Electricity in North America

Baseline and Literature Review

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1. Executive Summary

This report explores the current status of North American electricity integration, and highlights themes of relevance, ranging from operational integration and physical infrastructure to stakeholder engagement and the business case for cross-border trade. Section 2 is an introduction that describes basic definitions and overarching challenges, including the inherent complexity of the North American system and the nascent nature of Mexican energy reforms, while highlighting "integrative elements" in the North American system that already exist: cross-border interconnections, North American cooperation in trade and reliability, and transmission access agreements. Section 3 focuses on high-level themes relating to U.S.-Canadian integration, highlighting the history and fragmentation of the Canadian power sector, and the extensive existing integration, with relevant electricity trade statistics. Section 4 explores the much less developed U.S.-Mexican integration, including a discussion of the history and consequences of the 2013 Mexican energy reforms, highlighting the importance of the Mexican industrial sector for cross-border trade. Sections 3 and 4 also contain four "case studies," each of which describes an example of a cross-border interaction highlighting interesting subregional approaches to specific challenges: converting competition to collaboration between Canadian hydro and U.S. renewable energy in MISO, stakeholder engagement for infrastructure development in New England, the potential for clean energy imports to satisfy U.S. state standards in Baja California, and the tension between ERCOT's traditional reluctance to interconnect and new cross-border business opportunities. Section 5 provides a detailed description of the governance and market structure of each subregional interconnection, and Section 6 explores each country's climate commitments and explores what is currently known about the potential for integration facilitate those commitments.

2. Introduction

2.1 A Potential Turning Point for North American Integration

At the highest levels of government in the United States, Canada, and Mexico, there has been a sustained interest in the benefits of enhancing North American energy integration. A number of recent developments make this discussion more relevant than ever before, including:

- The completion of the regulatory framework of the energy reform in Mexico in the oil, gas, and electricity sectors;
- A new administration in Canada with a stated interest in bringing greater focus and more global engagement to the clean energy discussion;
- The climate change agreement from the Paris COP 21 and the tremendous steps needed to implement NDCs globally;
- The acceleration of the deployment of renewable energy technologies, which raises new questions about grid management and the benefits of integration; and
- The shale gas boom in the United States, which presents new opportunities for natural gas trade, and new questions about land use, trade opportunities, and air emissions.

The significant electricity integration that already exists between the United States and Canada, and the new possibilities opened by Mexico's recent energy reforms, suggests that these developments cannot be overlooked by international policymakers. Identifying the most efficient opportunities in the changing North American paradigm will require extensive effort and thought leadership from governments, which must balance national priorities and regional benefits, while utilizing existing institutional and regulatory frameworks with asymmetrical federal, state, and local jurisdictions. To navigate this process effectively, it is critical that policymakers have a clear understanding of the current status of integration.

2.2 Stakeholder Views and Challenges Regarding North American Energy Integration

Though enhancing integration does not automatically result in benefits for all parties, it is a central concept in economics that international integration has the potential to provide new opportunities for growth, largely through trade and increased productive efficiency.[1]

This view has been further supported by a number of studies globally, from the United Nations,[2] the World Bank,[3] the World Energy Council,[4] the Organization of American States,[5] and the Commission for Environmental Cooperation,[6] an organization created along with the North American Free Trade Agreement (NAFTA). Others have noted that cross-border energy trade can make energy-intensive economic sectors more competitive, improve energy security, dampen short-term energy price volatility, and stimulate continent-wide economic growth.[7] More specifically, integration can leverage the specific strengths of the constituent countries. For example, with the significant acceleration of variable renewable energy use in the United States, Canadian hydropower could help balance loads.[8] Greater energy demand in Mexico could lead to commercial opportunities on both sides of the border in California as well as Texas. Additionally, increased transmission capacity between the U.S. and Mexico could provide reliability benefits to grids on both sides of the border.[9] A list of electricity-specific sector benefits to integration is reproduced in Table 1, and an example of how integration can lead to enhanced efficiencies is represented in Table 2.[10]

However, in spite of the broad consensus among governments and industry players that enhanced integration can bring significant benefits to society, there are myriad challenges to moving in this direction, as well as pitfalls for inefficient integrative policy. The barriers can be grouped roughly into categories: system complexity, regulatory policy, and social/political considerations.

System Complexity: While significant integration already exists between the United States and Canada, such integration evolved historically from an evolving "bottom-up" approach among provincial and State authorities without a "top-down" strategic vision or standardized process. As a result, U.S.-Canadian integration reflects both countries' market structures, which are largely fragmented and involve a range of federal, provincial, and state government jurisdictions as well as a range of industry, non-government, and society stakeholders,[11] resulting in a system of complex systems. While the U.S. did try to simplify its own market through a standard market design initiative led by FERC in 2005, this effort did not proceed as designed,[a,12] and no equivalent initiative has been attempted in Canada to adopt a national common market framework. Unlike the United States and Canada, Mexico does have a federal system, allowing greater structure for top-down strategic system design; however, the ongoing implementation of its 2013 energy reforms creates new uncertainties in the sector's governance, as many relevant policies and regulations are still in development.

Regulatory Policy: As with any sector that requires infrastructure development, the policy and regulatory framework is critical to the pace of development. While regulatory policy naturally varies regionally to reflect the specific priorities of different jurisdictions (i.e. economic development, environmental protection, sustainable development, social engagement), it can also lead to significant inefficiencies in permitting, siting, licensing, as well as tax, tariff, and incentives policies that reduce the possibilities of integration. The private sector has complained in all countries that permitting/siting/licensing requirements are slow, costly, and onerous, though some industries speak more positively of their experience complying with Canadian cross-border regulations.[13]

Tariff policies, can also provide disincentives for cross-border trade. Even nationally-focused energy incentives, while not always a direct disincentive to cross-border investment, may also influence cross-border trade opportunities. For example, the U.S. Federal Solar Investment Tax Credit (ITC), which is only provided to United States-based solar installations, makes U.S. installations more competitive than Mexican-sourced installations when competing in the U.S. market. This has resulted in a focus on wind or natural gas-based energy in Mexico for exports to the United States.[14]

[a]Though the Standard Market Design initiative did not move forward as proposed in 2005, significant elements have been incorporated into RTO processes.

Table 1: A summary of potential technical benefits from power sector integration. (Pineau, 2013)

TABLE 13.7 Potential Technical Benefits from Power Sector Integration (CEC, 2002; ESMAP, 2010; Pineau, 2012; UN, 2006)

Improving reliability and pooling reserves	With access to the production facilities of its neighbors, each region gains access to much greater resources to meet the demand in the case of incident. This increases reliability and reduces the need for local reserves of production capacity.
Reduced investment in generating capacity	Thanks to pooling, each region can avoid costs of adding further capacity on its own.
Improving load factors and increasing demand diversity	Greater geographic reach often provides a more diverse demand, where peak periods do not coincide. This helps to avoid operating generating plants only for peak periods, and it uses the generator fleet in a more constant and efficient manner.
Economies of scale in new construction	With guaranteed access to a much larger market, larger generating stations can be installed, making some economies of scale accessible.
Diversity of generation mix and supply security	With more types of generation producing electricity, over a larger territory, the system is less exposed to events that affect a particular source of energy (low rainfall, lack of fuel, etc.). This increases the overall security of the integrated system.
Economic exchange	With a more diversified generating fleet and production costs, it is possible to use less costly technologies, situated in other regions, to meet various energy needs. It becomes possible to use lower cost, but distant, energy resources if equivalent local resources are not available. This reduces the overall operating costs of the system.
Environmental dispatch and new plant sitting	With a larger territory in which to choose the location of generation facilities, the best sites can be chosen (e.g., areas with less fragile ecosystems or zones with the most favorable winds for wind power).
Better coordination of maintenance schedules	Greater flexibility and reduced impact can be obtained with a more extensive production fleet.

Table 2: Summary of the motivations and objectives of a number of global integration initiatives. Abbreviations are as follows: Greater Mekong Sub-region (GMS); Southern Africa Power Pool (SAPP); South East Europe (SEE); Central American Electrical Interconnection System (SIEPAC); Gulf Coast Countries (GCC); Nile Basin Initiative (NBI); Nam Theun 2 (NT2). (World Bank, 2010)

Scheme	Motivations/Objectives	Comments
TRANSMISSION & TRADE		
GMS	Efficient, environmentally sound development of the power sector to aid economic growth; support to regional projects and electricity trade as means for these objectives	Planned stages: (1) bilateral export projects (well advanced); (2) trade between any pair of GMS countries; (3) interconnections expressly for trade, with third party access effective; (4)integrated, competitive regional power market (still conceptual)
SAPP	Development of a safe, efficient, reliable, and stable interconnected electrical system and of a regional power trading mechanism	Subsidiary objectives are harmonized standards and regulations (well advanced)
Argentina-Brazil	Reduce drought vulnerability of Brazil's hydropower-dominated system and expand Argentina's trading opportunities	In practice, following political and economic crisis in Argentina and suspension of electricity exports, power flows have been from Brazil to Argentina (and also to Uruguay), but the system is fulfilling its energy security purpose
SEE	Create a regionally integrated electricity market, forming part of the wider EU single market	Political commitment to join the EU provides motivation for aligning with EU energy directives; economies-of-scale and access to lower-cost regional resources also a consideration for generation and transmission investment
SIEPAC	Create an integrated regional electricity market in Central America	Regional market seen as means to improve efficiency, security of supply, lower costs, attract foreign investment, and contribute to economic development
GCC	Share reserve capacity, thereby reducing generation investment requirements	Shared reserves is effective; trade in electricity is still under development
NBI	Ensure coordinated power investment in Nile Basin to meet social and economic development objectives in the region	The power integration component is part of a broader scheme for the optimized management of water in the Nile Basin with irrigation as the main concern
GENERATION		
Cahora Bassa	Import of clean power for more reliable electricity supplies in South Africa	Objectives fall within those of SAPP, but the project was initially developed on a purely bilateral basis
Manantali	Contribute to meeting the power needs and increase the efficiency and reliability of power systems in Mali, Mauritania, and Senegal	Initially, the purpose of the project was the regulation of Senegal River for irrigation purposes; power generation was a secondary aspect
NT2	For Lao PDR, revenues from hydropower exports; for Thailand, access to cost competitive and diversified electricity supplies	One of a number of Lao PDR-Thailand hydro-power projects in operation or under develop-ment

Social/Political Considerations: Finally structural, and potentially transformational change to the status quo, integration can inspire passionate discussions about national sovereignty, interdependency, environmental safety and sustainability, national industries and jobs, and the creation of "winners and losers." While there is no easy solution to many of these concerns, it is well-documented that fair and transparent regulatory processes, extensive community stakeholder engagement, and a clear quantification of the costs and benefits for a community can enhance the chance of a project's success.[15] The first installment of the QER[16] and the QER 1.2 Environment Baseline[17] include more detailed discussion of these issues and the various efforts that U.S. federal agencies have underway to improve the efficiency and transparency of permitting and review processes.

