil demand. Similarly, the emergence of cost-effective alternative fuels like advanced ethanol would increase oil's demand elasticity, making consumers more responsive to potential price increases.

Taken altogether, these trends could cumulatively cut U.S. oil consumption by 2 million barrels below today's level by 2040 and even more by mid-century (EIA 2016). Decreased oil consumption of that magnitude would greatly temper the effect on the United States of any disruption in Gulf oil supply.

#### 5.3.2.2 Improved Security Alternatives

Second, this scenario sees the United States, along with several other countries, increasing the size of their strategic petroleum reserves (SPRs), limiting the effects of any supply disruption. The U.S. SPR holds up to 727 million barrels of oil, or roughly 150 days of import protection at current consumption (DOE n.d.a). The International Energy Agency (IEA) requires its members, who represent nearly half of worldwide oil consumption, to keep 90 days' worth of import cover, (IEA n.d.a). Collectively, these governments hold 110 days of global import cover, with an additional 119 days stored in the private sector (IEA n.d.b).

Though the U.S. government has not indicated plans to increase the SPR's capacity, it may do so in the future, as doing so would be cheaper than costs associated with protecting Gulf oil. At an oil price of roughly $50 a barrel, expanding the SPR by 50% would only cost between $10 and $40 billion (Glaser and Kelanic 2017). It is also plausible that other countries would develop their own strategic reserves by midcentury, collectively creating a more effective buffer to global supply distributions. Already, non-IEA countries are developing their own oil stockpiles. China's reserve reportedly already holds 600 million barrels (Mufson 2016). In this scenario, the world's cumulative stockpiles would increase relative to global demand. Importing countries would be able to shield themselves from supply shocks by coordinating stock releases to balance disruptions. Thus, oil prices would not experience significant volatility even in the event of a major disruption to oil supply.

#### 5.3.2.3 Scenario Summary

Thus, the U.S. would be largely protected from an oil crisis in the Gulf, having satisfied two requirements: its economy would need less oil to function, and it would have better safeguards to mitigate supply disruptions that come to pass. And if global oil demand flags and Gulf production lags behind that of other regions, Gulf oil will be even less important to global oil markets and the U.S. economy. As these trends unfold, U.S. policymakers might finally decide to scale down America's military presence in the Gulf.

### *5.3.3 Implications*

Something as simple as a strong push toward reduced defense spending—a subject of continuing debate in Congress—could force the U.S. to reevaluate the value of its military commitment toward securing oil flows. If limited, what exactly might America's force posture in the region look like in 2050? The British withdrawal from the Middle East provides one prominent example.

Until the late 1960s, the United Kingdom maintained a large military presence in the region chiefly to secure access to oil. Indeed, after World War II, Gulf oil supplies accounted for most of the world's non-Soviet oil and were therefore critical to British security and that of its European allies (Luce 2009). Britain maintained garrisons with air and naval support in Sharjah and Bahrain while also financing local police and military forces in Oman and Abu Dhabi (Sato 2009).

Despite this, the need to cut defense spending and stimulate the economy forced the United Kingdom to abdicate its special influence. In 1968, the British government announced a complete military withdrawal "east of the Suez" (Sato 2009). Most of the military was either redirected to Europe to confront the Soviet Union or cut altogether.

Dennis Healey, UK secretary of defense at the time, noted, "Although we have important economic interests in the Middle East, Asia, and elsewhere, military force is not the most suitable means of protecting them, and they would not alone justify heavy British defense expenditure" (Francis 2000).

With far lower dependence on Gulf supplies, American policymakers could reach a similar conclusion by 2050. A persuasive push to rein in ballooning defense costs—as in the United Kingdom—could compel the United States to withdraw from the Gulf. In fact, it may become strategically sensible for the U.S. to abdicate its role as security guarantor if that role is perceived as a responsibility and burden to secure supply for other countries. Support for maintaining America's military presence could evaporate when it becomes clear that India and China, not the United States, would actually suffer most from an oil supply disruption (Murtaugh et al. 2016). There may be little support for shouldering security costs that benefit other countries that are more dependent on global oil markets and Gulf production.

Yet the United States is unlikely to completely relinquish an active presence in the Gulf because of its commitments to combatting terrorism and checking Iranian aggression. Still, whatever military assets remain would require more specific justification than the broad fiat exercised today. America's role may mirror its current security posture in Sub-Saharan Africa, where it maintains a relatively small handful of bases and spends comparatively less on counterterrorism operations (Taylor 2014).

Concretely, the United States could forego its legacy of permanent military bases and naval assets in favor of a lighter footprint. America could pursue its non-oil-related strategic goals in the Gulf by relying on coalition building with regional and international partners. The president might deactivate the Bahrain-based Fifth Fleet or redirect it to the Asia-Pacific where it originally operated. In coming decades, China's growing influence in the region may drive the United States to build a stronger presence there.

However, the same trends of reduced oil demand that could reduce U.S. military interest in the region may also portend increased instability in the Gulf, intensifying the need for America's security guarantee. Many Gulf countries rely heavily on oil revenues to maintain security. Widespread clean energy adoption globally at the expense of oil and gas would place enormous fiscal pressure on these countries to slash budgets (Saha 2016). Nations unable, or unwilling, to do so could incite new waves of regional instability. If this occurs, the United States will have to decide whether to intervene.

## 5.4 Nuclear: Proliferation, Market Power, and Leverage

The rise of clean energy will have geopolitically significant implications beyond just the reduction in fossil fuel dependence. A good place to start is with nuclear power, the geopolitics of which have already been extensively studied. The tradeoffs between expanding nuclear energy and increasing the risk of proliferation are well documented, and America's strategic interests are clearly intertwined with the future of nuclear power.

Although the rest of this volume focuses on future increases in renewable energy, this chapter takes the stance that the most plausible future scenarios in which clean energy has mostly displaced fossil fuels include nuclear energy in the zero-carbon energy mix. Nuclear energy is currently the world's second largest source of zero-carbon energy (hydropower is the largest), and attempting to replace fossil fuels with clean energy without using nuclear power would require unprecedented and unrealistic growth rates in renewable energy (Cao et al. 2016). Although expansion of nuclear power has stalled in the developing world, emerging economies remain eager to adopt it to improve energy security, power economic growth, and reduce emissions and air pollution. Moreover, nuclear energy could be crucial to enabling the integration of large amounts of renewable energy by providing a load-following function (Jenkins and Thernstrom 2017).

Therefore, this section explores the potential geopolitical implications of rising global nuclear power deployment from a U.S. perspective, taking into account current indications of which countries are poised to become leading nuclear suppliers in the future.

### *5.4.1 Context*

Though seemingly at odds, nuclear nonproliferation and support for civilian nuclear power have been pillars of U.S. foreign policy for more than half a century. In 1953, President Eisenhower gave his "Atoms for Peace" speech to the UN, in which he advocated for an international agency to both control and promote the deployment of nuclear power for peaceful use (Peters and Woolley n.d.b). Shortly after, Congress passed the Atomic Energy Act of 1954, which declassified U.S. reactor technology and opened research and development (R&D) to the private sector and other nations.[1]

The prospect of the rapid expansion of nuclear power raised strong concerns over the proliferation of hazardous fissile material. Many of the same technologies and materials used for civilian nuclear power—for example, highly enriched uranium (HEU)—can also be exploited for military use. In response to these fears, the International Atomic Energy Agency (IAEA) was created to supervise and monitor civilian nuclear power programs globally.

