Chapter VI

INTEGRATING NORTH AMERICAN ENERGY MARKETS

This chapter takes a broader look at the current energy trade and the continuing integration of energy markets and infrastructure in the North American region. Its discussion includes cross-border infrastructure with Canada and Mexico, impacts of climate change on energy infrastructure in the Arctic, and the evolving energy needs of the Caribbean region. For each major geographic focus of this chapter, the status of Administration initiatives is discussed and recommendations for further action are presented.

FINDINGS IN BRIEF:
Integrating North American Energy Markets

Overall North American Findings

- **The United States has significant energy trade with Canada and Mexico, including oil and refined products, gas, and electricity.** Canada is the largest energy trading partner of the United States, with energy trade valued at $140 billion in 2013. Mexican energy trade was valued at $65 billion in 2012. Both countries are reliable sources of secure energy supplies.
- **Greater coordination will improve energy system efficiency and build resiliency to disruptions of the North American energy market, data exchanges, and regulatory harmonization.**

Findings on Canada

- **The electricity systems of the United States and Canada are fully interconnected.** There are currently more than 30 active major transmission connections between the United States and Canada, trading approximately $3 billion worth of electricity in 2014. If the transmission projects filed with the Department of Energy in the last 5 years are constructed, they would add approximately 4,100 megawatts of additional hydropower to the U.S. electricity mix.
- **Canadian natural gas production is expected to slightly outpace consumption with exports rising slowly over the projection period.** Oil production is anticipated to continue to grow over the next 30 years.

Findings on Mexico

- **Mexico has reformed its energy sector.** Mexico amended its constitution and reformed its energy sector in 2013, retaining government control over its assets while opening oil and gas resources to private sector exploration and development. These reforms provide an opportunity for increased trade with the United States.
- **Increasing U.S. natural gas exports** may help Mexico generate more gas-fired electricity and achieve its environmental goals.

Findings on the Arctic

- **Changing climate conditions in the Arctic are expected to continue with the melting of permafrost and reduced sea ice extent, which will affect increasing energy development that is underway.** This presents both an opportunity for greater cooperation between the United States and Canada, but also a need for both countries to undertake risk mitigation.

Findings on the Caribbean

- **There is an opportunity to lower Caribbean electricity costs and emissions.** The Caribbean is largely reliant on foreign sources of oil with little energy resources of its own. Energy demand is driven largely by electricity generation, mostly from fuel oil. A 30-percent decrease in carbon dioxide emissions could be achieved by displacement of fuel oil by natural gas—and even more if this were combined with renewable energy.

Benefits of North American Energy System Integration

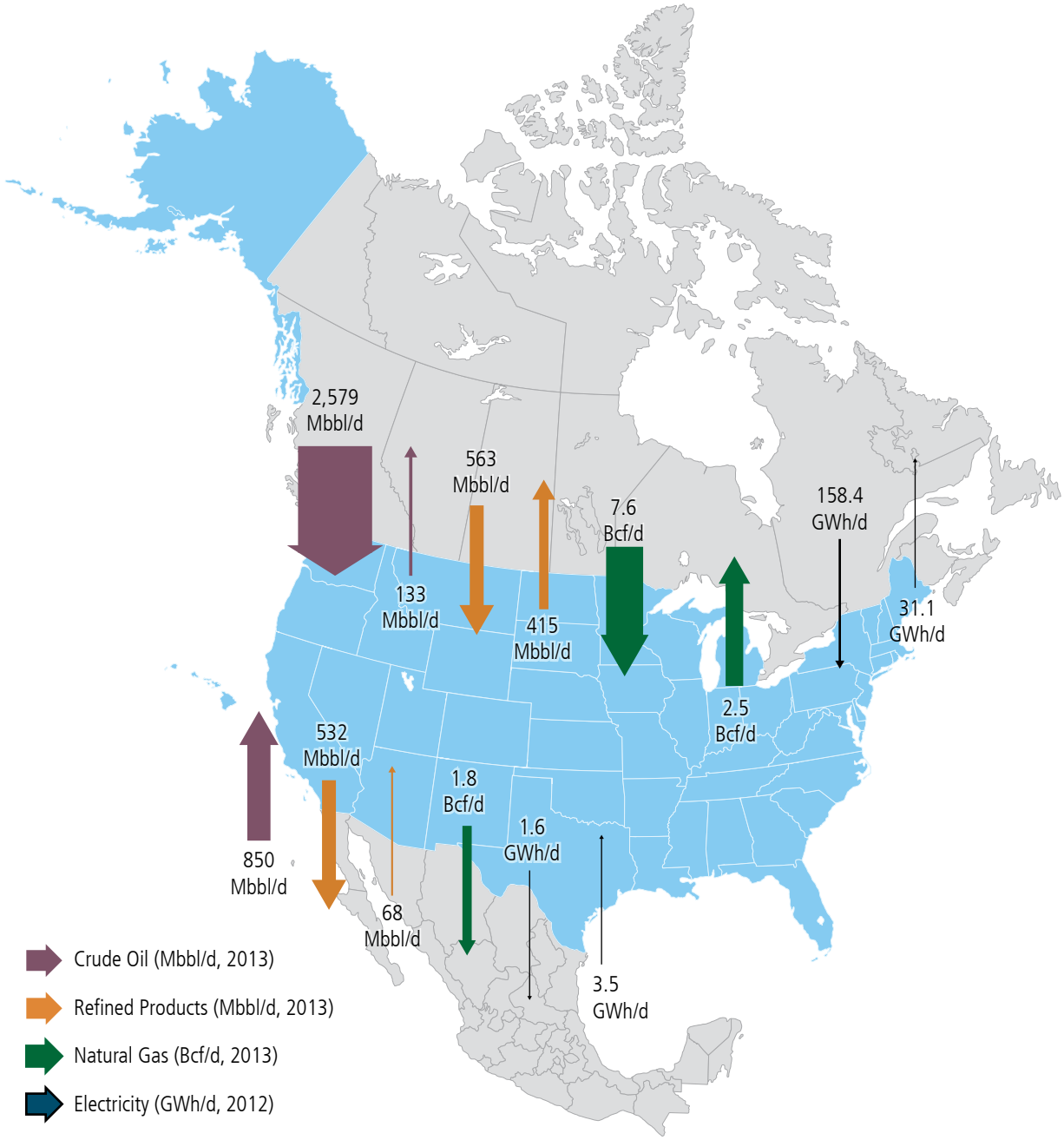
The United States has a robust energy trade with both Canada and Mexico and the potential to increase its energy trade with the Caribbean region. Policymakers throughout North America understand and value the benefits derived from our common energy market, our shared environmental and security goals, and the infrastructure that undergirds our economies. Individual projects and policies will continue to be evaluated by each government. This chapter considers the role of transmission, storage, and distribution (TS&D) infrastructure as part of a broader discussion of past energy trade relationships; current developments and trends in both Canadian and Mexican energy systems; ongoing initiatives for better market integration; and future challenges and opportunities, especially in the Arctic and the Caribbean.

Energy trade in North America has a long history. The first recorded international electricity interconnection crossed the U.S.-Canada border near Niagara Falls in 1901.[1] For several decades, the United States largely has been a recipient of energy resources (whether for internal consumption or for refining and re-export). Developments in energy production, processing, and consumption in the past 10 years have dramatically altered North American energy flows. At the same time, U.S. electricity demand has fallen, and all three countries have begun implementing policies to reduce greenhouse gas emissions from their energy sectors. This changing North American energy landscape presents opportunities for increased integration of markets and policies to further energy, economic, and environmental objectives.

In 2013, energy trade between the United States and Canada reached approximately $140 billion,[2,3] and energy trade with Mexico exceeded $65 billion in 2012.[4] Electricity, liquid fuels, and natural gas cross U.S. borders with Canada and Mexico at many points and in large quantities on an annual basis (see Figure 6-1).