While no federal authority in the United States or Canada can unilaterally mandate movement towards greater integration, federal governments still play a key role in the sector's thought leadership, strategic planning, analysis, tool development, and convening of critical stakeholders to explore new opportunities. Federal governments are responsible for maintaining a prosperous economy, delivering on international commitments (including emissions reductions relating to climate change), and ensuring energy security for their citizens. The recent meetings of the Energy Ministers of the U.S., Mexico and Canada affirms all three governments' priorities in advancing these opportunities trilaterally. [18]

2.3 Scope and Overarching Issues: Defining Integration and Harmonization

While integration and harmonization are topics of discussion among a broad range of cross-border power sector stakeholders, there is no consensus on the exact definition of the terms "integration" and "harmonization." These terms are often used interchangeably, with each referencing a wide range of activities and comprehensiveness. Others use "integration" as a shorthand for the term "renewable energy integration."

For the purposes of this report, we define integration to include basic information sharing in policymaking and planning and the coordination of policies and decision-making.[19] For the power sector, this includes any level of coordination in the planning, system operation, and the basis for electricity trades, price-setting, and regulation. Table 3 describes how different levels of coordination of each of these areas can result in a spectrum of different levels of integration: physical interconnection, loose power pool, tight power pool, and competitive electricity market.[20]

Table 3: A description of different levels of integration, and the implications for a number of system features. Across North America, a variety of different levels of integration can be observed, from physical interconnection in ERCOT-Mexico to a competitive electricity market in MISO in which Manitoba Hydro can directly participate. Adapted from (Ben Amor, 2011).

	Levels of Integration			
	Physical Interconnection	Loose Power Pool	Tight Power Pool	Competitive Electricity Market
Structures allowed	Vertically-integrated utilities, unbundled	Vertically-integrated utilities, unbundled	Vertically-integrated utilities, unbundled	Usually unbundled

Planning	Independent but with information exchange	Independent but with certain common projects	Common	Left to market forces (under the monitoring of regulators)
System Operation	Synchronization of activities	Coordination of production	Centralized planning	Independent network operator
Basis for Electricity Trades	Firm long term or emergency contracts	Benefit Sharing	Benefit Sharing	Competitive Market
Sources of Cost Reduction	Economies of scale	+ reliability and reserves	+ minimization of total costs	+ competition
Price	Set in a distinct manner	Set in a distinct manner but directly influenced	Set in a common process	Freely set by the marketplace
Regulation	Independent	Independent	Common	Common
Basis for Reliability	Emergency power	Shared power reserves	Shared power reserves	Integrated reliability responsibilities

A number of examples of North American integration already exist, as were discussed in a report on RFF/DOE Workshops on regional electricity integration:[21]

- *As an example of information sharing, in 2014 the three countries signed a Memorandum of Understanding on the sharing of energy-related data and definition of terms (led by the US Energy Information Administration).*
- *An example of considering impacts on the other nations (in this case, all other nations) is the use in some US federal government regulatory decision-making of a global damage estimate for greenhouse gas emissions.*
- *An example of broadly coordinating policies and integrating others into planning processes and decision-making is the North American Electric Reliability Corporation, which involves Canada, the United States, and northern Baja California. The linked greenhouse gas emission cap-and-trade programs of California and Quebec provide another example.*
- *An example of policy coordination between the United States and Canada is the tightening of standards for railcars, tracks and the like after the major spill of Bakken oil in Lac-Mégantic in 2013. In this case, no attempt was made to make these policies the same, but there was recognition that the countries should communicate about the changes being contemplated.*
- *Finally, an example of more complete policy harmonization is in Canadian automobile emissions and fuel economy policies; these mirror those of the United States in stringency over time, primarily because the US and Canadian vehicle markets are fully integrated.*[22]

2.4 Existing Integrative Elements in the North American System

While an in-depth description of power sector governance structure in Canada and Mexico is included in sections 3 and 4, this section will briefly reference those institutions, agreements, and regulatory elements that are relevant to all three countries. Table 4 also provides a summary overview of Canadian, U.S., and Mexican power sector structures and institutions.

2.4.1 Governance of the North American Grid

A complete description of North American industry structure, coordination framework, value streams, regulation, and markets – a set of characteristics also known as "grid architecture" -- can be found elsewhere,[23] but certain basic elements, of particular relevance to the North American power system, are summarized below.

Basic Entities:

- **Interconnections**: Overall, the North American power system has evolved with geographically-based grid architecture structures, including five blocks of internally-synchronous interconnected regions known as "interconnections": Western, Eastern, Texas, Quebec, and Mexican interconnections. Trade takes place between interconnections via inter-tie stations.

Table 4: ***Summary of Electricity Authorities in North America.*** *While Canada's provinces are largely non-integrated and have independent models for power sector governance, the U.S. system is more complex, and grouped into ISOs/RTOs and other power pools that range from state-contained (ERCOT, CAISO, NYISO) to cross-border (MISO, PJM). U.S. States listed with an asterisk (*) have only minor geographic areas included in the listed jurisdiction; power marketing administrations (PMAs) are indicated in the Ministry/Agencies involved section in italics. Mexico, in contrast, relies on a federal system where most power sector governance is centralized, with the notable exception of the northern Baja California region, which is not interconnected to the rest of the Mexcian federal grid, and participates on the Western Electricity Coordination Council (WECC). Acronyms for Canadian provinces used are British Columbia (BC), Alberta (AL),Saskatechwan (SK), Manitoba (MB), Ontario (ON), Quebec (QC), New Brunswick (NB), and Newfoundland and Labrador (NL). (adapted from (Pineau, 2013) for Canadian data, EPSA synthesis for U.S. and Mexico data.)*

	National/ subnational government (s)	NERC Balancing region	Market Operator/RTO /ISO	Ministry/ Agencies involved	Regulator	Market Design	Capacity in MW
CANADA (border provinces)	Federal	--	--	Natural Resources Canada (NRCan)	National Energy Board (NEB)	--	135,000
	BC	WECC	BC Hydro, participates in NWPP	Energy and Mines	BC Utilities Commission	Centrally managed model with bilateral contracts	15,220
	AL	WECC	Alberta Electric System Operator, participates in NWPP	Department of Energy	Alberta Utilities Commission	Mandatory power pool	12,298
	SK	MRO	SaskPower	Provincial Cabinet and Crown Investments Corporation of Saskatchewan	Saskatchewan Rate Review Panel	Centrally managed model with bilateral contracts	4,042
	MB	MRO	Manitoba Hydro	Innovation, Energy and Mines	Public Utilities Board	Centrally managed model with bilateral contracts	5,640
	ON	NPCC	Independent Electricity System Operator	Energy	Ontario Utilities Board	Power pool for real-time energy market with bilateral contracts, PPAs, and regulated tariffs	34,276
	QC	NPCC	HQ	Natural Resources and Wildlife	Régie de l'énergie	Centrally managed model with bilateral contracts	42,485

	NB	NPCC	New Brunswick System Operator	Department of Energy	Energy and Utilities Board	Physical bilateral market with a redispatch market	4,625
UNITED STATES	Federal	--	--	DOE	FERC, EPA, BLM, NRC	--	1,063,000
	WA, MT, ID, OR, WY*, CA*, NV, UT	Western Electricity Coordinating Council (WECC)	Control area opeartors: “Northwest Electric Markets”	*Bonneville Power Administration (BPA); Western Area Power Administration (WAPA)*	State regulatory commissions;	Traditional wholesale electricity markets	78,964
	MN, MI, MT, IA, IL, ND, SD, WI, MI* AK, KY*, IN*, LA, MS, TX	Midwest Reliability Organization (MRO)	Midcontinent ISO (MISO)	*WAPA*	State regulatory commissions;	RTO/ISO competitive markets	180,711
	NY	Northeast Power Coordinating Council (NPCC)	New York ISO (NYISO)		New York State Public Service Commission (PSC)	RTO/ISO competitive markets	30,039
	VT, NH, ME, MA, CT, RI	NPCC	New England ISO (ISO-NE)		State regulatory commissions;	RTO/ISO competitive markets	31,000
	OH*, IL*, KY*, WVA, MD, PA, DE, IN, NJ, NC, TN*, VA, DC	Reliability First (RF)	PJM	*Southeastern Power Administration (SEPA)*	State regulatory commissions;	RTO/ISO competitive markets	183,604
	FL, GA, AL, MS, NC, SC, MO, TN	Florida Reliability Coordinating Council (FRCC), Southeastern Electric Reliability Council (SERC)	Control area opeartors: “Southeast Electric Power Markets”	*Tennessee Valley Authority; SEPA*	State regulatory commissions;	Traditional wholesale electricity markets	238,000

	AZ, NM, NV, WY, SD, CO, TX	WECC	Control area opeartors: "Southwest Electric Markets";	*WAPA*	State regulatory commissions;	Traditional wholesale electricity markets	50,000
	MT*, ND*, SD*, WY*, NB, IA*, KA, OK, TX*, NM*, AR, MO*, LA*	Southwest Power Pool, RE (SPP)	Southwest Power Pool (SPP)	*Southwest Power Administration (SWPA)*	State regulatory commissions;	RTO/ISO competitive markets	78,953
	TX	Texas Reliability Entity	Electricity Reliability Council of Texas (ERCOT)	*SWPA; WAPA*	Public Utility Commission of Texas	RTO/ISO competitive markets	75,964
	CA, NV*	WECC	California ISO (CAISO)	*WAPA*	California Public Utilities Commission (PUC)	RTO/ISO competitive markets	60,000
MEXICO	Federal	*(none)*	CENACE (wholesale); CFE (residential users)	SENER, SEMARNAT	CRE	Wholesale competitive market for industrial users; regulated rates for residential	62,000
	Baja California	WECC					2,341

- **Reliability regions:** Within interconnections, there are reliability regions managed by reliability coordinators who continuously monitor the state of the grid within their regions, and perform operational and contingency analysis to maximize grid reliability. Reliability coordinators are overseen by the North American Electric Reliability Organization, NERC (see below).