In collaboration with the IAEA, the United States has been a strong advocate for global non-proliferation efforts. U.S. nonproliferation policy centers on policing the flow of potentially dangerous nuclear materials, as well as deterring countries from pursuing nuclear weapons. The United States helped found the Nuclear Suppliers Group (NSG), which aims to prevent the transfer of nuclear material without IAEA safeguards. Under IAEA safeguards, countries file regular detailed reports and allow international inspectors to visit nuclear facilities to verify the reports (Nye 1981). In 2010, the Obama administration spearheaded the first Nuclear Security Summit (NSS) in an effort to secure loose nuclear materials globally and prevent nuclear terrorism. Between the last two summits in 2014 and 2016, an additional 20 countries have invited peer review of their nuclear security, including China,

[1]See: Energy Reorganization Act Of 1974. Pub. L. No. 93-438, 88 STAT. 1233 (1974).

Nigeria, and South Korea and fifteen countries including India, Pakistan, and Ukraine have implemented physical security upgrades or acquired security or detection equipment (Nuclear Security Summit 2016).

Despite U.S. efforts to limit the spread of nuclear materials, proliferation remains a serious threat to national security. The global inventory of civilian HEU stands at roughly 137 tons, enough to construct 5000 nuclear bombs (NTI 2016a). And 24 countries currently have enough nuclear material for weaponization (NTI 2016b). Compounding this, hundreds of tons of nuclear material around the world are stored under inadequate security standards. Despite the potentially catastrophic effects of nuclear theft or sabotage, international law regarding nuclear security remains weak (NTI 2016b).

At the same time, the U.S. largely benefitted from the rapid expansion of atomic power. Until the 1990s, the United States dominated the market as the main supplier of nuclear technology to the rest of the world (NEI 2012). This commercial leadership allowed the United States to design international nuclear security standards and cultivate long-term partnerships globally.

Despite the United States' early lead, other countries have since raced ahead in the nuclear export market, reducing the U.S. to a minor player (WNA 2016). Russia and China are collectively building two-thirds of the world's new reactors while the United States only accounts for 7% (David 2014).

The rise of Russia as a leading nuclear exporter is particularly important from a geopolitical perspective, given the range of international issues on which it and the United States are at odds. Russia's nuclear exports have grown steadily through aggressive government support and technological innovation. In 2013, the Russian government earmarked $37.5 billion for Rosatom, Russia's state nuclear firm, for the next eight-year period in an effort to strongly position its exports in the marketplace (Carbonnel 2013). Because of Moscow's support and Rosatom's willingness to provide loans to poorer countries, Rosatom is able to sell its nuclear reactors at far lower costs than its international competitors (Thoburn 2015). By 2010, the development and construction of a nuclear plant in Russia was $2.9 billion, about 20–50% less than Western equivalents (Matlack and Humber 2010). All the while, U.S.-based companies have been beleaguered by heavy regulation, cost overruns, and competition from cheap natural gas. What was once the most successful American nuclear company, Westinghouse, has filed for bankruptcy, signaling the possible end of new nuclear reactor construction in the United States (Clenfield et al. 2017).

### *5.4.2 A Nuclear Renaissance*

Despite the decline of nuclear in developed countries, the world might see nuclear energy rapidly grow in tandem with renewables in emerging economies. In such a scenario, developing countries would commit to adopting nuclear technology as they fuel economic growth and work toward achieving increasingly ambitious climate goals. And countries like Russia with advanced nuclear industries would continue to innovate, making atomic energy more attractive and less expensive while pushing exports for political gain. The following discussion lays out the details of such a scenario of the future.

#### 5.4.2.1 Demand Growth in the Developing World

Admittedly, nuclear power has been in steady decline in parts of the developed world like the United States, Japan, and Germany. However, future demand in emerging economies could more than offset this decline (WNR 2015). In an effort to combat climate change, ten countries—including three without nuclear programs—are already incorporating nuclear power into their climate pledges made under the Paris Agreement (IAEA 2016). India, whose climate plans predominantly rely on solar deployment, plans to boost its nuclear capacity eightfold (IAEA 2016). So far, nuclear energy is the only globally available source of clean and reliable power that can economically operate at a high capacity factor and modulate its power output to complement renewables.

It is plausible for the world to dramatically increase nuclear power capacity by 2050. Indeed, that is good news, given that global nuclear capacity would have to double by 2050 to limit global climate change under current projections (IEA 2015). International commitments to confront climate change might well speed the deployment of nuclear power. The Paris Agreement requires countries to update climate plans every five years to be more ambitious starting in 2020 (Northrop and Krnjaic 2016). By 2050, 195 countries would have strengthened their plans seven times over, suggesting that even more countries may incorporate nuclear power into their climate pledges. In this future, most growth in nuclear would come from developing countries, which currently have non-existent or limited nuclear power programs. And most of those emerging economies would be in Asia, which is already expected to increase nuclear generation sixfold by 2040 (EIA n.d.a).

Firms and countries are already investing in commercializing new nuclear technologies, which could open vast, new markets to nuclear power. In particular, small modular reactors (SMRs) could help civil nuclear programs thrive globally in coming decades. SMRs are nuclear reactors roughly one-third of the size of current plants (DOE n.d.b). These new reactors—compact and factory-fabricated—circumvent many barriers that prevent less developed countries from adopting nuclear power today. SMRs require lower initial capital investments, have greater scalability and siting flexibility, and can be transported by truck or rail (DOC 2011). Simply put, this means that nuclear power could be sited in countries that currently have financial and geographical barriers (DOE n.d.c). They are also much safer than existing reactors, which have sparked public fears.

And light-water SMRs may provide a bridge to the commercialization of the next generation of post-LWRs known as Generation IV reactors. These reactors are designed to be inherently safe and resistant to meltdown. Moreover, they can be more efficient, cheaper, and consume rather than create nuclear waste. SMRs and

Generation IV reactors alike could enable more renewable power because they are designed to quickly increase and decrease power output. As more intermittent renewable power is added to the grid, power generators that previously could operate as “baseload” sources will have to become dynamic, able to vary their power output to avoid blackouts and negative pricing. Generation IV reactors are expected to come online starting in the 2030s (NEA 2014).

In this scenario, by midcentury, new nuclear technologies would mature with demonstration and become more cost-effective through learning and production effects. Countries around the world would deploy advanced reactors, multiplying the overall number of nuclear sites and expanding geographic distribution of reactors. By 2050, it is easily possible that more than one-third of countries would have at least one nuclear reactor (Donovan 2015).

#### 5.4.2.2 A New Nuclear Suppliers Club

Russia will likely be a leader, alongside China, in the world’s burgeoning nuclear export market. Because Russian market power carries the most serious geopolitical implications from the perspective of the United States, this discussion focuses on Russia rather than China.

Rosatom already has export orders valued at more than $300 billion, 60% of the overall market, for 34 plants in 13 countries (WNA 2017). U.S. exports will remain uncompetitive unless Congress incentivizes investments in R&D and deregulates the cumbersome export approval process. Simply negotiating a nuclear cooperation agreement with the United States can take several years (CSIS 2013).

Russia’s market share will expand as long as the Kremlin considers it a matter of state policy. Over the last several years, Russian President Vladimir Putin has embarked on a series of international tours to sign nuclear power deals to shake off isolation after Crimea’s annexation and undermine U.S. diplomatic efforts (Chandler 2015). So far, Rosatom has already signed broad agreements or memoranda of cooperation on nuclear power with a variety of countries on nearly every continent (see Fig. 5.1) (Stratfor 2015). Russia is also racing ahead in the innovation race with plans to deploy two Generation IV reactors domestically by 2025 (WNN 2016). The combination of favorable financing and advanced technology could sustain Russia’s competitive edge for decades to come.