The 1994 implementation of the North American Free Trade Agreement—which prohibits most import and export restrictions, including those placed on energy commodities—did not apply to Mexico for energy commodities due to its constitutional provisions.[5] As a result, while the North American Free Trade Agreement has promoted U.S. and Canadian energy market integration, it has been less successful in achieving energy market integration between the United States and Mexico. Recent regulatory reforms undertaken by Mexico in both the hydrocarbon and electricity sectors are anticipated to open its energy market to foreign investment, to present an opportunity for increased integration with the broader North American energy system, and to elevate the importance of its energy commodities in trade with the United States and Canada via the North American Free Trade Agreement.[6]

Figure 6-1. North American Energy Flows[7]



Energy trade between Canada and the United States dominates the North American market, but Mexico's reforms provide an opportunity for increased integration and trade. The size of the arrows is roughly equivalent to the quads of energy of the imports or exports.

Energy system integration is in the interest of all North American countries, as it expands the size of energy markets, creates economies of scale to attract private investment, lowers capital costs, and reduces energy costs for consumers. Expanding energy systems may also allow for the development of a more diverse mix of energy resources (including renewable energy), processing facilities, and end uses—all of which increase energy security.

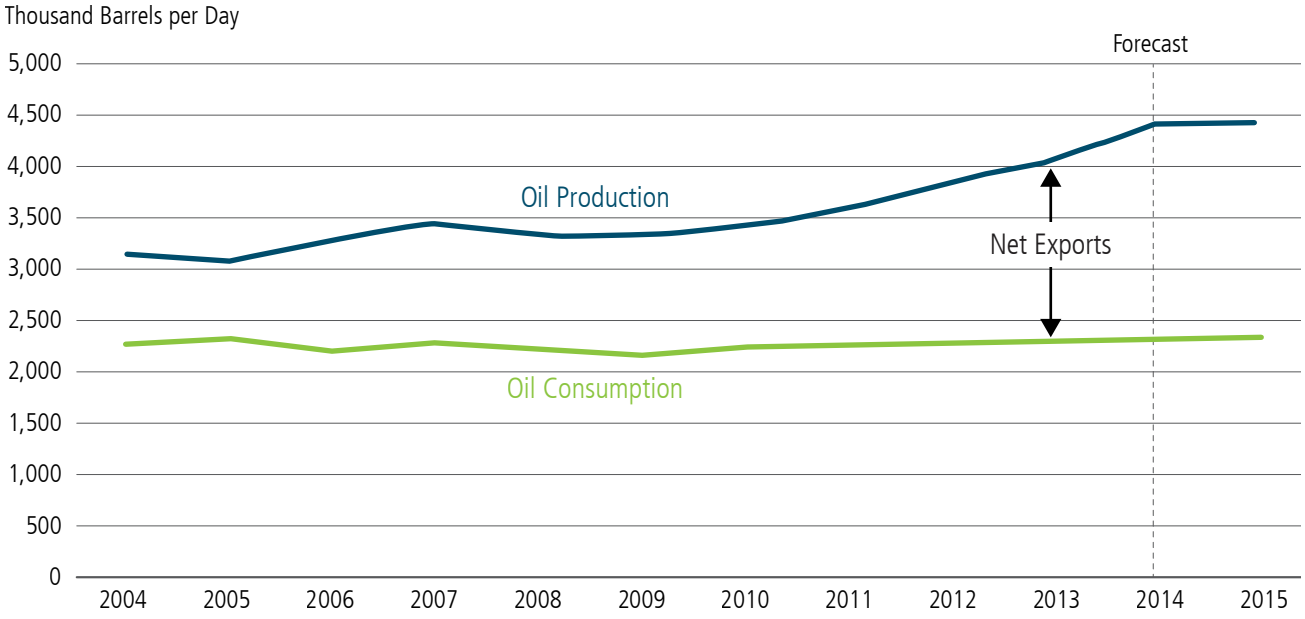
TS&D infrastructure already plays an important role in integration of North American energy markets. This infrastructure allows these markets to operate more efficiently and with greater resilience to disruptions. For example, the integration of the U.S. and Canadian electric reliability systems considerably enhances performance and resilience. Bilateral and trilateral collaboration among the U.S., Canadian, and Mexican governments, as well as each country's participation in multilateral energy initiatives, has also contributed to establishing and harmonizing the policies and programs most useful to the efficiency and resilience of the North American energy system.

Energy Trade with Canada

The energy relationship between the United States and Canada is highly intertwined. For many purposes, the energy sectors of the two countries are considered as one market. There are more than 80 transboundary pipelines and more than 30 electricity transmission lines (69 kilovolts or greater) that transport crude oil, refined products, natural gas, and electricity across the border.[8,9] Although the predominant flow of trade is from north to south, it is not entirely one-sided. Canada is an overall net exporter of energy to the United States, but the roles are reversed in certain regions, particularly where there are infrastructure constraints.

The Energy Information Administration (EIA) reported Canadian production of petroleum and other liquid fuels grew to more than 4 million barrels per day in 2013, an increase of more than 930,000 barrels per day from a decade ago (see Figure 6-2) and including 3.3 million barrels per day of crude oil and a small amount of lease condensate.[10] Canada is the largest supplier of crude oil and refined products to the United States, exporting 3.1 million barrels per day in 2013.[11] EIA's 2014 International Energy Outlook forecasts that Canada's petroleum production will experience 2.1 percent annual growth between 2010 and 2040, which would lead to a 51 percent growth by 2030.[12]

Figure 6-2. Canadian Oil Production and Consumption, 2004–2015[13]

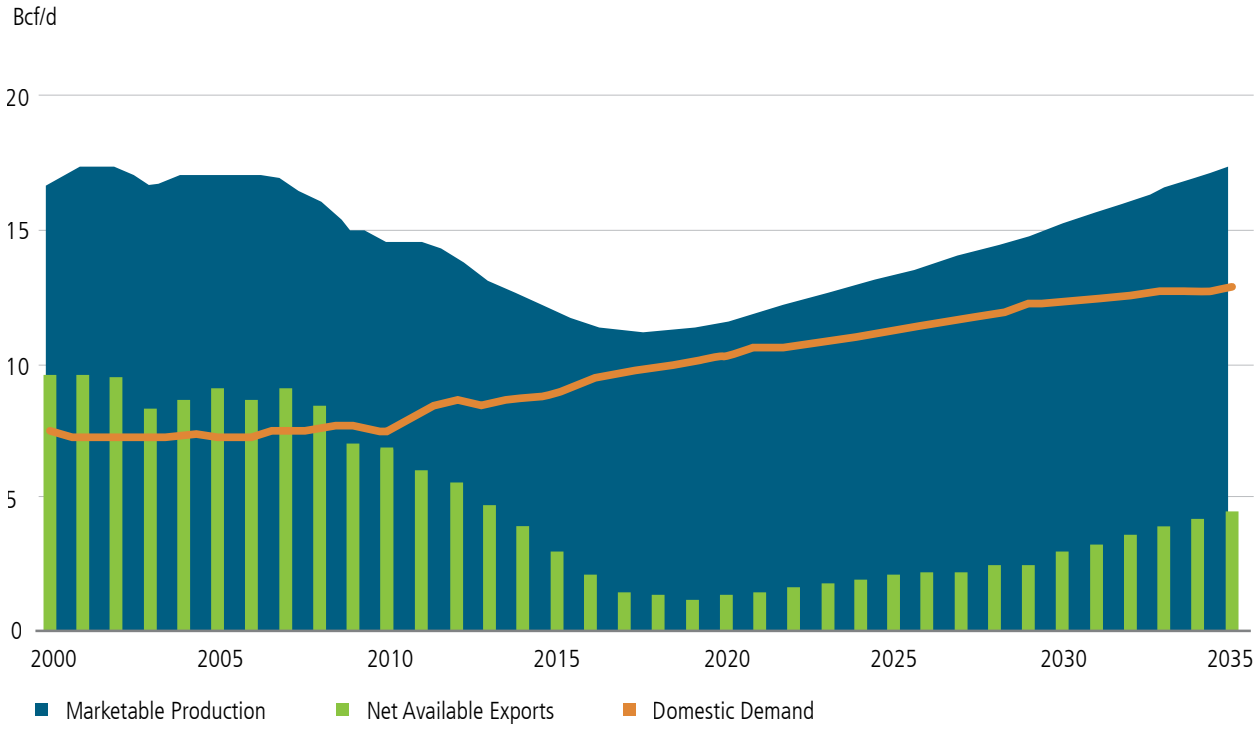


With production growing and consumption flat, Canada's exports have increased over the last several years. Canada is the largest supplier of foreign oil to the United States.