- **Balancing authority areas:** Within reliability regions, grids are further broken down into balancing authority areas. Each reliability region has a Balancing Authority that performs control functions, including generation dispatch and balance, interchange scheduling with other balancing authority areas, and local frequency control.

- **Utilities:** The EIA defines utilities as "a corporation, person, agency, authority, or other legal entity or instrumentality aligned with distribution facilities for delivery of electric energy for use primarily by the public." This can include a variety of structures, including investor-owned electric utilities, municipal and State utilities, Federal electric utilities, and rural electric cooperatives.[24] Throughout North America, utilities can have authority over contiguous or non-contiguous geographical areas.

- **Regional Transmission Operators, Independent System Operators (RTOs/ISOs):** To enhance coordination among multiple interconnected power systems, through Orders Nos. 888/889 in the 1990s, FERC suggested the concept of Independent System Operators as a mechanism to ensure fair and non-discriminatory transmission access for existing tight power pools. Order No. 2000 took this a step further, encouraging the formation of voluntary Regional Transmission Organizations and setting criteria that such organizations must meet. RTOs are independent, membership-based, non-profit organizations that ensure reliability and optimize the wholesale power system; like ISOs, they ensure fair access to transmission, but they are also required to engage in transmission planning and expansion for their region. In practice, the distinctions between ISOs and RTOs in the United States have become very minor. One important distinction for international affairs, however, is that while ISOs are prohibited from involving international partners, RTOs are not. This is particularly salient in the case of the MISO: formerly known as the Midwest Independent Transmission System Operator, in 2001 it received FERC approval to become the first United States RTO, changing its name to the Mid-continent Independent System Operator (keeping the same "MISO" abbreviation), and accepted Manitoba Hydro as a member. This was also the first example of an international extension of a U.S. RTO.[25]

- **Power Marketing Administrations (PMAs)**: A result of the history of federal government involvement in the development of hydropower resources in the United States, power Marketing Administrations are officially federal agencies within the Department of Energy, which carry the responsibility of marketing wholesale power. Though they generally do not own electric generating plants, they are often involved in transmission and electric power systems, and can have a number of additional responsibilities, including as balancing authorities and transmission owners/operators. Most PMAs market hydropower, with the exception of the Bonneville Power Administration, which also has nuclear assets.[26]

The Future of U.S. Grid Architecture Reform?

Within the United States, there is significant discussion and increasing concern about whether the existing power system will be able to respond to the evolution of distributed generation, the potential regulatory impact of the Clean Power Plan, and the deployment of greater renewable energy technology, among other innovations. Such fundamental changes could affect the interplay between the regulatory structure, management, and reliability responsibility of the power sector. One point is widely accepted: "the structure of the grid determines important system properties and limits," and the current grid architecture is likely insufficient to maintain operability and reliability for future needs.[27] The current system consists of geographically-siloed grid control elements, with hierarchical layers of responsibility for reliability. Such a system may not be sufficient for the evolution of "bifurcation of generation" (i.e. that some end-users can also act as generators), responsive loads, and net load versus gross load dynamics.[28]

There are many viewpoints about the best way to redraw regulatory boundaries to resolve these issues, which are beyond the scope of this baseline. However, it is worth noting that some have suggested that the current, geographically-derived grid architecture in the U.S. could be improved by including the management of assets across jurisdictional lines, to include consumers. Such an approach would require significant regulatory changes in state and local laws, as well as new protocols for communication and interoperability. Some U.S. States are also exploring changes in their reliability models.[29]

Close U.S.-Canadian integration implies that any transformational changes in the U.S. grids operations and reliability will affect and be affected by the Canadian system (and potentially the Mexican system, if integration advances significantly in the coming decades), and may require greater international coordination.

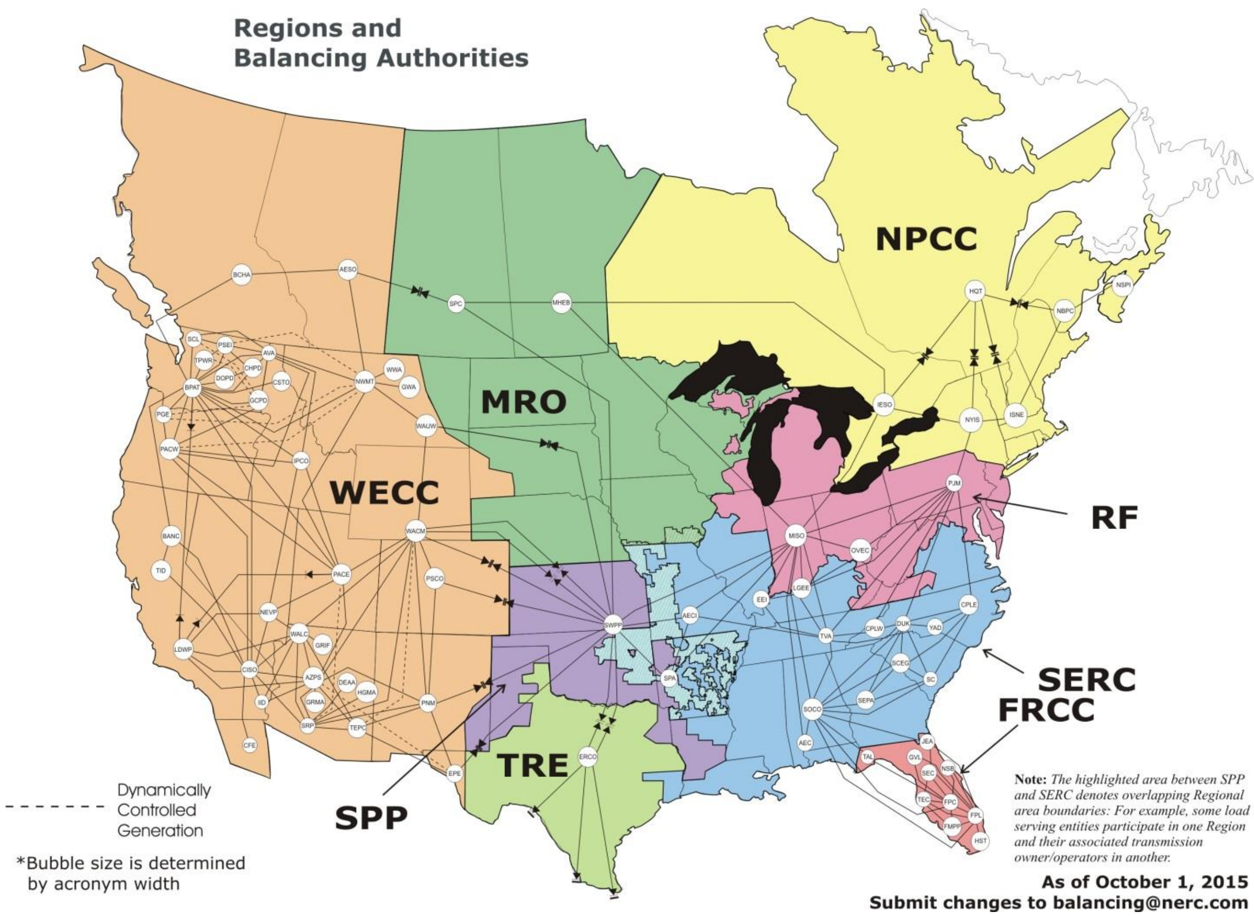
2.4.2 North American Institutions and Agreements

The following is a list of North American institutions and agreements that have relevance to cross-border electricity integration.

- **North American Electric Reliability Corporation (NERC):** A not-for-profit international regulatory authority that seeks to assure the reliability of the bulk power system in North America, including the continental United States, Canada, and the northern portion of Mexico in Baja, California. NERC is the official electric reliability organization for North America, and receives oversight from FERC as well as Canadian government authorities. NERC's responsibilities include the development and enforcement of reliability standards, annual assessment of seasonal and long-term reliability, monitoring of the bulk power system, and the education, training, and certification of industry workers.[30] The NERC Reliability Regions are shown in Figure 1.

- **North American Free Trade Agreement (NAFTA):** In effect since January 1, 1994, NAFTA is a trilateral free trade agreement between Canada, the United States, and Mexico, which sets the rules of trade and investment in the three countries. NAFTA limited tariffs on a majority of goods traded trilaterally, and called for the gradual elimination (over 15 years) of most remaining barriers to cross-border investment, as well as the movement of goods and services. While the agreement was, and continues to be highly controversial in all three countries,[31] it is credited with modest economic gains and labor market restructuring.[32] Mexico, due to constitutional restrictions at the time, took exception to opening the oil and gas drilling sector to foreign competition, but trade in crude oil and natural gas was covered by the agreement, and did increase over the following two decades. Electricity trade was also included under tariff-elimination rules under NAFTA, though its classification can become complicated as different elements of the power sector (generation, transmission, and distribution) defy simple definitions as "goods" or "services." There are, however, a number of conditions where NAFTA members may restrict or prohibit electricity flows, including cases where the energy is being re-sold to a non-NAFTA member, or where restricting trade will relieve critical shortages. Mexico – which entered NAFTA before the recent energy reforms -- also filed "reservations" on strategic activities to reserve the right to supply electricity within Mexico and exclude foreign parties from entering the sector, except under excepted circumstances.[33]

Figure 1. The NERC reliability regions (colored regions) and balancing authorities (circles), with interconnections shown as lines. The significant U.S.-Canadian integration is evident from the cross-border reliability regions, as well as the connections between balancing authorities on both sides of the border. While Mexico is not listed explicitly among the current NERC balancing regions, the northern portion of Baja California, which is not interconnected to the rest of the Mexican grid, is a member of the Western Electricity Coordinating Council (WECC). (NERC, 2015)



- **North American Agreement on Environmental Cooperation (NAAEC):** NAFTA was also accompanied by the establishment of the NAAEC, known informally as the environmental "side agreement," which was formed in response to concerns that NAFTA would lead to significant environmental damage. The NAAEC established the Commission for Environmental Cooperation (CEC), which is a trilateral organization through which Canada, Mexico, and the United States collaborate on "the protection, conservation, and enhancement of North America's environment." The CEC focuses on initiatives relating to climate change, ecosystems, green economy, and pollutants, and also provides community grants for initiatives in the border region. Though the CEC does not focus on energy, it does have responsibilities relating to the enforcement of pollution limits set on certain fuel sectors, such as maritime transport.