#### 5.4.2.3 Scenario Summary

In this scenario, at least one-third of all nations would have a nuclear reactor by 2050. Most added nuclear capacity would be built in the developing world, specifically in Southeast Asia and the Middle East where agreements have already been signed. In this future, Russia would be a leading exporter of nuclear reactors. The amount of unsecured fissile material through 2050 would multiply, significantly increasing the risk of nuclear terrorism.

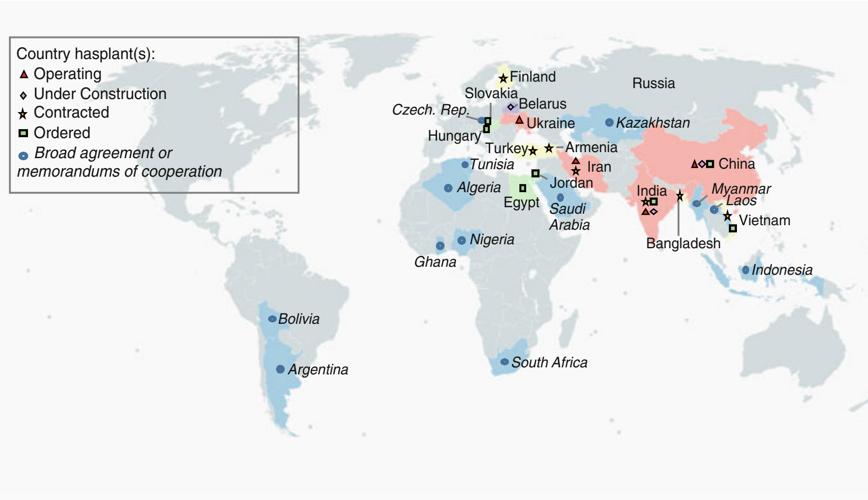


**Fig. 5.1** Russian exports of nuclear power plants (2015). *Source* World Nuclear Association (WNA)

## *5.4.3 Implications*

The resulting proliferation of nuclear material would create security risks for the United States, as well as its allies around the world. In response, the United States might try to invest abroad to help countries secure their nuclear stockpiles, an expensive proposition. It might also try to lead international fora to develop stronger nonproliferation standards.

But Russia, empowered by its booming nuclear exports, may be able to stymie these efforts as well as America's diplomatic agenda more broadly. Given the undesirable menu of choices the United States would face, the most pressing priority for America to undertake should be to revitalize its domestic nuclear industry and regain its status as a global nuclear powerhouse, with all the attendant diplomatic and security benefits.

### 5.4.3.1 Nuclear Proliferation

The widespread proliferation of nuclear material to less secure locations could grant terrorist organizations more targets for nuclear theft. Today, even though there are large quantities of unsecured materials, most of the world's civil nuclear stockpiles are sited in stable countries. By 2050, this may not be the case. How might America handle this emerging threat? U.S. support for Pakistan, an unstable country and nuclear power, offers one glimpse into how the United States might stem potential hazards.

Pakistan has the worst nuclear security of any country with weapons-grade fissile material (Oswald 2012). Its instability, fueled by poor governance and constant terrorism, provokes U.S. unease. In recent years, terrorist groups have been bold enough to mount raids on air bases storing nuclear warheads (Nelson 2012). The United States cooperates closely with the Pakistani government to prevent nuclear theft. The U.S. government has provided technological and financial assistance to Pakistan to help secure its nuclear systems (Cohen 2016). Though it is hard to quantify the entire scope of U.S. support, the United States has invested roughly $100 million in setting up nuclear security programs including sales and technology transfers from U.S. companies (Fair et al. 2010, 33). To ensure stability, the United States has also relegated human rights in Pakistan to a lower priority (Fair et al. 2010, 142).

By 2050, tens of other developing countries may have ramped up their use of nuclear energy. Accordingly, America's relationship with those nations could mirror its current one with Pakistan. U.S. spending on nuclear security, including international programs, stands at $500 million, down from $800 million in 2012 (Bunn et al. 2016). If America chooses to be the world's patron of nuclear security, these costs could balloon rapidly into the billions. In such a scenario, the United States could need to provide funds to India, Indonesia, Saudi Arabia, Turkey, and parts of Eastern Europe simultaneously to improve the physical security of fissile materials (Bunn et al. 2016). Such a sum could be politically unpopular, especially if Russia profits politically and financially from exports without stepping up on nuclear security.

#### 5.4.3.2 Nuclear Market Power

Not only would the United States face a heftier bill for safeguarding nuclear material around the world, but it might also run into obstacles if it tries to strengthen the institutional framework that governs international nuclear security. America could even find itself more diplomatically isolated on totally unrelated global issues.

As the world's dominant nuclear supplier, Russia would likely do little to improve global nuclear security standards. Its own lax standards are well-known. Instead, Russia could use its market power for political gain. The country already has a notorious history of using resource wealth as a tool of foreign policy. In 2005, Russia, the primary natural gas supplier for much of Europe, halted flows to Ukraine after the country elected Western-leaning President Viktor Yushchenko (Kramer 2006). Russia's nuclear industry is already showing signs that it could function similarly to foster and exploit dependency. This could threaten a broad range of U.S. interests globally.

The business model Rosatom employs provides a great deal of influence. The firm operates on a Build, Own, and Operate (BOO) scheme, which means the firm offers to construct nuclear reactors for developing countries even if they are unable to finance them on their own (Reuters Staff 2013). Under this model, Rosatom owns the plant and offers the full range of services needed for nuclear power from construction, financing, and maintenance. The process results in little transfer of technology or expertise. Instead, the result is that importing countries are reliant on Russia for a substantial part of their energy needs.

By 2050, Russia could use its market power to unduly influence importing countries' domestic politics. In many cases, countries with Russian nuclear reactors would be locked into using Russian fuel, giving the Kremlin leverage (Dobrev 2016). For some countries, this is already the case. Hungary, Slovakia, the Czech Republic, and Ukraine, which constitute a population of 80 million Europeans, are collectively dependent on Russian nuclear cooperation for about 42% of their electricity (Sharkov 2015). In Hungary, Rosatom plans to finance the Paks nuclear power plant, which supplies roughly 40% of Hungary's electricity. Hungarian Prime Minister Viktor Orban has since called for the EU to normalize relations with Russia (Than 2015). Into 2050, Russia could similarly influence major economic powerhouses and strategically important countries around the world like Turkey, Jordan, Saudi Arabia, Vietnam, and Indonesia.

As a result, U.S. security and international influence could suffer because of the new dynamics of the nuclear market. If Russia achieves primacy in the nuclear market, it could more easily oppose not only U.S. efforts to ensure nonproliferation, but also U.S. diplomatic interests broadly. If the United States attempted to convene countries to construct an updated nuclear nonproliferation regime, it could more easily be thwarted by Russia and its coterie of client states. A U.S. attempt to promote more stringent nuclear security standards in international fora like the IAEA, NSG, and NSS would require cooperation from the world's nuclear economies. Countries that receive Russian exports and benefit from laxer standards could disregard future multilateral meetings at Russia's request.