Canada's National Energy Board projects that, starting in 2017 and continuing through the forecast period, natural gas production and consumption will closely track one another (see Figure 6-3).[14] However, the price for U.S. gas may influence this; according to some analysts, the low cost and increasing supply of Marcellus production could price western Canadian gas out of the market.[15] EIA projects that net pipeline imports from Canada will drop 80 percent in the next 15 years, from 2.0 trillion cubic feet in 2012 to 0.4 trillion cubic feet in 2030.[16] This in turn could limit the need for new transborder natural gas pipeline development between the United States and Canada.

The Dawn Hub, located in southeastern Ontario, illustrates the multiple benefits of U.S.-Canadian regional natural gas system integration. Able to store supplies from western Canada, the U.S. Northeast, Midwest, and Gulf Coast, the underground storage facilities in the Dawn area held 221.9 billion cubic feet in December 2014,[17] and they are used to balance seasonal peak demand in Ontario and supply downstream markets in the United States.[18]

Figure 6-3. Canadian Natural Gas Production, Domestic Demand, and Net Available Exports through 2035[19]



While Canadian natural gas production and demand are roughly equivalent in the 2017 to 2022 time frame, natural gas available for exports increases steadily after that through 2035.

Both the United States and Canada benefit from a relatively seamless border that allows grid managers to optimize electricity generation assets on both sides of the border in order to improve electric reliability and efficiency. Currently, there are more than 30 active major transmission connections (69 kilovolts or greater) between the two countries, trading approximately $3 billion (U.S. dollar) of electricity in 2013.[20, 21] Three of eight North American Electric Reliability Corporation regions span the U.S.-Canadian border, coordinating among and setting standards for U.S. and Canadian utilities and regulators to assure electric reliability.[22] Most Canadian electricity exports to the United States go to New England, New York, and the Upper Midwest, mainly from Quebec, Ontario, and Manitoba.[23] Most U.S. electricity exports to Canada (about 75 percent) go to British Columbia, but U.S. exports made up only 18 percent of electricity trade between the two countries in 2014.[24] Applications filed with the Department of Energy (DOE) in the last 5 years for Presidential permits

for electric transmission facilities crossing the U.S.-Canada border suggest an increased interest in utilizing Canadian hydropower to meet demand in the United States. If these projects were to be constructed, they would add approximately 4,100 megawatts of additional hydropower to the U.S. electricity mix.[a, 25] This carbon-free generation has the potential to help the United States achieve its long-term greenhouse gas reduction goals.

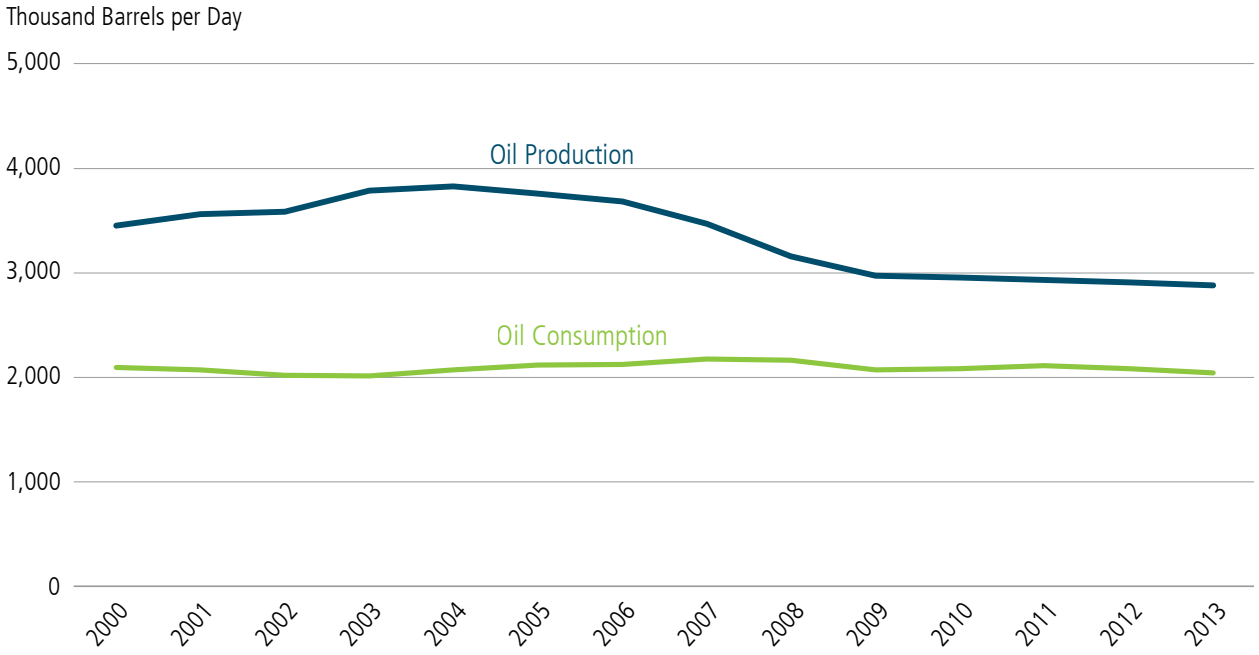
As noted, the United States and Canada share one of the world's great inland lake and waterway systems in the Great Lakes and St. Lawrence Seaway. The Army Corps of Engineers lists more than 60 commercial harbors on the U.S. Great Lakes coast alone.[26] In 2013, nearly one-quarter of all shipments in and out of U.S. ports in the Great Lakes system were energy commodities moving between the United States and Canada. In that year, 7.4 million tons of coal and petroleum products moved across the Great Lakes.[27] U.S. coal exports to Canada have fallen approximately two-thirds between 2003 and 2013, even as overall U.S. coal exports have grown more than 170 percent—in part as a result of Canadian energy policies limiting coal use in the power sector. Imports of Canadian coal have also fallen by approximately one-half, from more than 2 million short tons in 2003; although, their share of total U.S. coal imports has grown from 8 percent to 13 percent over the same time period.[28]

Energy Trade with Mexico

In December 2013, Mexico amended its constitution and reformed its energy sector. The principal factors driving these decisions were, in part, Mexico's declining oil production over the past decade (see Figure 6-4), as well as its interest in promoting economic growth. Mexico's reforms retain government control and ownership of assets while opening oil and gas resources to private exploration and development. They also include new governance structures for Petróleos Mexicanos and the Federal Electricity Commission and four new contract structures for oil development that align with international standards. The reforms establish Independent System Operators to manage electricity transmission. The reforms also will gradually adjust the retail fuel market. In August 2014, the Mexican Ministry of Energy announced "Round Zero" fields that Petróleos Mexicanos will retain, as well as "Round One" in which foreign companies will be allowed to participate for bidding through July 2015.[29]

[a] Recent Presidential Permit applications received by DOE's Office of Electricity Delivery and Energy Reliability, National Electricity Delivery Division, indicate certain companies' intentions to import hydropower from Canada. Specifically, Champlain Hudson Power Express, Northern Pass Transmission, and New England Clean Power Link would each deliver electricity from Hydro Quebec facilities. Great Northern Transmission Line would deliver electricity from Manitoba Hydro.