2.4.3 Transmission Access Agreements

The United States, through FERC, has implemented agreements to ensure that all generators have fair and competitive access to transmission infrastructure, with the intention to "*remove impediments to competition in the wholesale bulk power marketplace and bring more efficient, lower cost power to consumers".* Though these agreements are not international in nature, FERC requires that any international entities that seek access to U.S. markets comply with these agreements, and Canadian provinces that export electricity to the United States have chosen to do so. Canadian provinces' voluntary observance of U.S. regulations has been a fundamental facilitator of U.S.-Canadian electricity trade.

- **Open Access non-discriminatory Transmission Tarriffs (OATT):** On April 24, 1966, FERC issues Order No. 888, which required public utilities to "*provide open access transmission service on a comparable basis to the transmission service they provide themselves*". This includes a requirement that public utilities that own transmission infrastructure file open access transmission tariffs that contain minimum terms and conditions for non-discriminatory service; and allows public and transmitting utilities to seek recovery of "*legitimate, prudent, and verifiable stranded costs associated with providing open access".* Order No. 888 was reformed slightly in 2007 to reflect recent changes in the utility industry, which were adopted in Order No. 890.[34]

- **Order No. 1000**: Order No. 1000 is a FERC rule that reforms the Commission's electric transmission planning and cost allocation requirements for public utility transmission providers. While the rule builds on Order No. 890, it extends beyond transmission access and into the transmission planning processes and cost allocation methods. It requires public utility transmission providers to participate in a regional transmission planning process under Order No. 890, mandates that local and regional transmission planning processes must consider transmission needs driven by public policy requirements, and – of particular note – that utility transmission providers in neighboring transmission planning regions must coordinate their efforts to identify the most cost-effective solutions. Order No. 1000 also establishes requirements for transmission cost allocation, including the requirement that utilities participation in a regional transmission planning process with clear cost allocation methods selected that satisfy six regional cost allocation principles. It also removes a public utility's right of first refusal to develop transmission infrastructure in regional transmission plans, which was seen as an unfair advantage for public utilities to capture (or design) lucrative transmission contracts.[35]

2.4.4 Information-Sharing in Cross-Border Cooperation

One key challenge to performing analysis of the North American bulk power system is the non-uniformity of energy data and definitions across borders. Though all three countries use rigorous methodology to collect energy data, minor differences in collection techniques and definitions complicate collaborations or comparisons.

In 2014, the Energy Secretaries/Minister of Canada, Mexico, and the United States met and signed a trilateral memorandum of understanding (MOU) on energy information cooperation. Through this cooperation, energy institutions from all three countries collaborate in the following areas:[36]

- *Comparing, validating, and improving respective energy import and export information;*
- *Sharing publicly available geospatial information related to energy infrastructure;*
- *Exchanging views and information on projections of cross-border energy flows;*
- *Harmonizing terminology, concepts and definitions of energy products.*

Participating agencies include:

- Canada: the Department of Natural Resources, Statistics Canada and the National Energy Board;
- Mexico: the Secretaría de Energía (SENER) (Secretariat of Energy), Comisión Reguladora de Energía, Comisión Nacional de Hidrocarburos, Petróleos Mexicanos, Comisión Federal de Electricidad, Centro Nacional de Control de Gas Natural, Centro Nacional de Control de Energía and the Instituto Nacional de Estadística y Geografía (INEGI) (National Institute of Statistics and Geography);
- United States: the Energy Information Administration (EIA) of the Department of Energy and the U.S. Census Bureau from the United States.[37]

The cooperation has resulted in a new website, http://www.nacei.org, which includes links to each country's national and international statistics, as well as interactive maps of infrastructure in all of North America. The EIA also produced a preliminary report.

3. Index of Current Status of North America Power Generation

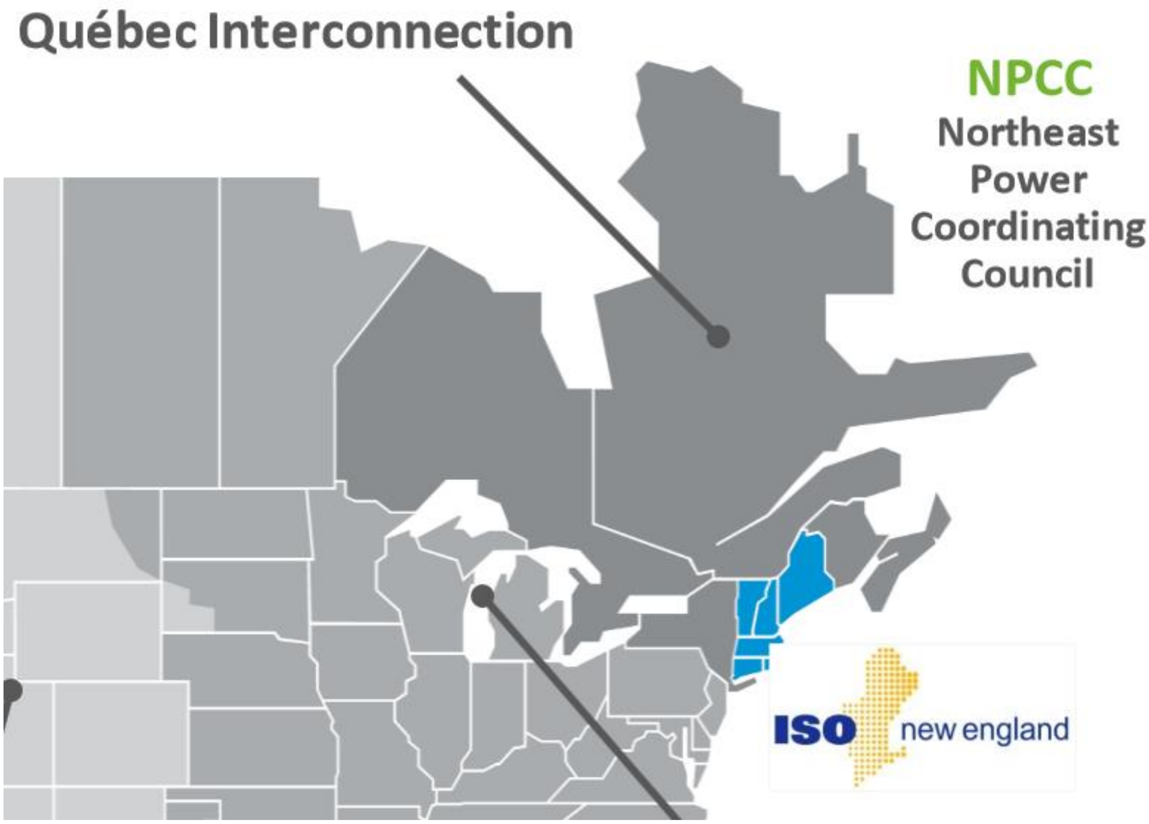
(Section 3 was prepared by NREL)

Although general themes on power sector governance and integration can be extracted across North America, the diversity in models for subregional cross-border integration makes a case-by-case breakdown informative. This section analyzes cross-border interconnections with ISO New England (ISO-NE), the Electric Reliability Council of Texas (ERCOT), New York ISO (NYISO), Midcontinent ISO (MISO), the Western States and Provinces in the Western Electricity Coordinating Council (WECC), and California ISO (CAISO).

3.1 ISO-NE

This section covers ISO New England (ISO-NE) and the main entities with which ISO-NE exchanges electricity, including Hydro Quebec, the New Brunswick Transmission and System Operator (NBSO), and the New York Independent System Operator (NYISO, Figure 2).

Figure 2: Map of ISO New England territory (in blue) and adjacent electric systems: NYISO, the Maritime Provinces system and the Quebec Interconnection (in darker gray). [38]

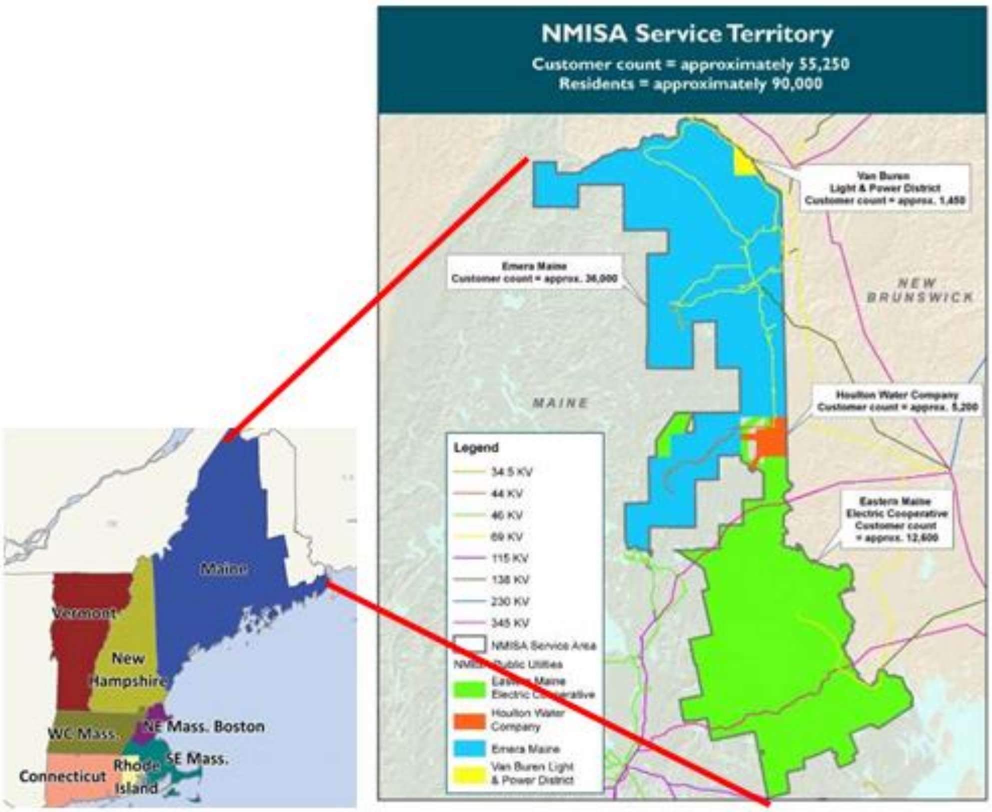


3.1.1 Market Structure and Regulation

ISO New England is an RTO registered with NERC. Its footprint includes the New England states (Maine, Vermont, New Hampshire, Massachusetts, Connecticut, and Rhode Island), except for a small portion of northeast Maine known as the Northern Maine Transmission System (NMTS), which is operated by the Northern Maine Independent System Administrator (NMISA, Figure 3).