This principle could apply for other issues as well. Today, America opposes Russia's support of authoritarian regimes and misinformation campaigns globally. If its nuclear market power pans out, Russia could find itself with more allies in 2050 and the United States fewer. Therefore, it is vital that the United States invest heavily in bolstering its domestic nuclear industry to provide a counterweight to a potential nuclear oligopoly. To do so, the United States should dramatically increase federal funding for nuclear research, development, and demonstration to commercialize small modular and Generation IV reactors. It should also revamp its domestic regulatory framework and impose a price on carbon so that the domestic U.S. market can help revitalize the U.S. nuclear industry.

## 5.5 The Transition to a 21st Century Grid: Opportunities and Threats

The rise of clean energy in the United States is sparking a transition to a more interconnected and technologically advanced grid. The U.S. grid is likely to transform in two ways. First, to incorporate intermittent renewable energy, grids across North America could become more connected, integrating the U.S. and

Mexican grids in particular, and changing the security dynamics in the North American neighborhood. Second, the U.S. power system is likely to evolve toward a smart grid with a mix of distributed and centralized energy resources and complex power and communication flows between customers and the grid.

These twin transformations could be a mixed bag for U.S. security interests. First, greater integration could offer an opportunity for the United States to cooperate with its neighbors. But the advent of the smart grid could open more security vulnerabilities than it closes because of the proliferation of internet-connected devices and infrastructure. As a result, opportunities for adversaries to carry out cyber-attacks on the United States could increase.

### *5.5.1 Context*

The U.S. electric grid comprises vital infrastructure that underpins the nation's economy. One of the greatest innovations of the 20th century, America's electric system evolved over the last century to offer greater interconnectivity to best deliver reliable and affordable power, mostly from central, fossil-fueled power stations. Looking ahead, grid expansion and interconnection will likely continue. But in addition, a new transformation could simultaneously take place—one in which the grid also becomes smarter and more decentralized to accommodate an increasing level of clean energy.

At the beginning of the 20th century, Americans received power from one of 4000 isolated utilities, which could only distribute electricity over short distances. But soon, utilities adopted alternating current (AC) technology, which can transport electricity over long distances. Once AC technology took hold throughout the electricity sector, utilities started to build larger, centralized power plants to serve broader swathes of customers (EIA n.d.b).

As power demand surged during the post-World War II economic boom, utilities interconnected their transmission systems to increase efficiency by reducing the amount of extra generation capacity required to be held in reserve and building larger, jointly-owned generating units to serve aggregate demand at lower cost. This integration resulted in three interconnected systems that service the eastern and western halves of the country and Texas.

The U.S. grid has similarly interconnected with northern neighbor Canada for the same benefits (see Fig. 5.2). The electricity systems between the United States and Canada today are highly integrated with more than 30 major transmission connections and roughly $3 billion in electricity traded between the two nations (DOE 2015). Around 10% of all Canadian generation capacity services U.S. customers. There are additional benefits as grid managers are able to optimize electricity generation on both sides of the border to ensure reliability and efficiency. In contrast, the United States engages in comparatively little cross-border electricity with Mexico (DOE 2015). Cross-border electricity trade with Mexico amounted to less than one-hundredth of a percent of total U.S. generation in 2013 (EIA 2013).

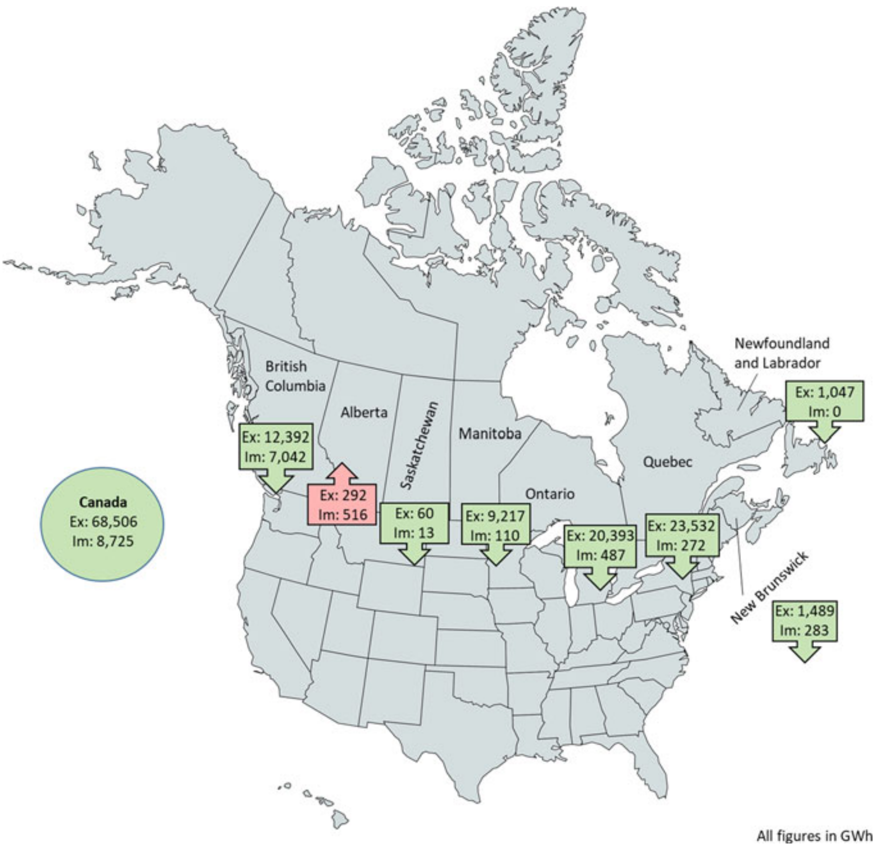


**Fig. 5.2** Electricity imports and exports between Canada and the United States (2015). *Source* Government of Canada National Electricity Board

Recently, two overlapping types of resources have begun to upend the traditional model of central fossil-fueled power stations supplying the grid with power. First, the amount of renewable energy connected to the grid—mostly from large solar and wind farms—has dramatically risen in recent years. In 2015, wind and solar collectively accounted for two-thirds of new capacity added to the U.S. grid, and renewable energy now constitutes 13% of U.S. electricity generation (EIA n.d.c). A second, more incipient, trend is the rise of distributed energy resources (DERs). DERs are locally sited resources like rooftop solar or distributed batteries, fossil-fueled generators like natural gas micro-turbines, demand-side appliances like smart thermostats, and many more resources. As costs have fallen and firms have introduced new products on the market, distributed generation has more than tripled since 2010, with more than 645,000 homes and business using solar panels in 2015 (McBride 2016).

Both trends are straining the 20th century paradigm of the electric grid. The intermittency of renewable power output makes it difficult to match instantaneous supply and demand. Weather fluctuations affect nearly all solar and wind capacity and can sway output for seconds, hours, days, weeks, or even seasons, creating uncertainties beyond what the grid was designed to handle (American Physical Society 2016). And the rise of DERs threatens to overload distribution grids that were not designed, for example, to handle reverse flows from a customer's solar panels to the grid or to charge fleets of electric vehicles.

As a result, grid expansion and modernization became U.S. federal priorities, especially under the Obama administration. To deliver variable renewable energy from areas of plentiful wind and solar resources to urban demand centers—often hundreds or thousands of miles away—the Federal Energy Regulatory Commission established rules to boost investment in the transmission infrastructure and improve power reliability. Expanding the grid reduces the costs of integrating intermittent renewable energy, smoothing supply and demand volatility through aggregation, and reducing the reserve generation capacity needed to ensure power system reliability.