Figure 6-4. Mexico's Oil Production and Consumption[30]

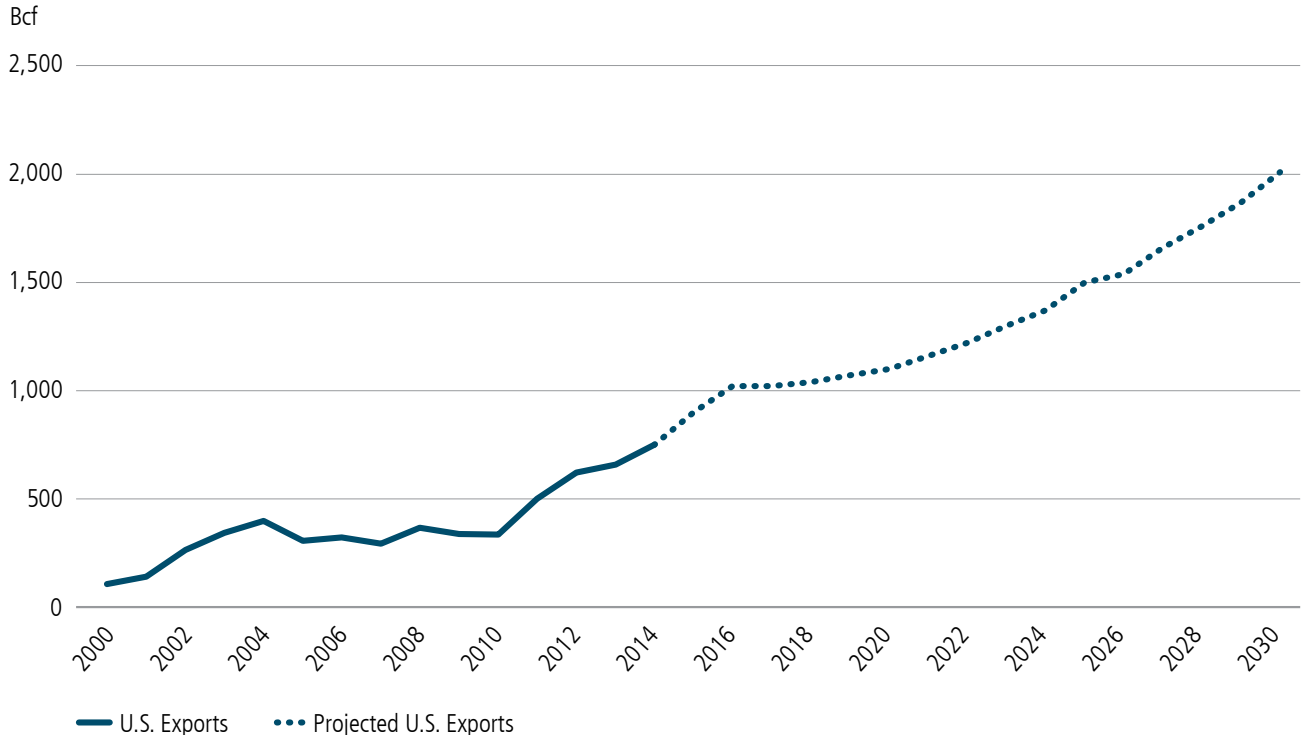


Recent trends in Mexican oil production and consumption indicate a decline in production and largely stable consumption. The Mexican energy reforms seek, in part, to reverse these declines in production.

Mexico's energy reforms present an opportunity to increase energy trade with the United States and enhance energy security for the region.

The main cross-border infrastructure needs, particularly over the last decade, have been natural gas pipelines. Since 2000, U.S. exports of natural gas have increased six-fold and are projected to continue to increase through 2030 (see Figure 6-5).[31, 32] More than 5 billion cubic feet per day of new pipeline export capacity has been added during this time period, with about half that amount in the form of expansions of existing pipelines.[33] By 2016, EIA projects that the United States will be exporting more than 1 trillion cubic feet of natural gas to Mexico annually, and, by 2030, that amount is expected to almost double.[34] This growth will be driven by continued increases in the use of natural gas for electric power generation, by demand for natural gas from Petróleos Mexicanos, and from consumers switching to natural gas when the infrastructure is in place to deliver additional volumes of natural gas.

Figure 6-5. U.S. Natural Gas Exports to Mexico[35, 36]



Mexican demand for U.S. natural gas is projected to grow through 2030, in large part driven by continued increases in the use of gas for electric power generation and residential use.

If Mexico's energy reforms achieve the goal of reversing the decline in its oil production, it is possible that Mexico will serve as a larger source of U.S. oil imports in 2030. Alternatively, if Mexico's refinery capacity expands, more of its oil may stay in the country, and Mexico may export refined petroleum products instead of crude oil—most likely overseas.

U.S. coal exports to Mexico have doubled between 2003 and 2013, but their share of total U.S. coal exports remained below 5 percent throughout this period.[37]

Currently, there is very little cross-border electricity trade between the United States and Mexico. Between southern California and Baja California, electricity is imported from a few power plants on the Mexican side to supply demand in the San Diego area, and a small portion of the grid in Baja California, Mexico, participates in the Western Electric Coordinating Council. At even lower voltage levels, a few ties connect southern and western Texas with the Mexican States of Tamaulipas and Chihuahua. Here, the transmission systems on either side operate independently, and trade mainly occurs during periods of constrained supply.[38]

There is potential for greater exchange of electricity between the United States and Mexico, particularly from natural gas-fired or renewable generation on both sides of the border.

TS&D Infrastructures: Cooperation among the United States, Canada, and Mexico to Achieve Common Objectives

Going forward, enhanced system integration holds the potential to advance several objectives, including more efficient and smoothly integrated markets and protection of the environment.

Enhanced coordination on energy data, which is important for the proper function of energy markets, including the planning, construction, and operation of TS&D infrastructure, requires that market participants and policymakers have reliable, transparent, and comparable data on the overall energy system. The benefits of integration would be greatly enhanced by harmonizing and improving the availability of relevant energy data.

In addition, there are opportunities to build on past collaboration involving regulatory and industry counterparts to promote harmonization of relevant regulations, both with respect to energy overall and with respect to infrastructure specifically. Opportunities for further regulatory harmonization with both Canada and Mexico exist across different resources, types of infrastructure, modes of transport, market structures, energy security, and environmental protection. Engagement on these topics may be particularly important on regional and local levels, where it has been limited in the past. Regulatory harmonization benefits regulated parties by eliminating duplicative requirements and generating savings in time or cost. It benefits consumers by lowering costs and making products available in both countries. It benefits regulators by enabling joint approaches to common risks.

The near-seamless integration of the U.S.-Canadian electricity grid has occasionally resulted in blackouts spanning the border, but in regional crises, cooperation among Federal, state, provincial and local governments, utilities, and regulators has provided benefits and enabled faster recoveries. Cross-border assistance for emergency response happens regularly in the electric sector.