NMISA operates as an independent and non-discriminatory administrator of transmission access and operates wholesale markets for energy and ancillary services. [39] NMISA is a small region with a peak load of 130 MW.[40] The New Brunswick System Operator (NBSO) is the regional reliability coordinator and balancing authority for NMISA and the Maritime Provinces system consisting of the electric grids in New Brunswick, Prince Edward Island, and Nova Scotia.[41] NBSO is a division of New Brunswick Power, the utility owned by the government of New Brunswick. The New Brunswick Energy and Utilities Board (EUB) is a government agency established by the legislature to regulate the electricity, natural gas, pipeline, and motor carrier industries in the province.[42] The National Energy Board of Canada (NEB) is the federal regulator for the interprovincial and international transmission and sale of electricity.[43]

Figure 3. Additional breakdown maps of ISO-NE and NMISA service territories. ISO-NE covers all regions in Maine, Vermont, New Hampshire, Massachusetts, Connecticut, and Rhode Island, with the exception of the Northeastern Maine NMISA service territories, which serve small communities (with a total capacity of 130 MW) on the border with New Brunswick. New Brunswick acts as the balancing authority for the NMISA Service Territory. [44]



Hydro-Québec (HQ) is owned by the government of Quebec and is the main utility in that province. HQ operates the largest transmission system in North America through its transmission division, TransEnergie Hydro-Quebec (HQTE). HQTE provides open access to its transmission infrastructure and administers a system capacity market where distributors, producers and marketers can bid on available transmission capacity. HQTE is also a reliability coordinator for transmission systems in Quebec.[45]

The Régie is Quebec's regulatory authority with primary jurisdiction over the economic regulation of the electricity sector. It approves HQ electric supply plan and reliability standards.[45]

3.1.2 Entities and Jurisdiction

The non-federal entities that either have jurisdiction over international trade or are related to the generation, transmission or commercialization of electricity consumed in the ISO-NE/Quebec/New Brunswick region are shown in Table 5.

Table 5: Entities and Jurisdictions for the New England/Canadian interconnections. ISO-NE, "What We Do"; NPCC, "Home - About NPCC"; NECPUC, "NECPUC Background."

Entity	Acronym	U.S. States / Canadian Provinces	Purpose	Internal Trade Mechanisms	Authority From
Northeast Power Coordinating Council	NPCC	CT, NY, MA, ME, NH, RI, VT / NB, NL, ON, QC	Promote reliability of international and interconnect bulk power system	Establish reliability and compliance standards	NERC
New England Power Pool	NEPOOL	CT, MA, ME, NH, RI, VT	Tracks generation certificates for all generation and imports in the ISO NE region.	General Information System (GIS) – used to measure RPS compliance	State PUCs
New England Conference of Public Utilities	NECPUC	CT, MA, ME, NH, RI, VT	Provides regional regulatory assistance on matters of common concern to PUCs	Policy briefs and Symposiums	No regulatory authority
New England States Committee on Electricity	NESCOE	CT, MA, ME, NH, RI, VT	Regional State Committee that represents the collective perspective of NE states in regional electricity matters.	Resource adequacy and system planning and expansion.	Recognized by FERC
ISO New England	ISO NE	CT, MA, ME, NH, RI, VT	As RTO: Operating the power system, administering wholesale electricity markets, and power system planning. Registered with NERC as a Reliability Coordinator, Balancing Authority, Interchange Coordinator, Transmission Operator and Transmission provider	Operation of day-ahead, real time, capacity, and reliability markets	FERC, NERC
Hydro-Quebec	HQ	QC	Generates, transmits, and distributes electricity	HQ Energy Services created as U.S. subsidiary to facilitate imports/exports. OATT since 1997	Régie de l'énergie, FERC

Independent Electricity System Operator	IESO	ON	Balances electricity system, power system planning, and overseeing wholesale electricity market	Operates energy markets. Active since 2002 and has mechanisms in place that simulate an OATT	Ontario Utilities Board, FERC
New Brunswick Transmission and System Operator	NBSO	NB	Owns and operates transmission system. Responsible for system planning	OATT since 2004	Energy and Utilities Board, NPCC, NERC
New Brunswick Energy and Utilities Board	EUB	NB	Monitoring and enforcement of N.A. reliability standards	Regulates electricity sector	NB Legislature
Newfoundland and Labrador Hydro	NL Hydro	NL	Generates, transmits, and distributes electricity	Utilizes HQ OATT for import to U.S. (2006)	Board of Commissioners of Public Utilities

3.1.3 System Planning and Operations

ISO-NE, NYISO and PJM participate in interregional system planning through the Interregional Planning Stakeholder Advisory Committee (IPSAC). The members of the IPSAC include the advisory committees of each participating ISO/RTO, plus government agencies, regional state committees, provincial entities, regional reliability councils and interested parties. The activities of the committee are administrated by the participating ISO/RTOs on a rotating basis.[46] TransÉnergie, the Independent Electric System Operator (IESO) of Ontario and the New Brunswick System Operator (NBSO) participate on a limited basis to share data and information.[47]

ISO-NE has two synchronous 345 kV ties with the Maritimes[b] (via the New Brunswick Power Corporation), and two asynchronous ties with Quebec (via Hydro-Quebec), a 120 kV AC-DC-AC and a 450 kV DC interconnection.[48] The majority of the NPCC region is synchronous, except for Quebec.[49]

Canadian generators can participate in ISO-NE wholesale markets. Any generating plant able to deliver power into New England can participate in electricity markets regardless of its geographic location, as long as it can demonstrate that is able to deliver electricity and comply with the applicable standards.[50]

Various inter-area agreements between ISO-NE, Hydro-Québec TransÉnergie, NBSO, NYISO and New England asset owners provide for the planning, operation, maintenance, and metering of interconnections between two electric power systems; for mutual assistance during emergencies; improved reliability through coordinated operations; and the trading of capacity and energy.[51] Members of the NPCC and PJM can voluntarily participate in the Shared Activation of Ten - Minute Reserve (SAR) program. This program is managed by the NPCC Task Force on Coordination of Operation and is designed to use transmission interconnections to help participants recover from a significant supply loss. Participants include NYISO, ISO-NE, the Maritimes, PJM and the Independent Electricity System Operator (IESO) in Ontario. Hydro-Quebec does not participate because they are not synchronously connected to the NPCC region.[52]

3.1.4 Reliability Standards

The Northeast Power Coordinating Council (NPCC) is one of ten regional reliability councils established within the framework of the North American Electric Reliability Council (NERC).. NPCC's geographic area includes New York, New England, the Maritimes, Ontario, and Quebec.

3.1.5 Known Challenges

As of January, 2015, the Northern Maine Independent System Administrator's (NMISA) network was connected to the Canadian utility New Brunswick Power Corporation, but not directly to ISO-NE.[53] Lower natural gas prices have allowed generators in New Brunswick to underbid some of NMISA's generators, which include a mix of hydropower, wind, diesel and biomass, triggering retirements that have raised reliability concerns.[54]

In the Maritimes load peaks in the winter while in New England it peaks in the summer. A higher transmission capacity between the two territories would increase the utilization factor of existing

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[b] The Maritimes is a region of Eastern Canadian made up of three provinces: New Brunswick, Nova Scotia, and Prince Edward Island.

generation capacity on both sides of the border, reduce the need for additional natural gas pipeline infrastructure, and lower generation infrastructure costs in the long term.

Renewable standards create a demand for renewable energy plants. Transmission is needed to bring renewables to market, including energy from remote wind plants and Canadian hydropower.[55]

3.1.6 Planned Transmission

Transmission projects have been proposed in order to reduce congestion in high demand areas (e.g. Boston) and to provide capacity to allow for additional Canadian hydro and wind imports. These projects, listed in no specific order, are as follows (project names in bold indicate ties that cross system borders):

- ***New England Clean Power Link***[c] – 1,000 MW HVDC transmission line that will provide power from the Quebec border into Vermont and New England. Currently under state and federal review and U.S. Presidential Permit was applied for May 2014. Expected completion in 2019[56].
- ***Northern Pass*** – 1,200 MW HVDC line with a 345 kW spur from Quebec to New Hampshire. Currently under state and federal review and U.S. Presidential Permit was initially applied for in October 2010 and reapplied for in July 2013 with a new route after protest over the initial project. Expected completion in 2017[57]. (The route controversy is further discussed in section 4.7.)
- ***Maine Green Line*** – 1,200 MW HVDC line that would run from Maine to Boston. While the project does not cross the border, the intent is to provide access to wind resources in Maine and enhance the capacity to trade Canadian-sourced hydropower. Expected completion in 2021[58].
- ***Vermont Green Line*** – 400 MW HVDC line that would run from New York to Vermont. While the project does not cross the border, the intent is to provide access to renewable resources in Maine and hydro resources in Canada. Expected completion in 2019 or 2020 [59].
- ***Northeast Energy Link*** - 1,100 MW HVDC line that would run from Maine to the Boston area. While the project does not cross the border, the intent is to provide access to wind resources in Maine and enhance the capacity to trade Canadian-sourced hydropower[60]. Expected completion in 2018[61].

3.1.7 Clean Energy Programs and Incentives

Renewable Portfolio Standards (RPS) create a regulatory driver for renewable energy growth. While states' RPS do not specifically exclude Canadian hydropower from qualifying towards compliance, most standards include a limit on the size of hydropower that effectively excludes Canadian generators from qualifying. Vermont is the only New England state that allows large-scale hydropower to qualify towards RPS compliance, but power must be purchased under a long term contract and must be considered eligible by the Public Service Board if the power is sourced from out of state[62]. This means that import of Canadian hydropower is mainly driven by economic factors and not RPS compliance measures[63]. Table 6 shows the RPS standards for ISO-NE states and Canadian provinces, along with considerations for hydropower. NEPOOL is responsible for the compliance with RPS standards in the U.S.