To improve the ability of the grid to handle more intermittent power and integrate DERs, the Department of Energy (DOE) has made the development of a smart grid—an automated, computerized power network utilizing two-way digital communications—a national priority (McBride 2016). Since 2010, the DOE has invested $4.5 billion in smart grid infrastructure (McBride 2016). Grid modernization could continue under President Trump, who campaigned on the promise of massive investments in national infrastructure.

## *5.5.2 A Twenty-First Century Grid*

By 2050, America's electricity grid could be far more integrated across its borders and even more distributed. In this scenario, a single, highly integrated North American grid would emerge, and the U.S. would invest heavily in developing a smart grid.

### 5.5.2.1 An Integrated North American Grid

It is likely that variable renewable energy will be prevalent across North America by mid-century. Such a shift will drive Canada, the United States, and Mexico to interconnect their grids to a high degree to limit the costs of integrating renewables. The three countries have already planned to generate 50% of their energy from clean sources by 2025, a target that would be easier to achieve across a unified power system (Dlouhy and Keane 2016). And renewable power could be as much as 80% of U.S. electricity generation by 2050 (NREL 2012). Given the United States' thriving electricity trade with Canada today, the most salient opportunities to interconnect grids would be between the United States and Mexico.

U.S.-Mexico cross-border electricity has been historically limited because, until 2013, Mexico's electricity market was a state-run monopoly closed to foreign trade. However, at the end of 2013, Mexico reformed its energy sector, allowing for competition in the power sector and private investment from both at home and abroad (Robles 2016). So far, Mexico shares only 11 transmission connections with the United States, but the country already plans to add roughly 28,500 miles of new transmission lines by 2040 (IEA 2016b). And Mexico's Ministry of Energy has prioritized increasing international electricity interconnections with the United States in its long-term power sector strategy. These interconnections could link regions of Mexico with high solar and wind potential like Baja California with major urban demand centers like Los Angeles and San Diego; similarly, they could link the sun-soaked American southwest and windy Oklahoma panhandle with demand centers like Mexico City. So, by 2050, cross-border electricity trade with Mexico could flourish.

Although the low-hanging fruit is more interconnection with Mexico, there is some opportunity to further increase U.S.-Canada cross-border electricity trade. In particular, Canadian hydropower currently supplies just 1% of U.S. electricity demand, but has the potential to more than double (Canadian Hydropower Association 2014). If Canada fully developed its potential hydropower and exported half of its production, exports to the United States would rise tenfold (IEA 2014). And by constructing pumped hydro storage facilities, Canada could provide energy storage to enable the United States to increase its share of intermittent renewable energy, much as Norway plays the role of Europe's battery. Under the assumption that the United States will act to maximize its share of clean power, interconnection projects like the Great Northern Transmission Line, Champlain Hudson Power Express, and Montana Alberta Tie Limited could gain traction, speeding construction. Taken together, increased interconnection between the United States and both Canada and Mexico—as well as increased grid integration within the United States would lead to a North American super grid by mid-century.

#### 5.5.2.2 A Smart, Decentralized Grid

Grid transformation will be driven by the rise of both variable renewable energy as well as distributed energy resources—much of it clean. Were these resources to all connect to a grid based on the 20th century paradigm, system costs would soar and reliability would suffer. Therefore, regulators and utilities around the country are likely to work together to invest heavily in smart grid technologies to enable the two-way flow of information between customers and the grid and improve grid operators' control and visibility over the distribution grid.

Smart infrastructure could be deployed on both sides of the customer meter. On the customer side, customers could install smart appliances, inverters, vehicles, and other intelligent electric loads and electronics. On the other side, utilities are likely to invest heavily in supervisory control and data acquisition (SCADA) systems to monitor and operate the grid more effectively. And the meters themselves are likely to change—smart meter penetration in the United States is already relatively high and expected to reach 80% by 2020, so by mid-century it could be practically universal and become even more internet-connected (Accenture 2016).

The overall number of "Internet-of-Things" (IoT) devices is expected to surge to 50 billion as soon as 2020, twice as many as in 2015 (FTC 2013). By mid-century, this figure could balloon to a trillion or more. This could enable a smart grid that replaces the current, centrally managed grids with complex bidirectional power flows and communications.

## *5.5.3 Implications*

If the scenario described above plays out, the 21st century grid could create both opportunities and threats for the United States. First, greater integration of the North American power system could bind the continent together even as other traditional pillars of cooperation, like trade, fall. But second, the exponential increase in digitally connected grid devices could expose America's most critical infrastructure to assault. The shared infrastructure would have a subtle, but important, geopolitical effect on America's relationship with its neighbors, particularly Mexico. And the modern grid would expose the nation to threats from geopolitical adversaries globally.

### 5.5.3.1 Opportunities to Bolster Relationships with Neighbors

For decades, free trade has been the foundation of regional cooperation among the United States, Canada, and Mexico. In the future, this may not be the case. The Trump Administration has threatened to terminate the North America Free Trade Agreement (NAFTA) and has advocated for stronger tariffs. Such policies could severely damage America's relationship with Mexico.

Fortunately, in a scenario where the North American grid becomes deeply integrated, the required cooperation to manage this shared energy infrastructure could countervail the potential animosity. Joint grid management requires deep levels of cooperation. The seamless integration of the U.S.-Canada grid provides one example of how the United States and Mexico could need to cooperate in the future. Canada and United States both participate in the North American Electric Reliability Corporation (NERC), which sets reliability requirements and standard business practices. Both countries also work together on cross-border emergency response. For example, roughly 800 Canadian utility workers traveled to New Jersey to help restore power after Superstorm Sandy left 2.7 million Americans without electricity (DOE 2015). By 2050, the United States could have a similar relationship with Mexico. U.S.-Canada energy cooperation predates many of the axes of cooperation between the two nations considered fundamental today. The first interconnection between them predates NAFTA by almost 100 years

(Canadian Electricity Association 2016). New grid interconnections would require deep cooperation on standards, data sharing, and disaster planning to manage electricity flows and mitigate hazards.

The United States should seize the opportunity to shore up a potentially deteriorating relationship. Indeed, in the future, energy cooperation might become the most concrete axis of cooperation in North America, especially if free trade fades as the region's lynchpin of diplomacy. Such is the case in the Eastern Mediterranean where shared energy resources have prompted cooperation in an otherwise hostile region. In a rare example of geopolitical rapprochement in the Middle East, Israel and Turkey normalized ties in 2016 after Israel discovered significant maritime natural gas reserves that would require help from Turkey to explore (Sezer 2016). Though the relationship between the United States and Mexico might not be as strained yet, energy cooperation could serve as a stabilizing force to smooth over some tensions within North America. In difficult geopolitical neighborhoods, opportunities to improve energy security and mutual economic gain often prove to be catalysts for cooperation.

#### 5.5.3.2 Rising Threats From Cyber Attacks

Unfortunately, the power grid of the future may also provide opportunities to those seeking to harm the United States. As smart grid technologies become more common, cyber access points to the grid will increase exponentially (McLarty and Ridge 2014). Compounding this, a broader array of devices, appliances, and systems—all able to send and receive information from the larger grid—could be connected to network control systems. Each digitally connected component of the smart grid is an access point to hack the grid and disrupt power flows. The result could mirror the leveling effect of nuclear weapons proliferation, which blunted the usefulness of America's conventional military capabilities. If the United States is asymmetrically exposed to cyber-attacks, the relative potency of its hard power could suffer.