Superstorm Sandy (2012) stands out among recent examples of North American cross-border emergency response to power outages and other extreme weather impacts on energy infrastructure. Due to the storm, 2.7 million customers were left without power in New Jersey alone.[39] Approximately 800 Canadian utility workers traveled to New Jersey to help restore power in the aftermath of Superstorm Sandy. New Jersey Governor Chris Christie declared December 6, 2014, "Canadian Utility Workers Appreciation Day" in response to their volunteered support.[40]

In late January 2015, Hydro-Quebec dispatched 180 employees and 75 trucks to the Boston area to assist with power outages due to the snowfall there in response to mutual aid requests coordinated through the North Atlantic Mutual Assistance Group (NAMA).[41] The group includes 21 utilities among 13 states, the District of Columbia, and 4 Canadian provinces, and it represents 1 of 7 Regional Mutual Assistance Groups organized by the Edison Electric Institute.[42]

Emergency response to electrical outages includes wheeling power through the grid to cover outages. A recent example of this practice occurred when Mexico supplied electricity to Texas to support Texas system operators threatened by blackouts.[43]

In addition to collaboration on preparedness and resilience, there are significant opportunities for the United States, Canada, and Mexico to cooperate on multiple initiatives, projects, and in international fora that promote clean energy and environmental responsibility. As Mexico develops its natural gas resources, better coordination of actions to mitigate methane emissions from natural gas systems, including TS&D infrastructures, could address climate concerns on both sides of the border. Similarly, to the extent that transmission projects enable access to new, existing, or expanded hydropower projects, the use of Canadian hydroelectric generation and pumped hydropower storage could help achieve U.S. clean energy goals by providing a low-cost addition to current state Renewable Portfolio Standard programs and by smoothing variable supply from renewable energy.[44, 45] A 2014 Argonne National Laboratory study indicated that advanced

pumped hydropower storage could provide a range of grid management and cost reduction services to the Western Interconnection, including the Canadian provinces of British Columbia and Alberta and some areas of northern Mexico.[46]

Such initiatives have precedent: the Columbia River Treaty, ratified in 1964, has for more than 50 years provided coordinated operational benefits for the U.S. Federal Columbia River Power System and the Province of British Columbia hydro system. The reservoir storage authorized by the treaty allows the United States and Canada to optimize clean, renewable hydroelectric power generation.[47] More recently, the Western Area Power Administration approved financing a portion of the Montana-Alberta Tie Line project—a 300-megawatt, 230-kilovolt electrical transmission line allowing the movement of power between Montana and Alberta, Canada. The 214-mile (345-kilometer) line ties into the Alberta grid at a new substation located 9 miles (15 kilometers) northeast of the City of Lethbridge. The project supports ongoing development of a rich wind-powered generation resource and allows much-needed energy to flow in both directions, ensuring increased availability of supply of electricity into the U.S. Pacific Northwest and Alberta. Northern Montana and southern Alberta are home to some of the best wind energy sources in North America.[48]

In addition to specific projects and regional programs, the United States, Canada, and Mexico have active governmental bilateral and trilateral engagements. At the 2014 North American Leaders Summit, leaders affirmed that energy is a trilateral priority and directed the three Energy Ministers to meet in 2014. Under a bilateral agreement between DOE and the Canadian Ministry of Natural Resources, signed September 18, 2014, one of the five areas of cooperation between the two agencies is "safe and modern infrastructure, including cyber security." Cooperative activities the agencies agreed to pursue are "sharing knowledge and exploring options to enhance reliability and security of the North American energy infrastructure." Under the U.S.-Mexico High-Level Economic Dialogue, the United States and Mexico agreed to enhance communication and collaboration between our energy agencies and improve data and information sharing on U.S.-Mexico energy flows. In March 2015, the United States and Mexico also launched a high-level bilateral clean energy and climate policy task force to further deepen policy and regulatory cooperation and coordination.

This cooperation is further extended through participation in multilateral efforts. The United States, Canada, and Mexico also participate in the Energy and Climate Partnership of the Americas, a flexible mechanism through which governments in the Western Hemisphere cooperate to accelerate clean energy development and deployment, advance energy security, meet climate challenges, and reduce poverty in the region. Mexico will host the second Energy and Climate Partnership of the Americas Ministerial on May 25–26 and chairs the Energy Efficiency Working Group. Canada chairs the Heavy Oil Working Group.

In May 2015, Mexico will host the sixth Clean Energy Ministerial (CEM) in Mérida.[49] CEM is a high-level forum of the world's major and forward-leaning countries working together to promote policies and share best practices to accelerate the transition to a global clean energy economy. Mexico participates in nine CEM initiatives, and through that work, it has developed voluntary standards for cool (reflective) roofs, including a national study on the energy savings potential of cool roof deployment across the country,[50] and it has drawn on international expertise on power system transformation to support its energy reform agenda. The CEM Clean Energy Solutions Center Ask-An-Expert service, which provides policymakers in emerging economies with up to 40 hours of free technical assistance from policy experts in CEM countries, has assisted Mexico with developing appliance standards and labeling programs, building certification rating incentives, and developing a clean energy policy database. Canada and Mexico have participated in CEM initiatives advancing efficiency through municipal lighting system replacements and the International Smart Grid Action Network, which has gathered and shared in-depth case studies on advanced metering infrastructure and demand-side management. All three countries have collaborated on CEM-led initiatives to support implementation of the ISO 50001 International Energy Management Systems Standards.

Canada and Mexico also participate in the Carbon Sequestration Leadership Forum, a Ministerial-level international initiative focused on developing improved cost-effective technologies for the separation and capture of carbon dioxide for its transport and long-term storage. Canada currently participates in eighteen projects, including the completed Alberta Enhanced Coal-Bed Methane Recovery Project, which aimed at demonstrating the feasibility of coal-bed methane production and simultaneous carbon dioxide storage in deep unmineable coal seams.[51]

The United States, Canada, and Mexico also cooperate in other fora, including the Asia-Pacific Economic Cooperation, the Major Economies Forum, and the International Partnership for Energy Efficiency Cooperation.

Administration Activities and Plans

Engagement on further integration of U.S., Canadian, and Mexican energy systems has led to a number of concrete outcomes, including the following:

Data Exchange. The United States, Canada, and Mexico are creating a framework for the sharing of publicly available information and data on their respective energy systems. This initiative was formalized in a memorandum of understanding (MOU) signed by the Department of Energy, Canada's Ministry of Natural Resources, and Mexico's Ministry of Energy on December 15, 2014. The trilateral MOU covers data, information, maps, and statistics that are publicly available (it excludes any information considered confidential, strategic, or fundamental for national security and sovereignty reasons). Areas of cooperation include comparing energy-flow data between countries; geospatial information related to infrastructure; projections for cross-border flows of natural gas, electricity, crude oil, and refined products; and sector terminology. The MOU is expected to facilitate further dialogue, comparisons, and joint and individual work products on each country's energy outlooks and information.[b]

The President's Fiscal Year 2016 Budget provides an increase of $1 million to the Energy Information Administration for the purpose of collaboration with Canada and Mexico to increase the quality, transparency, and integration of energy-related data.

DIALOGUE WITH CANADA AND MEXICO ON THE QER

Development of the Quadrennial Energy Review (QER) has provided an opportunity to engage Canada and Mexico in a deeper dialogue on the integrated nature of North American energy systems—including transmission, storage, and distribution infrastructure. This engagement included contacts with energy ministries in Canada and Mexico, invitations to public entities in those countries to submit comments through the QER process, and two formal dialogues: one with the Ministry of Natural Resources of Canada (September 19, 2014) and the other with the Ministry of Energy of Mexico (December 4, 2014). The formal dialogues with Canada and Mexico included participation from multiple relevant government agencies, industry, non-governmental organizations, and academic institutions. The input received from these sessions and through the formal public comment process (as described in Chapter X, Analytical and Stakeholder Process) has been considered in developing this section of the QER.

Secretary Moniz, Secretary Joaquín Coldwell, and Minister Rickford met on December 15, 2014, in response to the call of the North American Leaders. They discussed in depth a strategic vision for North America's energy sector and signed a trilateral memorandum of understanding. Key topics included public energy data and statistics collaboration; Mexico's energy reform, its vision, perspectives, and opportunities for trilateral cooperation; and creating resilient infrastructure for North America.