[c] Transmission lines in bold designate interconnections with systems outside of ISO-NE.

Table 6: Renewable Portfolio Standard Requirements in ISO-NE states, and their definitions for qualifying hydropower resources. Currently, no Northeastern states count Canadian imports towards their RPS standards. Vermont and Maine have the highest RPS standards in ISO-NE and also import the most hydro from Quebec – this is to meet their need for more (and more diverse) energy resources. [64]

State	RPS Requirement	Compliance Date	Hydro Considerations
CT	27%	2020	< 30 MW and in the NE area qualifies for RPS
MA	15% - new sources, 6.03% from existing	2020	Small hydro counts towards Class I and II resources
ME	40%	2017	< 100 MW qualifies for RPS
NH	24.8%	2025	< 5 MW qualifies for RPS[d]
RI	15%	2019	< 30 MW qualifies for RPS
VT	75%	2032	Large scale hydro counts towards RPS (H. 781)
NB	40% of in-province sales	2020	large scale hydro imports count towards RPS
NL	50 MW of wind energy		
ON	20 GW of renewable energy	2025	Hydro counts towards renewable target
QC	Increase renewable energy production by 25%[e]	2030	Hydro counts towards renewable target

Vermont and New Hampshire have promoted measures for Canadian hydropower to count towards RPS standards, but these legislative actions have been blocked by local groups that have concerns that Canadian hydro projects will compete with local economies[65]. Reforms that would allow Canadian hydropower to count toward RPS compliance would be a driver for cross border trade of electricity.

The ISO-NE states participate in the Regional Greenhouse Gas Initiative (RGGI) that is discussed further in depth in section 6.2.3. Currently, imported electricity from non-RGGI states is not covered under the carbon cap. There have been calls for RGGI to measure and monitor emission leakage (emissions associated with generation import outside of RGGI states) to ensure effectiveness of the program. As most of the power exported from Canada to New England is emission-free hydropower, benefits could be realized if these imports were tracked. Additional discussion of emissions tracking and the Clean Power Plan (CPP) are in section 6.2.3.

3.1.8 Growth in Electricity Demand

In the ISO-NE region the retirement of more than 4,200 MW of non-natural gas generators is expected by 2018, with another 6,000 MW at risk of retiring by 2020. This is almost one third of ISO-NE's 31,173 MW currently installed. These retirements are mostly coal- and oil-fired units and two nuclear plants.[66] Energy efficiency measures are expected to keep total annual energy use fairly flat over the 2015-2024 timeframe and increasing utilization of solar and wind resources will result in overall growth of installed

[d] The NH legislature introduced a bill that would allow for Canadian hydropower to count towards the RPS, but it encountered stiff opposition from renewable energy and environmental groups.
[e] QC has an RPS carve out for wind. Calls for the development of 4000 MW of wind energy.

generation capacity. Even though annual energy use is projected to remain flat, the summer peak demand is projected to rise modestly, from 29 GW to 30.5 GW over this time period.[67]

3.1.9 Projected Renewable Growth

In 2014, ISO-NE had a total of 31,173 MW installed capacity, with 3.7% of this capacity from non-hydro renewables and 4.9% from hydro resources.[68] Over the 2015 to 2024 timeframe, ISO-NE projects an increase of 6,000 MW in renewable and energy efficiency resources.[f][69] This increase is made up of 3,200 MW of wind in the ISO generation interconnection queue, 1,500 MW of PV, and 2,100 MW of energy efficiency measures.[70]

3.1.10 Projected Gas Generation Growth

Currently, natural gas generation accounts for 49% of ISO-NE generation. Over the 2015 to 2024, ISO-NE projects an increase of 8,200 MW of natural gas capacity (60% of all proposed additions).[71] This increased capacity may exacerbate the current natural gas transmission pipeline constraints, which are already at capacity just to meet heating demands in the winter.[72] For example, unit production cost of natural gas generators is $27/MWh in the summer, but rises to $77/MWh in the winter due to supply constraints.[73] These constraints can lead to the utilization of coal or oil fire plants to meet load.[74] There are currently proposals to build five pipelines (Northeast Energy Direct, Connecticut Expansion, Atlantic Bridge, Access Northeast, and Continent to Coast) to provide 3 billion cubic feet to the region, but this still may be not enough to meet natural gas demand in 2030.[75]

A summary of statistics relating to generation, demand, installed capacity, and electricity exchange are summarized in Table 7.

[f] QC has an RPS carve out for wind that calls for the development of 4000 MW of wind energy.

Table 7: Overall Energy Statistics for ISO-NE and Canadian Provinces.[76] While ISO-NE generation is expected to remain roughly constant in the coming decade due to a balance of planned coal/oil retirements and the development of new renewable energy capacity, Ontario's generation is expected to fall due to nearly 6 GW of scheduled nuclear plant retirements, while generation in New Brunswick, Newfoundland and Labrador, and Quebec are set to continue increasing modestly. On cross-border trade, while Quebec has additional capacity for development, it is limited in its ability to increase exports to the United States due to transmission capacity restrictions.

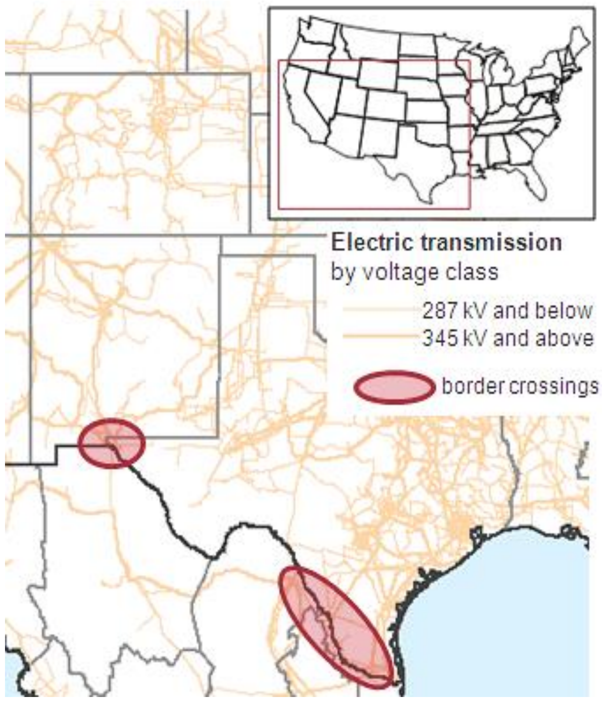
Overall Statistics	ISO-NE		NB		NL		ON		QC	
Year	2015	2024	2015	2024	2015	2024	2015	2024	2015	2024
Installed Capacity (GW)	31.2	-	4.9	5.1	7.5	7.8	38.6	39.2	44.4	47
Generation (TWh)	128	127.5	107.1	117.8	41	44.8	170.2	161.2	194.9	210.2
Peak Demand (GW)	29	30.5	-	-	-	-	-	-	-	-
Planned Retirements	4,200 MW expected; 6,000 MW at risk (mostly coal and oil)		-	-	-	-	5,950 MW of nuclear expected		-	-
Energy Efficiency/Demand Response (GW)	1.5	3.6	-	-	-	-	-	-	-	-
Installed Renewable Capacity (GW)										
Hydro	1.53	1.53	0.96	0.99	6.8	7.6	8.95	9.14	40	40.9
Wind	0.80	4.2	0.41	0.44	0.05	0.05	3.38	5.73	3.28	4.84
Solar	0.90	2.4	0	0	0	0	1.76	4.6	0	0
Installed Natural Gas Capacity (GW)										
NG - CC	49% of generation	(+) 8.2 GW	0.25	0.25	0	0	5.93	7.12	0.51	0.51
NG - CT			0.94	1.04	0.22	0.22	1.05	1.05	0.28	0.28
NG - ST			1.05	1.05	0.5	0	3.06	2.76	0	0
Electricity Exchange (GWh)										
Imports	-	-	2299	2378	0	0	3276	5731	1165	1165
Exports	-	-	2278	2278	0	0	16644	8760	26820	26820

Net Exports	-	-	-21	-100	0	0	13368	3029	25115	25115

3.2 ERCOT – Mexico International Trade

Regions analyzed in this section include the Electric Reliability Council of Texas (ERCOT) and the Mexican states which ERCOT exchanges electricity with, namely, Tamaulipas and Chihuahua. Additionally, the cross-border tie between New Mexico and Chihuahua is briefly examined, given its relatively low level of energy trading (Figure 4).

Figure 4. Texas, New Mexico and bordering Mexican states. Adapted from EIA.[77]

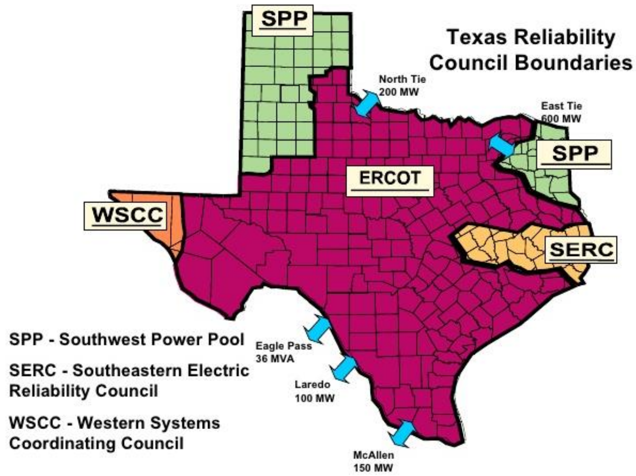


3.2.1 Market Structure and Regulation

ERCOT operates Day Ahead and Real Time energy markets in a territory that covers most of Texas (Figure 5). ERCOT's regular market needs are met within its operating borders and interconnections with other balancing authorities are currently used only for emergency reliability purposes.[78]

Since 2014, when the implementation of the Mexican energy reforms started taking shape (described in section 5.2), six companies in Texas—Global Pure Energy, Frontera Marketing, Del Norte, Vitol, Elan Energy Services, and Lion Shield Energy—have applied for Export Authorizations to export power into Mexico, where industrial customers pay up to two times the price industrial customers pay in Texas.[79,80]

Figure 5. Texas territory served by ERCOT.[81]



On the Mexican states that border ERCOT, two manufacturing companies—Parker Hannifin and Bard Reynosa—, and Frontera México Generación have received permits to import electricity since 2014.[82] Frontera México Generación's permits allow the importation of energy from a natural gas power plant in Texas. The plant can also sell energy in the Texas market if prices are higher and in Mexico.[83]

3.2.2 Entities and Jurisdiction

Entities and jurisdictions are listed in Table 8.