Generally, utilities have kept electricity infrastructure safe so far by separating it from the rest of the internet. This may not continue as the smart grid emerges. Exploitable flaws have already been discovered in power generation sources like wind turbines and utility SCADA systems (McLarty and Ridge 2014). According to Michael Rogers, head of the National Security Agency and commander of U.S. Cyber Command, "it is only a matter of when, not if, we are going to see something dramatic," referencing a potential attack on critical infrastructure like power generation (Bordoff 2016).

Indeed, opportunities could increase for actors around the world to attack the U.S. grid. States with which the America has a tense relationship—like Russia, China, and Iran—are reportedly already probing the U.S. grid for digital vulnerabilities as a standard practice (Williams and Bennet 2016). Some of these countries have already demonstrated the ability to conduct large-scale attacks on power infrastructure. For instance, U.S. investigators confirmed that Russia used malware to cause a blackout for 225,000 in Ukraine in December 2015 (Volz 2016). Security experts have already demonstrated that two-way communications between the grid and smart grid technologies like smart meters can be used to shut down entire electricity networks (Steitz and Wolde 2014).

Despite mounting hazards, the U.S. government and private sector have done little to prepare for, prevent, or mitigate cyber-attacks. So far, there has been no major legislation on critical infrastructure protection and cybersecurity and security on IoT devices remains unregulated (McLarty and Ridge 2014; Schneier 2016). Local utilities, as well, have invested little in protecting electricity systems (Gahran 2016). As a result, the power sector is arguably the area of critical infrastructure most vulnerable to cyber-attack (Bennet 2015). Therefore, to protect itself, the United States should invest heavily in grid security alongside other investments to modernize the grid. Legislation like the Enhanced Grid Security Act of 2015 and previously proposed Energy and Water Development appropriations bills have been introduced in Congress advocating for such steps. Such legislation would task the development of advanced cybersecurity applications in the energy sector, implement cyber-testing and cyber-resilience programs, and fund R&D to shield the grid from cyber-attacks.

Although Congress has become increasingly partisan in recent years, protecting critical infrastructure from cyber threats abroad should be a clear bipartisan priority. Finally, U.S. regulators at both the federal and state levels should push utilities to become leaders, rather than distant followers, in designing cyber security protocols for the grid. Utilities can learn from enterprise software companies, which have developed software suites that offer easy, internet-connected access to numerous users while strictly enforcing a secure hierarchy of access privileges in which downstream nodes are firewalled from attacking upstream control points. Federally funded national laboratories, like the National Renewable Energy Laboratory, are already helping utilities move in this direction and should continue to accelerate this security transition (Sivaram 2016). The United States should also improve its own offensive cyber capabilities to deter adversaries from using their own.

## 5.6 Trading Blows: How the Rise of Clean Energy Could Provoke Global Trade Wars

Trade in energy is central to the global economy. Indeed, crude oil and natural gas today are two of the top three most traded commodities around the world. To mitigate the risks of energy dependence, the United States has historically developed alliances with exporters like Saudi Arabia whose wealth and geopolitical influence were built entirely through the energy trade.

In the future, the energy trade may well remain central to the global economy and continue to shape global geopolitics. But two major differences could distinguish the future from the present. First, the energy products being traded could instead be clean energy products—including solar panels, wind turbines, batteries, and nuclear reactor components—whose traded value by mid-century could rival that of fossil fuels today. And second, there would no longer be any inherent reason why some countries are exporters and some are importers. Although only some countries are endowed with natural fossil fuel resources, any country can participate in the manufacturing supply chain for most clean energy products.

If such a future materializes, trade disputes over energy may frequently erupt, endangering norms of free trade that have brought the United States immense prosperity. Because countries will want to reap the benefits of domestically manufacturing and exporting clean energy products, they may flout international trade rules against protectionism. Already, the United States has been embroiled in trade disputes over clean energy products with Asian countries even though clean energy composes a small fraction of global energy trade. In the future, such clashes could be much more frequent.

### *5.6.1 Context*

Already, at the beginning of the 21st century, several disputes have emerged over the burgeoning global clean energy trade. Most of these disputes relate to China, which has raced ahead as the undisputed leader in manufacturing clean energy products—including solar panels, wind turbines, and batteries (Clean Energy Manufacturing Analysis Center 2017). Some disputes allege that the Chinese government has illegally supported its domestic industries; others arise from other countries seeking to protect their own industries to compete with China's.

First, the United States and other developed countries have accused China of illegally supporting its domestic clean energy industries. In 2012, the U.S. government accused Chinese solar companies of dumping below-cost, government-subsidized solar panels in the American market and responded with punitive tariffs (Daily 2012). In response, China retaliated with its own tariffs on U.S. polysilicon, the raw material used to manufacture solar panels (Li and Ma 2014). In 2013, the EU and China similarly almost sparked a trade war over illegal dumping of $25 billion worth of solar panels; the eventual settlement limited the volume of Chinese imports into Europe and set a floor on their price (Reuters 2016). In a separate dispute, the United States brought a case to the World Trade Organization (WTO) challenging Chinese government subsidies to domestic manufacturers of wind power equipment. Before the case was settled, China terminated the grant program (Asmelash 2015).

A second category of trade disputes involves countries seeking to build up their own domestic manufacturing capabilities by requiring WTO-noncompliant "domestic content" policies to compete with China to do so. In 2012, a WTO panel ruled against a Canadian program that required a majority of the solar panels and wind turbines that received a particular government incentive to be manufactured locally. And, in 2016, the WTO ruled against an Indian policy requiring a share of solar panels to be domestically manufactured. So far, India has defended its policies through the WTO, launching its own complaint against subsidies in the U.S. solar industry in several states, and appealed the decision of the original case.

Third, China again ran afoul of WTO rules in 2015 for its export quotas on rare earth elements. These elements were, until recently, almost entirely produced in China, and are important components of clean energy technologies—for example, the magnets in wind turbines. Beginning in 2010, China restricted exports of these elements, possibly to gain leverage on unrelated international diplomatic issues, raising world prices. Ostensibly in response to the WTO ruling, China has removed its export restrictions (Feketekuty 2000).

Looking ahead, more trade disputes seem likely. For example, to date, no formal dispute has yet arisen over Chinese policies that attract foreign equipment manufacturers—of wind turbine parts, for example—to invest in China with the requirement that they transfer technology to local partners. Coerced technology transfer is illegal under WTO rules, yet China's clear intention to build domestic expertise in producing clean energy technologies could easily run afoul of this ban (Lewis 2007).

### *5.6.2 Exports for All*

The trade disputes to date may be just the beginning, foreshadowing all-out trade wars when clean energy products are as commonly traded and important to the global economy as oil is today. Assuming global clean energy demand continues to grow rapidly through mid-century as countries decarbonize their economies, the value of trade in clean energy will surpass that of any other class of goods. And it is plausible to envision a future in which countries would rationally choose to wage trade wars to secure the domestic benefits of producing and exporting clean energy products.