[b] Department of Energy. "Memorandum of Understanding among the Department of Energy of the United States of America and the Department of Natural Resources of Canada and the Ministry of Energy of the United Mexican States Concerning Cooperation on Energy Information." December 2014.

QER Recommendations

NORTH AMERICAN ENERGY MARKET INTEGRATION

There are opportunities to build on past accomplishments in further enhancing North American energy integration. Accordingly, we recommend that all three countries carry out the following:

Continue advances that have been made in the North American energy dialogue: All three countries should encourage further business exchanges and regular minister-level engagement.

Increase the integration of energy data among the United States, Canada, and Mexico: Provide resources for EIA to collaborate with its Canadian and Mexican counterparts to systematically compare their respective export and import data, validate data, and improve data quality. In addition, efforts should be taken to better share geographic information system data to develop energy system maps and review forward-looking assessments and projections of energy resources, flows, and demand.

Undertake comparative and joint energy system modeling, planning, and forecasting: All three countries should enhance comparative and joint modeling, planning, and forecasting among U.S., Canadian, and Mexican energy ministries and related governmental agencies. The current scale of activities has aided bilateral and individual goals; however, increasing trilateral engagement on planning, modeling, or forecasting activities would capture greater efficiencies and enhance each country's ability to reach economic, security, and environmental goals. DOE's Offices of Energy Policy and Systems Analysis and International Affairs should lead modeling workshops with their Canadian and Mexican counterparts to share methodologies and collaborate on North American analysis.

Establish collaborative programs in each country for academic institutions and not-for-profits to develop legal, regulatory, and policy roadmaps for harmonizing regulations across borders: In partnership with universities, qualified not-for-profits, and relevant U.S. energy regulatory authorities, state/provincial, local, and national energy regulations will be compared to identify gaps, best practices, and inconsistencies with regulations in Canada and/or Mexico with the goal of harmonization.

Coordinate training and encourage technical dialogue: This coordinated training and enhanced dialogue of technical staff in government agencies of the three North American countries that share similar responsibilities to evaluate and implement cross-border energy projects.

Energy Security and the Arctic

Energy delivery to remote areas in the Arctic—including diesel fuel for electricity generation and heating in remote communities, industrial uses in mining and other industrial operations, and military installations—increases costs due to the broadly dispersed market and challenges of transporting energy products. Through its Power Cost Equalization program for rural communities, the Alaska Energy Authority reported serving more than 190 remote or rural communities, which used nearly 28 million gallons of diesel for electricity generation at an average price of $4.21 per gallon in fiscal year 2014.[52]

Impacts of Climate Change on TS&D Infrastructure in the Arctic

The entire Arctic is undergoing rapid changes on land and at sea due to the changing climate. Climate change is specifically affecting TS&D infrastructure in the North American Arctic region, including Alaska and U.S. territorial waters in the Bering, Chukchi, and Beaufort Seas, as well as Canada and its territorial waters. Warming in the Arctic region is resulting in increased risk of land subsidence from thawing permafrost, which threatens infrastructure.[53] It also leads to a reduction in late-summer sea ice extent, which increases

opportunities for offshore hydrocarbon and mineral exploration and extraction. The combination of these effects will likely affect Alaska and Canadian Arctic energy infrastructure onshore and offshore over the next several decades.[54] These changes are becoming more significant as both the United States and Canada increase energy production in the region. Cooperation between the United States and Canada on a range of issues from Arctic energy infrastructure to climate and ocean science may become an important new dimension to the U.S.-Canadian energy relationship.

Climate impacts—including primarily land subsidence caused by thawing permafrost, but also coastal impacts—are estimated to add between $3.6 billion and $6.1 billion (10 percent to 20 percent) to current costs of maintaining public infrastructure in Alaska over the next 20 years. Road, harbor, and airport maintenance comprise 57 percent of these projected additional maintenance costs through 2030.[55] The design of the Trans-Alaska Pipeline System illustrates the challenges posed by building on permafrost. Elevated above the tundra for approximately 400 miles with supports that allow for extensive vertical and horizontal movement to prevent damage from seismic or subsidence incidents, the Trans-Alaska Pipeline System cost $8 billion to build in 1977—a sum that indicates the expense that such adaptive measures entail. A 2008 U.S. Geological Survey study estimated that major disruptions caused by subsidence activity requiring replacement of the Trans-Alaska Pipeline System pipeline sections could result in $1.25 million per kilometer in repair costs.[56]

Climate changes affect energy exploration, development, and infrastructure for access to resources. It also creates more unpredictable work seasons and transportation conditions. For example, since the 1970s, permafrost changes have led to a 50-percent decrease in the length of time during which oil and gas exploration on tundra is allowed.[57] As transmission and storage facilities and vessels are increasingly employed to access Arctic energy resources, safety and spill and leak-prevention standards or regulations will also need to be tailored to the region given its changing climate and harsh conditions.

Administration Activities and Plans

The Administration is committed to taking a thoughtful and balanced approach to oil and gas leasing and exploration in the Arctic, recognizing its substantial oil and gas potential, as well as the marine and coastal resources that Native communities depend on for subsistence and the unique and sensitive ecosystems that it harbors. In early 2015, the Department of the Interior took steps to resolve judicial concerns that had prevented a final decision on whether to award leases in the Chukchi Sea under a 2008 oil and gas lease sale[c] and released a Proposed 5-Year Plan for additional offshore oil and gas exploration that solicited comment on three additional lease sales in waters offshore Alaska during the 2017 to 2022 period.[d] The Administration also moved to protect some sensitive undersea areas in the Beaufort and Chukchi Seas by withdrawing them from future leasing for oil or gas exploration and development.[e] The Administration's policy is to develop scientific information and stakeholder feedback to proactively determine, in advance of any potential offshore lease sale, which specific areas offer the greatest resource potential while minimizing potential conflicts with environmental, subsistence, and multiple use considerations.[f]

[c] Department of the Interior. "Department Releases Updated Assessment for Chukchi Sea Lease Sale." February 12, 2015. http://interior.gov/news/pressreleases/interior-department-releases-updated-assessment-for-chukchi-sea-lease-sale.cfm. Accessed February 26, 2015.

[d] Department of the Interior, Bureau of Ocean Energy Management. "2017–2022 Outer Continental Shelf Oil and Gas Leasing Draft Proposed Program." January 2015. http://www.boem.gov/2017-2022-DPP/. Accessed February 26, 2015.

[e] The White House. "Presidential Memorandum – Withdrawal of Certain Areas of the United States Outer Continental Shelf Offshore Alaska from Leasing Disposition." January 27, 2015. http://www.whitehouse.gov/the-press-office/2015/01/27/presidential-memorandum-withdrawal-certain-areas-united-states-outer-con. Accessed February 6, 2015.

[f] Department of the Interior, Bureau of Ocean Energy Management. "2017–2022 Outer Continental Shelf Oil and Gas Leasing Draft Proposed Program." p. S-6. January 2015. http://www.boem.gov/2017-2022-DPP/. Accessed February 26, 2015.

Administration Activities and Plans (continued)

On February 20, 2015, the Department of the Interior released proposed regulations to ensure that future exploratory drilling on the U.S. Arctic Outer Continental Shelf is conducted safely and responsibly, guided by the highest operational standards. The proposed rule for Arctic standards focuses solely on the Beaufort Sea and Chukchi Sea Planning Areas. The regulations seek to ensure that operators take the necessary steps to plan and safely operate through all phases of offshore exploration in the Arctic environment, including mobilization, drilling, maritime transport, and emergency response. The enhanced regulatory framework would ensure that operators and their contractors are appropriately prepared for Arctic conditions and that operators have developed an integrated operations plan to cover all operations. The proposed regulations released incorporate some of the lessons learned from Shell's 2012 operations and recommendations from the Department's review.