3.2.3 System Planning and Operations

ERCOT is an ISO that operates a grid entirely contained within Texas and does not fall under the plenary jurisdiction of FERC. The conventional explanation that ERCOT's lack of interstate commerce allows its unique exemption from FERC jurisdiction fails to properly account for the complexity and history of ERCOT's jurisdictional architecture, particularly because ERCOT does have interconnections to WECC, the Eastern Interconnection and Mexico. ERCOT's exemption from FERC jurisdiction is not complete and is the result of a long legal and political process.[84] A full explanation is beyond the scope of this section. On the Mexican side, CENACE has a role similar to an ISO in the United States. The law establishes the following responsibilities for CENACE: planning and operating the electric system nationwide, guaranteeing open access to the national transmission and distribution system, and operating the wholesale electricity market.[85]

Table 8. Relevant Mexican and Texas entities.

Entity	Acronym	States	Purpose	Mechanisms that affect international trade	Authority From
Comisión Federal de Electricidad	CFE	Mexican territory	Generates, distributes, and markets electric power (as a “productive state enterprise”)	CFE is able and has set up bilateral contracts with U.S. suppliers of electricity	Mexican Government
Centro Nacional de Control de Energía	CENACE	Mexican territory	Exercise operational control of the national electrical system. Acts as an ISO	As the electric system operator, CENACE controls electricity imports and exports	Mexican Government
Comisión Reguladora de Energía	CRE	Mexican territory	Regulates the activities of the energy industry	Grants permission to import or export electricity	Mexican Government
Secretaria de Energía	SENER	Mexican territory	Set Mexico's energy policy	Governs electricity policy	Mexican Constitution
Electric Reliability Council of Texas	ERCOT	TX	Manages flow of electric power in Texas, operates wholesale market, and implements reliability regulations	Operation of electricity market and responsible for system planning	Texas Legislature, PUCT
Texas Reliability Entity	TRE	TX	Sets reliability regulations in Texas	Set reliability standards for ERCOT region	NERC
Public Utilities Commission of Texas	PUCT	TX	Regulates Texas electrical utilities	Oversight of retail rates outside of ERCOT jurisdiction	Texas Legislature
New Mexico Public Regulation Commission	PRC	NM	Regulates New Mexico electrical utilities	Sets fair and reasonable electricity rates, ensure adequate electrical service for customers	New Mexico Constitution

Currently, there are seven interconnections between ERCOT and Mexico; three are emergency interconnections and four interconnections are permanent that allow for electricity imports and exports (Table 9). All of these interconnections are asynchronous.[86]

Table 9. Transmission Interconnections between ERCOT and Mexico

Name	Mexican State	Import Capacity to Mexico (MW)	Export Capacity from Mexico (MW)	Voltage (kV)	Purpose
Brownsville - Matamoros	Tamaulipas	24	25	69	Emergency Interconnection
Military Highway - Matamoros	Tamaulipas	176	80	138	Emergency Interconnection
Presidio - Ojinaga	Chihuahua	6	6	<69 kW	Emergency Interconnection
Railroad - Cumbres	Tamaulipas	300	300	138	Permanent Interconnection (asynchronous)
P. Frontera – Cumbres	Tamaulipas	150	150	138	Permanent Interconnection (asynchronous)
Laredo - Nuevo Laredo	Tamaulipas	100	100	230	Permanent Interconnection (asynchronous)
Eagle Pass - Piedras Negras	Coahuila	25	36	138	Permanent Interconnection (asynchronous)

In New Mexico, El Paso Electric (EPE) interconnects with the Mexican electric system through two 115 kV lines. EPE is not a part of the ERCOT market and under the authority of WECC rather than TRE. EPE uses this this interconnection to export electricity to CFE under a bilateral contract. The importance of this intertie is relatively small. The energy traded annually through these lines had a median of 3 GWh between 2004 and 2014.[87] A DOE export authorization limits exports to 200 MW.[88]

3.2.4 Reliability Standards

The Texas Reliability Entity (TRE) develops reliability standards that meet or exceed NERC standards. Reliability standards that are specific to ERCOT include:

- *BAL-001-TRE-1, Primary Frequency Response in the ERCOT* Region – This standard regulates resource and interconnection frequency responses, setting deadband and droop parameters.
- *IRO-006-TRE-1, IROL and SOL Mitigation in the ERCOT Region* – This standard establishes procedures to mitigate system operating limits (SOL) or interconnection reliability operating limits (IROL) exceedances.[89]

On the Mexican side, reliability standards are set by Comisión Reguladora de Energía (CRE).[90] With very few exceptions (the northern part of Baja California that is under the authority of WECC), the federal system in Mexico does not currently comply with NERC standards.

3.2.5 Known Challenges

As discussed in detail in Section 5, Mexico has been aggressively building new pipelines to import natural gas from the United States. Mexico will increase its natural gas imports from the United States from 620 billion cubic feet per year (bcf/y) in 2014 to 3,285 in 2019.[91, 92] From the perspective of the Mexican Energy Secretariat (SENER), it is likely that the demand for U.S. shale gas will continue to grow within the United States and internationally, applying an upward pressure on the price of natural gas. In the longer term, this could in turn have a dampening effect on the investment in and operation of natural gas plants and industrial operations in Mexico.[93]

3.2.6 Planned Transmission

There are currently no planned Presidential Permit applications before DOE for transmission lines between ERCOT and Mexico. However, there are two power marketing companies that have pending Export Authorization applications to Mexico. Frontera Marketing is requesting a ten-year authorization, and Tenaska Energia de Mexico is requesting a five-year authorization.[94]

3.2.7 Clean Energy Program and Incentives

Mexico has implemented a Clean Energy Certificate (CEL) program with the aim of having 35% of electricity come from renewable sources by 2024. Load serving entities can purchase CELs from qualifying generators, providing an additional source of income for clean energy generators (the CEL program is discussed in greater detail in Section 5.2.1 and 6.2.2). It is unclear if Texas generators will qualify for the CEL program.

Texas has a Renewable Portfolio Standard that was established in 1999, which mandated 5,880 MW of installed renewable energy capacity by 2015 and 10,000 MW by 2025. As Texas currently has surpassed this goal-- wind capacity alone has reached 16,500 MW -- its RPS will likely not drive international electricity trade. A bill in the Texas legislature in 2015 that called for the end of Texas' RPS and Competitive Renewable Energy Zones (CREZ) did not pass.[95]

3.2.8 Growth in Electricity Demand

According to an analysis by ERCOT, roughly 4000 MW of additional coal retirements starting in 2025 areexpected due to CPP implementation.[96] Significant installation of renewable resources will be needed to ensure meeting demand (roughly 18,000 MW of wind and solar additions from 2015 - 2030), which may lead to higher curtailment of these variable generators.[97]

According to SENER, in the Northeast region of Mexico generation is projected to grow from 91,905 GWh in 2015 to 120,344 GWh in 2025.[98]

3.2.9 Projected Renewable Growth

Currently, ERCOT produces 17.4% of its generation from renewable resources (95% from wind generators).[99]

3.2.10 Projected Gas Generation Growth

Currently, natural gas makes up 50.6% of total generation in the ERCOT region (36.8% is CC/CT and 13.8% is ST). Planned capacity additions for natural gas generators are expected to grow from 57 GW in 2015 to 79 GW in 2025.[100]

A summary of statistics relating to generation, demand, installed capacity, and electricity exchange are summarized in Table 10.

Table 10: Overall Energy Statistics and Projections for ERCOT and Northeast Mexico.[101] Due to the differing information available from sources, total generation in MWh is included for some Mexican statistics in green for comparative purposes.

Overall Statistics	ERCOT		Northeast Mexico	
Year	**2015**	**2025**	**2015**	**2025**
Installed Capacity (GW)	98.2	134.3		
Generation (TWh)	350	398	91.5	120.3
Peak Demand (GW)	69.6	77.7		
Planned Retirements	4,000 MW of coal		-	-
Energy Efficiency/Demand Response (GW)	-	-	-	-
Installed Renewable Capacity (GW)				
Hydro	-	-	280	1006
Wind	16.5	26.2	0	2644
Solar	0.3	2	-	-
Installed Natural Gas Capacity (GW)				
NG - CC	57[g]	79	65520	84767
NG - CT			93	0
NG - ST				

[g] Natural Gas accounts for 50.6% of ERCOT's generation – 36.8% from CC/CT and 13.8% from ST

3.3 MISO – Canada International Trade

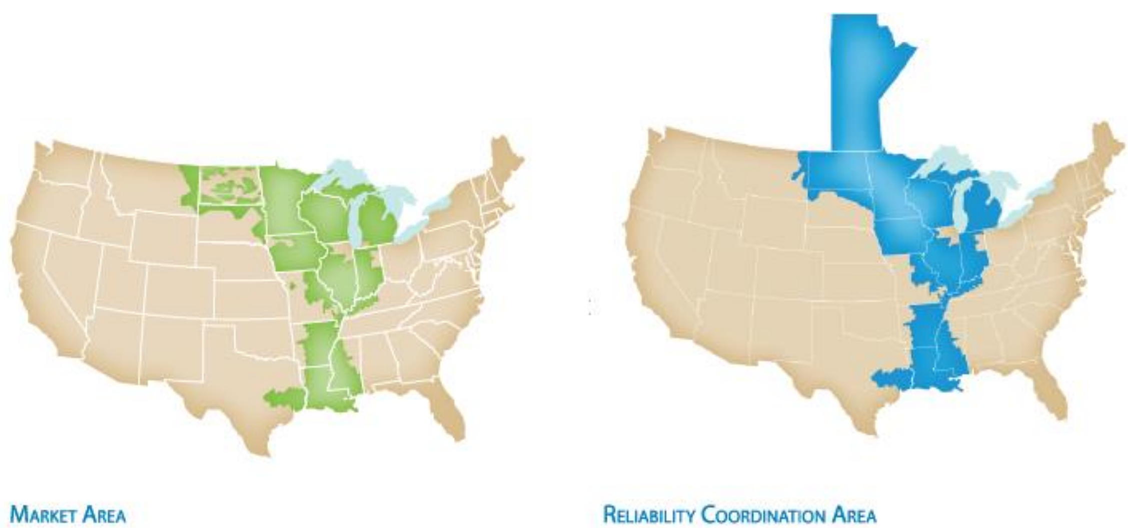
This section discusses the international electricity trade between the MISO operating region and Canada, primarily Manitoba and Ontario.