China has a formidable head start in cornering the global clean energy trade (see Fig. 5.3). The solar market alone, which China already dominates, is expected to grow by 13% annually (Fialka 2016). Chinese manufacturers also lead in wind turbine production and intend to export to emerging markets in North America, South America, and Africa (Clark 2016a) And in addition to producing much of the world's rare earth elements, China has bought lithium mines abroad to command all parts of the supply chain to make lithium-ion batteries for electric vehicles and grid storage (Sanderson 2016). The United States, by contrast, lags far behind China in clean energy manufacturing, and its endowment of natural resources useful to clean energy products is questionable (for example, it remains uneconomical to extract rare earth materials from U.S.-produced coal, despite hopes that this route might revitalize the coal industry and reduce dependence on Chinese rare earths; and ongoing efforts to mine lithium in Nevada, though promising, have not yet yielded substantial amounts of the material) (Rathi 2017; Tullis 2017).

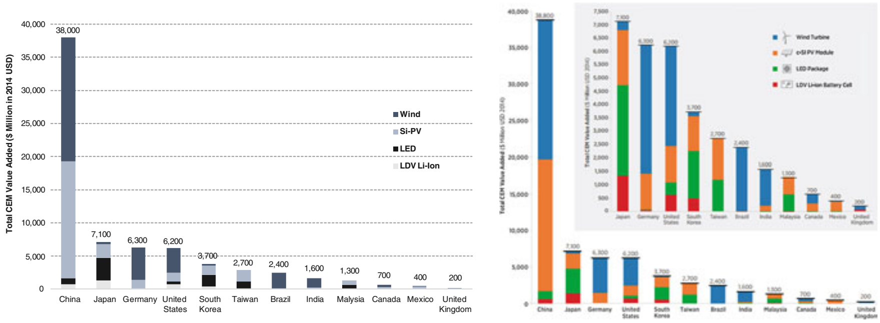


**Fig. 5.3** Total clean energy manufacturing value added by country (2014). *Source* National Renewable Energy Laboratory

It is unlikely the rest of the world will accept a continuation of this state of affairs, in which China dominates a rapidly growing set of industries and monopolizes the enormous economic value they represent. Instead, countries are much more likely to view the transition toward clean energy as an opportunity to cash in on a global manufacturing boom for clean energy products. And as countries implement increasingly ambitious climate plans, they will be loath to bear the economic costs of an energy transition without reaping the benefits of increased exports and domestic job growth.

This could lead to a proliferation of protectionist policies, like domestic content requirements already deployed in Canada and India to give domestic producers a leg up over international competitors. And if China continues its habit of using public subsidies to boost domestic production, it could invite trade disputes and retaliatory action. International trade law is very clear, however, in its prohibition of discriminatory policies that favor domestic over international production.

### *5.6.3 Implications*

This scenario sees the slow erosion of international trade rules in favor of ever-growing climate ambitions. Currently, it is rare for countries to flout WTO dispute settlement decisions. In 2050, non-compliance could become commonplace. Countries could instead protect their own domestic clean tech industries to boost economic output, reduce pollution, and increase energy security. While the WTO would still likely exist, it would lose its potency. Given the intricacy of international trade, noncompliance within trade in clean energy products could extend into other industries as non-energy products are dragged into wide-ranging bilateral spats. This could reprise the early 20th century when European countries hoarded industrial coal and steel.

The WTO's lengthy arbitration process may not be up to the task of mediating these disputes (Lincicome and Connon 2014). For example, it may take half a decade to resolve a dispute against China if it illegally dumps batteries for electric vehicles on global markets. At the conclusion of a lengthy WTO dispute resolution process, the United States might be allowed to enact retaliatory tariffs, but to no avail. Within several years, aggressive Chinese dumping would have had the desired effect. And this scenario might repeat, with other low-cost developing country producers following the playbook that China has already developed.

If the protectionist stances of the Trump administration endure, the United States is unlikely to defend the WTO and champion international trade rules. Instead the United States may join in, enacting tariffs on a wide swath of Chinese goods to protect its own manufacturers. The resulting world order might reflect the disarray prior to the WTO's formation. Trade around the world might devolve into smaller, bespoke patchworks of bilateral deals and a convoluted system of antagonistic tariffs.

To avoid a future where protectionism undermines global trade, the United States should lead by example, avoiding discriminatory policies that preference domestic industries in favor of international competitors. Free trade is the best way to minimize the cost of clean energy products, lowering the price tag of a clean energy transition in the United States. And the United States is better served by investing in domestic research, development, and demonstration of advanced clean energy technologies, rather than erecting trade barriers to prop up otherwise uncompetitive industries manufacturing less advanced products. The ideal future outcome for the United States and for most countries around the world is for America to develop innovative new clean energy products and for American companies to invest in supply chains around the world so that a range of countries enjoy benefits from the rise in the clean energy trade.

## 5.7 Clean Tech and Climate: A New Axis of International Cooperation

The preceding sections have laid out grim scenarios in which the rise of clean energy undermines free trade, empowers U.S. geopolitical adversaries like Russia, and prompts America to retrench militarily, economically, and diplomatically. But this is not inevitable. Rather, by asserting its leadership, the United States can ensure that the clean energy transition proceeds quickly enough to confront climate change and use the resulting diplomatic leverage to navigate an increasingly complex geopolitical landscape.

Thanks to its leading role in concluding the 2015 Paris Agreement on Climate Change, the United States earned goodwill internationally. In future decades, the United States can strengthen important geopolitical relationships—for example, in Asia and Europe—by continuing to lead global efforts to develop new clean energy technologies and combat climate change. By contrast, U.S. abdication of leadership on climate and clean energy—exemplified by President Trump's 2017 announcement that the United States will exit the Paris Agreement—will invite international opprobrium and make it more difficult for the United States to achieve its strategic aims.

### *5.7.1 Context*

America's stance on climate change has spilled over into other areas of foreign policy. Early in his presidency, President George W. Bush withdrew the United States from the Kyoto Protocol, which set targets for industrialized countries to reduce emissions. Bush's rejection of the treaty prompted sharp rebuke from European counterparts who favored ambitious climate action. Because of the discord, it became more difficult for the United States and EU to cooperate on issues like joint military cooperation and global free trade.

Under the Obama administration, the United States stepped up its leadership on climate. American leadership was vital in creating consensus on the Paris Agreement between developed and developing countries. In addition to driving the formal UN process forward, the United States also spearheaded the creation of various fora to spur international cooperation. For example, the Clean Energy Ministerial continues to convene major economies to share best practices on the deployment of clean energy; many of the same countries are also members of Mission Innovation, a U.S.-driven initiative that has committed major economies to doubling their public energy R&D funding within five years. Most importantly, the Obama administration elevated climate to the top of its diplomatic agenda, requiring it to be raised at every single head-of-state meeting. And indeed, climate and clean energy issues soon came to dominate relations between America and the other two largest greenhouse gas emitters—China and India—both of which are geopolitically important countries to the United States.

With China, climate change has emerged as a rare area of genuine cooperation. In recent years, U.S. and Chinese officials have met regularly to discuss climate talks; jointly announced the U.S.-China climate pledge in 2014; and are actively collaborating on the U.S.-China Clean Energy Research Center (CERC) where Chinese and American researchers work side-by-side on clean energy research in areas such as clean coal and grid development (Innes-Ker et al. 2015). As a result, U.S.-China relations—which otherwise would have likely soured over disputes in the South China Sea, human rights violations, and cyber–espionage—remained constructive.

Similarly, cooperation on clean energy and climate change has boosted relations between India and the United States. Historically, India has kept the United States at arm's length owing to its diplomatic doctrine of nonalignment and disagreements over nonproliferation and trade. But, in 2009, the United States and India launched the Partnership to Advance Clean Energy (PACE), which focuses on solar energy,

energy efficiency in buildings, next-generation biofuels, and smart grids. Warm relations, to which cooperation on climate and clean energy have contributed, have in turn made it easier for the two countries to cooperate on increased trade and investment, defense, and, to a limited extent, nuclear nonproliferation (Council on Foreign Relations n.d.).