In addition to these steps, at the request of Secretary of Energy Moniz, the National Petroleum Council undertook a study on Arctic research requirements and the technology constraints that must be addressed to ensure prudent oil and gas resource development, advance U.S. energy and economic security, and ensure environmental stewardship there. The study focused on technology constraints for offshore oil and natural gas liquids development, primarily in shallow depths.[g]

In response to energy needs in Arctic communities, the Department of Energy's National Renewable Energy Laboratory, in partnership with the Department of the Interior, developed the Remote Communities Renewable Energy partnership, which aims to develop, demonstrate, and deploy smaller-scale, hybridized, modular platforms to harvest energy from local renewable energy resources, reduce diesel fuel dependence and distribution requirements, and create an independent microgrid operation.[h]

Beginning in April 2015, the United States will assume the chairmanship of the Arctic Council for a 2-year term and will propose collaborative initiatives for the council to implement in such areas as addressing the impact of climate change and Arctic Ocean stewardship and scientific research. In advance of the chairmanship, President Obama issued an Executive Order on January 21, 2015, establishing an Arctic Executive Steering Committee led by the Director of the White House Office of Science and Technology Policy.[i, j]

Within the U.S. Arctic Council agenda under the Sustainable Arctic Communities pillar, the State Department has proposed a suite of renewable energy programming to address region-specific barriers to project deployment and convening best practices. These projects include constructing a high-penetration wind-diesel hybrid system based on the Remote Community Renewable Energy partnership design in a rural Arctic community. The Arctic Council's Sustainable Development Working Group is also sponsoring an Arctic Energy Summit in Fairbanks, Alaska, this September that will address energy challenges including renewables, oil and gas development, remote and rural heat and power, and energy transmission and transportation. The State Department also plans to sponsor an Arctic Renewable Energy business plan challenge through our Arctic embassies.

[g] National Petroleum Council, Committee on Arctic Research. "Arctic Potential: Realizing the Promise of U.S. Arctic Oil and Gas Resources." March 31, 2015. http://www.npcarcticpotentialreport.org/pdf/AR_Exec_Summary.pdf. Accessed April 2, 2015.

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[i] Executive Order No. 13,689. "Enhancing Coordination of National Efforts in the Artic." 80 Fed. Reg. 4191. January 26, 2015. http://www.gpo.gov/fdsys/pkg/FR-2015-01-26/html/2015-01522.htm.

[j] The member states of the Arctic Council are Canada, Denmark, Finland, Iceland Norway, the Russian Federation, Sweden, and the United States. Other countries have observer status on the council. Recent U.S. and European Union sanctions may affect coordination with Russia over the next few years.

QER Recommendations

ARCTIC ENERGY TS&D INFRASTRUCTURE

Through the U.S. chairmanship of the Arctic Council and in partnership with Canada, the U.S. government should provide leadership on energy safety, reliability, and environmental protection in Arctic regions, and on improving energy availability in remote areas, through the following:

Partner with Canada and the Arctic Council on Arctic energy safety, reliability, and environmental protection: DOE, the Department of the Interior, the Coast Guard, and the State Department should partner with Canada and other Arctic Council members, including the Arctic Regulators Forum, to emphasize research and information sharing on the effects of spills and the effectiveness of countermeasures, the identification and mobilization of the resources necessary to mitigate the effects of a pollution incident, and the development of international guidelines for preparedness and response in this logistically challenging region.

Partner with Canada and the Arctic Council on energy delivery to remote areas: Additionally, under the Arctic Council, and domestically, DOE, the Department of the Interior, and the State Department should promote the Remote Community Renewable Energy partnership: first by developing, testing, and demonstrating its proposed modules in the United States and second by seeking avenues to deploy small-scale, hybridized conventional fuel-renewable generation platforms in other Arctic Council countries.

Infrastructures for Diversification of Caribbean Energy Supply

The Caribbean energy market is not large, but, given its proximity to the North American markets and energy systems, it could be a beneficiary of the North American energy renaissance. Current dependence on high-cost fuel imports for transportation and electricity generation is a major challenge for Caribbean islands, has local environmental and affordability impacts, and raises regional energy security and market concerns. Several strategies have emerged throughout the Caribbean to address the economic, environmental, and energy security issues associated with reliance on oil imports for electricity and transportation there.

The principal cause of high energy prices for electricity and transportation is the reliance of many Caribbean islands on oil imports. Currently, much of the Caribbean's oil imports come from Venezuela through its Petrocaribe organization, financed in part by deferred payment structures.[k] From June 2005 through the first quarter of 2009, Venezuela delivered approximately 90.5 million barrels of crude oil and refined products at an estimated $14 per barrel price reduction from market price among receiving countries.[58] Recently, Venezuela has been cutting the oil it supplies under these terms, which, in some cases, is leading to supply shortages on the islands.

[k] On June 29, 2005, 14 Caribbean and Central American nations signed the Energy Cooperation Agreement, establishing Petrocaribe during the First Energy Meeting of Heads of State/Government of the Caribbean on Petrocaribe. Presently, the now 18-member energy alliance consists of Antigua and Barbuda, the Bahamas, Belize, Cuba, Dominica, the Dominican Republic, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Nicaragua, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Saint Lucia, Suriname, and Venezuela.

Risk and Resilience in the Caribbean

Recent history has illustrated the potentially devastating consequences of natural disasters in the Caribbean. Small Island Developing States, including many Caribbean nations, face high risks and potential losses due to their size, location, economic characteristics, capital stock, and investment ability. For example, the United Nations reported that climate change leads to an additional $1.4 billion in the expected average annual losses associated with wind damage alone in the Caribbean through 2055.[l]

Apart from volatile energy prices, which affect Caribbean electricity generation and transportation, Caribbean islands face climate impacts to their energy infrastructure. Changes in precipitation may impact water availability on larger islands, including Jamaica, Haiti, and the Dominican Republic, for hydroelectric and thermal plants. Additionally, sea-level rise projections indicate greater impacts in the Caribbean due to gravitational and geophysical factors, and these impacts may affect coastal facilities, including power plants, oil refineries, and port facilities that receive oil and gas deliveries. Tropical storms represent a current and significant threat to Caribbean islands, and recent storms have resulted in the damage to energy production and distribution infrastructure, including damage to offshore platforms, pipelines, railways, roads, and bridges. Given the region's current reliance on oil for electricity generation, disruptions to transportation infrastructure also impact energy reliability.[m]

Since its establishment in 2007, the Caribbean Catastrophe Risk Insurance Facility (CCRIF), the world's first multi-country risk pool, has made nine payouts for extreme weather events (tropical cyclones, excess rainfall, and trough systems), totaling nearly $27 million to six member countries.[n, o, p] The CCRIF also performs regional tropical cyclone risk modeling in order to produce country profiles for its members. For example, using historic data, exposure assessment, and tropical cyclone risk modeling, the CCRIF profile of the Bahamas estimates a national loss of nearly $2.5 billion for a tropical cyclone with a 20-year return period.

[l] United Nations International Strategy for Disaster Relief. "Making Development Sustainable: The Future of Disaster Risk Management, Global Assessment Report on Disaster Risk Reduction." 2015. http://www.preventionweb.net/english/hyogo/gar/2015/en/home/GAR_2015/GAR_2015_1.html. Accessed March 26, 2015.

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[n] Caribbean Catastrophe Risk Insurance Facility. "Annual Report 2013-2014." October 2014. http://www.ccrif.org/sites/default/files/publications/CCRIF_Annual_Report_2013_2014.pdf. Accessed March 26, 2015.