Although it is difficult to directly measure how U.S. climate and clean energy policy has influenced broader foreign policy, it is reasonable to say that American leadership on an issue that other countries deeply care about has eased diplomacy. Despite these benefits, it is likely that the United States will step back from leadership on climate change and clean energy under the Trump administration.

### 5.7.2 The Future of American Climate Leadership

Climate change will inevitably rise in priority on many countries' diplomatic agendas. Whether the United States embraces international climate action will likely have profound implications on its larger global agenda. The sections below provide two scenarios: one of a renewed American commitment to international climate talks and another of enduring withdrawal.

#### 5.7.2.1 If America Steps Up

The benefits that the Obama administration enjoyed because of its climate and clean energy leadership suggest that President Trump's drawback from these issues may end up a historical aberration. It is plausible to imagine future administrations reverting to the much more prudent course of leading international climate negotiations and collaborations.

In such a scenario, by mid-century, the United States would have shepherded the world toward a series of compacts that had helped dramatically slash global greenhouse gas emissions. A well-functioning international institution would measure and verify each country's compliance with its emissions targets, and countries would regularly convene to set more ambitious goals for themselves, in accordance with the Paris Agreement. And the United States would have led a surge in financing from the richest countries in the world to support the mitigation and adaptation efforts of the poorest. Still, considerable work would remain, since the effects of climate change would have become increasingly pronounced, and net global emissions would need to drop below zero in the second half of the century to stabilize the world's climate.

Given this urgency, the world's nations would look to the United States as the undisputed leader of efforts to confront this crisis, affording it wide latitude in its international affairs. Such is the case with international approaches to address other tragedies of the global commons like nuclear proliferation and ocean resources extraction. The United States, because of its vast resources, enjoys broad fiat in setting global policies on these issues.

Moreover, in this scenario, the most important factor is the eventual mass commercialization of revolutionary clean energy technologies. Most of these would have been developed either domestically in the United States—which would have the world's most generously funded and advanced R&D facilities—or through the dense network of technology collaborations that the United States would have established with major economies around the world. As a result, American companies, having collaborated with Chinese or Indian or Brazilian counterparts, would have footholds to sell their jointly developed products into all of those markets.

#### 5.7.2.2 If America Backs Down

If President Trump's stance endures beyond this administration, America could stand to lose immense diplomatic leverage. China has already demonstrated a willingness to pick up the mantle of leadership (Clark 2016b). In this scenario, by 2050, China would instead inherit many of the benefits detailed above by simply following up on earlier U.S. efforts.

In this future, China would lead a number of international institutions that will shape the global energy landscape. For example, China could steer the Clean Energy Ministerial and Mission Innovation to extend its commanding lead in clean energy industries.

Lastly, at the helm, China will be able to shape the finer details of the Paris Agreement that negotiators tabled for future discussions. In this future, China could push for less transparency in emissions reporting and tepidly improve its emissions targets. Such actions would reduce the world's chances of limiting climate change.

### *5.7.3 Implications*

These scenarios hold disparate consequences for U.S. global influence. Especially as the effects of climate change become more pronounced into 2050, the United States cannot afford to abdicate leadership on a crucial diplomatic issue.

Stepping up would benefit both the United States and the world immensely, resembling the asymmetric costs and benefits of U.S. foreign aid. At present, U.S. foreign aid constitutes less than 1% of the federal budget but provides myriad benefits including preserving stability in strategically located countries like those in the Gulf, helping U.S. exports gain preferential market treatment, and providing a bargaining chip for negotiations (Rutsch 2015).

Even bigger prizes are possible from leading on climate and clean energy. The United States has already led the world toward a climate compact in which nearly every country made an independent commitment to curb rising emissions. And in disparate economic sectors, from electronics to pharmaceuticals, the United States has fostered world-beating, innovative industries. Doing so in energy will require hefty investments in domestic R&D and a network of partnerships with countries around the world, but the United States has already made considerable progress to date.

If, instead, the United States does not step up and cedes leadership to China and the European Union, it might squander a historic opportunity (Sivaram and Saha 2016). The United States would cede not only goodwill, but also diplomatic capital with strategic allies and the benefits of global trade. This chapter has taken pains to explain why the stakes are far too high to make such a mistake. Tectonic shifts are ahead for the global energy landscape—with reverberations that will echo in geopolitical arenas—and the United States stands to lose out if it shies away from leading in the 21st century.

## 5.8 Conclusion

It is difficult to know how the relationship between energy and U.S. strategic interests will evolve by 2050, but there are several good assumptions to make. The United States will continue to have geopolitical allies and adversaries spanning the entire globe. Energy, as has been the case for decades, will strongly shape those relationships. And clean energy and its attendant technologies will gradually displace fossil fuels in importance and use.

The sections above have introduced several geopolitically significant aspects of a clean energy future from a U.S. perspective. First, it may make military and economic sense to reduce its presence in the Middle East as fossil fuels wane in importance and U.S. exposure to oil markets dwindles. By 2050, the United States may withdraw from the Middle East and increase its presence in the Asia-Pacific. China and Russia will likely continue to be geopolitical rivals. The United States will lose crucial diplomatic leverage to both countries if it cannot compete in the next wave of energy technologies, particularly in nuclear power. The global norms America has built up over the last half century, like free trade, could crumble if countries embrace protectionism as clean energy industries rise in value. And the prospect of a sophisticated, internet-connected grid could expose the United States to threats from both state and non-state actors. It may seem that the disruptive influence of clean energy will subvert a postwar international order centered on the United States.

Still, new axes of international cooperation are on the horizon. An integrated grid could bind the United States, Canada, and Mexico closer together. And U.S. leadership on clean energy and climate could improve America's economic and diplomatic position even as geopolitical considerations shift. Cooperation on clean energy research and climate change has smoothed diplomacy between the United States and China. And India, a historically nonaligned country, has increased engagement with America because of its interest in these two issues. By adopting sensible policies, the United States could build on these diplomatic gains through the midcentury.

Although the United States is in many ways an exceptional player in international geopolitics, many of the U.S.-specific implications of a clean energy transition are consistent with the broader themes introduced in Chap. 1. That chapter laid out an overarching framework to understand the geopolitics of a future dominated by renewable energy. It predicted a shift away from a paradigm in which countries enjoy geopolitical influence in relation to their localized fossil-fuel deposits. Such a paradigm shift could affect America by reducing its security and economic interests in the Middle East and sparking a global competition—one possibly destructive to international trade norms—to become the energy suppliers of the future.

Another geopolitically significant theme that Chap. 1 introduced was increased electrification resulting from increased reliance on renewable electricity. Indeed, this is also relevant to the United States in two ways. First, as the United States relies more on electricity and increases its grid interconnections with its neighbors, the importance of regional energy relations will rise. And second, the risk of cyberattacks from international adversaries could also grow as more Internet-connected devices touch the U.S. grid.

A clean energy transition may well have a disruptive effect globally. But the United States and the world will be best served if America continues to lead. To maintain geopolitical influence, the United States should invest in clean energy research in renewables, nuclear, grid, vehicle, and other technologies or cede leverage to great power rivals like China and Russia. Leadership on climate action and continued championing of global free trade will also advance U.S. and global interests.

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