[o] Caribbean Catastrophe Risk Insurance Facility. "About Us." January 2015. http://www.ccrif.org/content/about-us. Accessed March 26, 2015.

[p] Current members include Anguilla, Antigua and Barbuda, the Bahamas, Barbados, Belize, Bermuda, Cayman Islands, Dominica, Grenada, Haiti, Jamaica, St. Kitts and Nevis, Saint Lucia, St. Vincent and the Grenadines, Trinidad and Tobago and Turks and Caicos Islands

Opportunities for Clean Energy Supplies for Caribbean Nations and Territories

Recognizing the need for tailored approaches to energy infrastructure in the region, the United States (with a delegation led by Vice President Biden) and several Caribbean partners developed the Caribbean Energy Security Initiative, which promotes and finances clean energy technologies in the region (see box on Current Administration Activities and Plans).

Recent increases in U.S. natural gas production—as well as longstanding natural gas production in Trinidad and Tobago[q]—may also provide opportunities to export liquefied natural gas (LNG) to Caribbean islands. This could lower energy costs, address the variability of renewable electricity generation resources, and reduce emissions from existing fuel oil-fired electricity generation.[59] Making natural gas a viable fuel source in the

[q] Trinidad and Tobago is unique among the Caribbean island nations in its significant fossil energy resource base. It has long been an oil and gas producer, and it exports significant quantities of LNG—approximately 675 billion cubic feet of LNG in 2012.

Caribbean would require the TS&D infrastructure associated with LNG imports. To date, Caribbean demand has been too small to justify the expense of the necessary infrastructure. However, a 2014 study commissioned by the Inter-American Development Bank determined that establishing a natural gas supply chain in the Caribbean (based on small-scale LNG transport and floating regasification infrastructure) presented an economical method of displacing fuel oil as a method for energy delivery to eight Caribbean region nations.[r, 60] The study estimated a 30 percent decrease in carbon dioxide emission by 2032, resulting from the displacement of fuel oil by natural gas in current generation.[61]

Other proposals to displace fuel oil have gained traction, including the use of propane, other liquid fuels, and renewable sources for electricity generation. In July 2013, the U.S. Virgin Islands Water and Power Authority began the process to design and construct propane TS&D infrastructure for two electricity generation units in St. Croix and St. Thomas. To produce the same amount of electricity as the fuel oil plants they are replacing, the propane generators will emit on average 96 percent less sulfur dioxide, 84 percent less coarse particulate matter, 85 percent less carbon monoxide, 24 percent less nitrogen oxide, and 17 percent less greenhouse gases.[62]

Administration Activities and Plans

U.S.-CARICOM Summit—Deepening Energy Cooperation. In April 2015, President Obama met with Caribbean leaders in a U.S.-CARICOM Summit in Kingston, Jamaica, to reaffirm the importance of our relationship with the region and the United States' commitment to partner with Caribbean countries to advance economic development, security, and good governance. Leaders discussed a broad range of issues, from our important trade and investment linkages to security cooperation, including the importance of improving energy security, reducing energy costs, and fighting climate change. This follows robust engagement on these issues over the last year, including the White House Caribbean Energy Security Summit hosted by the Vice President in January 2015 and the launch of the Caribbean Energy Security Initiative (CESI) coordinated by the State Department. The United States is deepening this collaboration through a Clean Energy Finance Facility for the Caribbean and Central America; an Energy Security Task Force, driving clean energy finance to support renewable energy and clean energy technology collaboration to promote energy efficiency and storage; spurring a clean energy transition; greening tourism through a new Clean Energy Program to establish the pre-conditions for clean energy development, optimize renewable energy integration, and accelerate private-sector clean energy investment.

Caribbean Energy Security Initiative. In 2014, Vice President Biden announced CESI, which recognizes the diversity of Caribbean nation economies, natural resources, and energy constraints. Led by the State Department, in coordination with the U.S. Overseas Private Investment Corporation, DOE, and other agencies, CESI seeks to improve energy sector governance, to increase access to affordable finance, and to improve communication and coordination among regional governments and their development partners. CESI also is aimed at the full spectrum of the Caribbean energy sector, from production and generation through transmission, storage, and distribution to end uses. This scope is broader than the transmission, storage, and distribution focus of this Quadrennial Energy Review, but infrastructure will play a key role in the success of the projects under CESI.

On January 26, 2015, the Vice President, Energy Secretary Moniz, Deputy Secretary of State Blinken, and other senior Administration officials joined Caribbean heads of government, multilateral development banks, and other international partners in a Caribbean Energy Security Summit in Washington, D.C. The summit highlighted ongoing CESI efforts, such as improved governance of the energy sector, and recognized the continuing need for legal and regulatory reforms to introduce a broad range of clean energy technologies into the Caribbean. A variety of other commitments to promote and finance clean energy projects were announced. Administration engagement to promote energy security in the Caribbean, including through support for the necessary transmission, storage, and distribution infrastructure, will continue to be a priority.

[r] The Inter-American Development Bank study discussed the Bahamas, Barbados, Belize, the Dominican Republic, Guyana, Haiti, Jamaica, and Suriname.

QER Recommendations

CARIBBEAN ENERGY TS&D INFRASTRUCTURE

The Department of Energy recommends that, as part of a larger Caribbean strategy, the United States should support the diversification of energy supplies, including actions to facilitate the introduction of cleaner forms of energy and the development of resilient energy infrastructure in the Caribbean.

RECOMMENDATIONS IN BRIEF:
Integrating North American Energy Markets

Continue advances that have been made in the North American energy dialogue. All three countries should encourage further business exchanges and regular minister-level engagement.

Increase the integration of energy data among the United States, Canada, and Mexico. Provide resources for the Energy Information Administration to collaborate with its Canadian and Mexican counterparts to systematically compare their respective export and import data, validate data, and improve data quality. In addition, efforts should be taken to better share geographic information system data to develop energy system maps and review forward-looking assessments and projections of energy resources, flows, and demand.

Undertake comparative and joint energy system modeling, planning, and forecasting. Enhance comparative and joint modeling, planning, and forecasting activities among U.S., Canadian, and Mexican energy ministries and related governmental agencies. The current scale of activities has aided bilateral and individual goals; however, increasing trilateral engagement on planning, modeling, or forecasting activities would capture greater efficiencies and enhance each country's ability to reach economic, security, and environmental goals. The Department of Energy's Offices of Energy Policy and Systems Analysis and International Affairs would lead modeling workshops with their Canadian and Mexican counterparts to share methodologies and collaborate on North American analysis.

Establish programs for academic institutions and not-for-profits to develop legal, regulatory, and policy roadmaps for harmonizing regulations across borders. In partnership with universities, qualified not-for-profits, and relevant U.S. energy regulatory authorities, state/provincial, local, and national energy regulations will be compared to identify gaps, best practices, and inconsistencies with regulations in Canada and/or Mexico with the goal of harmonization.

Coordinate training and encourage professional interactions. This should involve the technical staff in government agencies of the three North American countries that share similar responsibilities to evaluate and implement cross-border energy projects.

Partner with Canada and the Arctic Council on Arctic energy safety, reliability, and environmental protection. Joint work should emphasize research and information sharing on the effects of spills and the effectiveness of countermeasures, the identification and mobilization of the resources necessary to mitigate the effects of a pollution incident, and the development of international guidelines for preparedness and response in this logistically challenging region.

Partner with Canada and the Arctic Council on energy delivery to remote areas. This should be done through promoting and disseminating the work of the Remote Community Renewable Energy partnership.

Promote Caribbean energy transmission, storage, and distribution infrastructure. As part of a larger Caribbean strategy, the United States should support the diversification of energy supplies, including actions to facilitate the introduction of cleaner forms of energy and the development of resilient energy transmission, storage, and distribution infrastructure in the Caribbean.

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