3.3.1 Market Structure and Regulation

MISO has been operating as an RTO in the United States since 2001. FERC approved their Open Access Transmission Tariff (OATT) in 2002. MISO is also a reliability coordinator of a territory that includes the Canadian Province of Manitoba (Figure 6).

Manitoba Hydro is a vertically integrated utility owned by the Province of Manitoba and governed by the Manitoba Hydro-Electric Board. The board's members are appointed by the Lieutenant Governor in Council of Manitoba.[102] Manitoba Hydro participates in MISO's electricity markets and has bilateral contracts with U.S. utilities.[103] The Manitoba Public Utilities Board approves Manitoba Hydro customer fees and has the authority to impose fines when it determines that NERC reliability standards have been violated.[104]

Figure 6. MISO's market and reliability coordination areas.[105]



In Ontario, the Independent Electricity System Operator (IESO) works as an ISO for the electric system. IESO does not have a day-ahead energy market. Instead it uses a day-ahead commitment process that ensures capacity scheduling and reliability.[106] IESO is regulated by the Ontario Energy Board (OEB). The Chair and Directors of the OEB are appointed by the government of Ontario.[107] NPCC is the reliability coordinator in Ontario.

3.3.2 Entities and Jurisdiction

Entities and jurisdictions are summarized in Table 11.

3.3.3 System Planning and Operations

MISO performs planning activities within its ISO territory, which does not include any part of Canada (Figure 6). However, entities in the provinces of Manitoba and Ontario participate in MISO's markets.

The Manitoba Hydro-Electric Board works as the planning committee for Manitoba Hydro and approves its Corporate Strategic Plan. From 2013-2014, 96% of Manitoba Hydro's energy was generated by hydro plants and 28% of Manitoba Hydro revenues came from exports to the United States.[108]

Imports from MISO into Manitoba can increase reliability in cases of extreme drought.[109] U.S. demand peaks in summer, whereas Manitoba demand peaks in winter. This allows Manitoba Hydro to have extra capacity to produce and export energy during the summer, when it receives higher prices, and reduce the capacity Manitoba Hydro needs to build to meet winter peak loads.[110] The importance of the MISO market to Manitoba Hydro is expected to continue in the long term due to the utility's proximity to large load centers in the United States, such as Minneapolis-St Paul, Madison, and Chicago.[111]

Table 11. Relevant entities and jurisdictions for the Midwest interconnection..

Entity	Acronym	States Provinces	Purpose	Mechanisms that affect international trade	Authority From
Midwest Reliability Organization	MRO	IA, IL, ND, NE, MN, MT, SD, WI MB, SK	Ensure compliance with reliability standards and ensure system ability to meet demand	Creates and monitors common reliability standards between MISO and Canada	FERC, NERC, NEB
SERC Reliability Corporation	SERC	AR, IA, IL, KY, LA, MO	Ensure compliance with reliability standards and ensure system ability to meet demand	Creates and monitors common reliability standards	FERC, NERC
Southwest Power Pool	SPP	AR, IA, MO, MN, ND, SD	Ensure compliance with reliability standards and ensure system ability to meet demand	Creates and monitors common reliability standards	FERC, NERC
Reliability First Corporation	RFC	IL, IN, MI, WI	Ensure compliance with reliability standards and ensure system ability to meet demand	Creates and monitors common reliability standards	FERC, NERC
Midwest Independent System Operator	MISO	AR, IA, IL, IN, KY, LA, MI, MN, MO, MS, MT, ND, SD, TX, WI MB	Operates as an RTO to provide transmission and reliability services to U.S. and Canada	Operation of day-ahead, real time, capacity, and reliability markets	FERC, NERC
Independent Electricity System Operator	IESO	ON	Balances electricity system, power system planning, and overseeing wholesale electricity market	Operates electricity markets Provides open access to transmission	Ontario Utilities Board, FERC
Ontario Energy Board	OEB	ON	Regulates the energy sector in Ontario	License and oversee energy companies and approve tariff rates	Canadian Government
Manitoba Hydro	MH	MB	Generates, transmits, and distributes electricity	Authorized OATT since 1997	MB PUB

Manitoba Public Utilities Board	MB PUB	MB	Acts as the regulator for MB Hydro	Oversees MB Hydro's development plan, facilitates long term power contracts	Canadian Government

Canadian laws prevent Manitoba Hydro from being a Transmission Owner, as defined by MISO's Transmission Owners Agreement, or from delegating authority over its assets or operations to any third party.[112] Manitoba Hydro's generation is not directly dispatched by MISO and load is not served under MISO's Transmission and Energy Markets Tariff (TEMT) (Manitoba Hydro 2013). To bridge physical and legal restrictions, Manitoba Hydro participates in the MISO market as a coordinating member via various agreements.[113] Manitoba Hydro and MISO coordinate on tariff administration services, congestion management, transmission planning activities, seams operations and reserve sharing.[114]

Current transmission connections between Manitoba and MISO are shown in Table 12. For Manitoba Hydro, the total export transfer limit is 1,950 MW while the import transfer limit is 700 MW.[115] This export capacity represents roughly 2% of MISO's peak demand.

Table 12. Current Interconnections between MB Hydro and MISO.[116]

Circuit Name	Voltage	Location	Year Completed
L20D	230 kV	Letellier, Manitoba to Drayton / Grand Forks, North Dakota	1970
R50M	230 kV	Winnipeg, Manitoba to Duluth, Minnesota	1976
D602F	500 kV	Winnipeg, Manitoba to Minneapolis, Minnesota	1980
G82R	230 kV	Glenboro, Manitoba to Rugby, North Dakota	2002

Interconnections between Michigan and Ontario consist of two synchronous 230/345 kV circuits, one 230/115 kV circuit, and one 230 kV circuit.[117] Transfers from Ontario to Michigan have a summer limit of 1,500 MW and a winter limit of 1,650 MW, and a summer and winter limit of 1,550 MW in the opposite direction.[118] There is one small synchronous 115 kV intertie between Ontario and Minnesota that can transfer 100 MW to Ontario and 150 MW from Ontario.[119]

3.3.4 Reliability Standards

IESO follows reliability standards set by NERC and the Northeast Power Coordinating Council (NPCC) (IESO 2014).

Both MISO and Manitoba Hydro follow reliability standards that are created and administered by MRO and NERC. Certain areas of MISO—such as parts of Montana, North Dakota, and South Dakota—participate in MISO's market, but fall under the coordination of bordering reliability coordinators such Peak Reliability and the Southwest Power Pool.

3.3.5 Known Challenges

The Michigan-Ontario connection has experienced loop flow in the Lake Erie region as discussed in Section 3.4.5.

3.3.6 Planned Transmission

In 2013, MISO studied the costs and benefits of increasing the interconnection capacity between MISO and Manitoba Hydro to allow for a higher synergy between Canadian hydro and MISO wind. The Manitoba Hydro Wind Synergy Study found that significant benefits can be realized from the addition of a 500 kV line between Manitoba and Minnesota.

The Great Northern Transmission line filed for a Presidential Permit in April of 2014 and is expected to be completed in June 2020. The 500 kV, 750 MW, AC line will connect Minnesota Power (MP) and Manitoba Hydro. The line will facilitate a PPA between MP and Manitoba Hydro that provides hydro capacity to Minnesota and will support the build out wind of resources in North Dakota by allowing MP's wind farms in North Dakota to send power to Manitoba for storage in pumped-storage hydro reservoirs (discussed further in Section 4.6.).[120]

The Manitoba Bipole III project is a 2000MW HVDC transmission project that is under construction that will deliver hydro and wind generation from northern Manitoba to southern Manitoba. The proposed route will not cross the United States – Canada border, but will facilitate movement of hydropower from northern Manitoba to markets in the United States. This line will also add reliability and redundancy to the Manitoba electrical grid. Completion is expected in 2018.

Table 13. RPS Requirements of States in the MISO Region as of 2015 NC Clean Technology Center, DOE, and NC State University, "Database of State Incentives for Renewables & Efficiency® - DSIRE," 2016.

State	RPS Goal	Target Year
IA	105 MW	N/A
IL	25%	2026
MI	10%	2015
MN	26.5% (IOUs)	2020
MN	31.5% (Xcel Energy)	2020
MO	15%	2021
ND	10%	2015
SD	10%	2015
WI	10%	2015

3.3.7 Clean Energy Program and Incentives

RPS programs in MISO participating states are included in Table 13. Two states in the MISO region, Minnesota and Wisconsin, have adopted laws that allow for hydro generators in Manitoba to qualify towards the state RPS. In March 2011, the Minnesota RPS may be met by hydro generators under 100 MW from Manitoba. In July 2011, Wisconsin State Bill 81 allowed new hydro generators, including Canadian generators, to count towards state RPS compliance.[121] Arkansas, Kentucky, Louisiana and Mississippi are the only states within MISO that do not have an RPS.

Manitoba Hydro is currently selling renewable energy credits (RECs) into the MISO market from wind generation at the St. Leon and St. Joseph projects and generation from small hydro resources (<100 MW) that meet Minnesota's RPS requirements.[122] Along with meeting RPS requirements, RECs can be sold in unbundled into voluntary green power markets. According to Manitoba Hydro, the sale of unbundled RECs into voluntary markets have provided some value, but will not be a large source of revenue to pursue in the future.[123]

To comply with the CPP, emissions in the U.S. MISO region would need to be reduced by roughly 30% compared to current levels. This could be met by retiring nearly one third of MISO's 65 GW of installed coal capacity.[124]

In December 2015, Manitoba's provincial government laid out clean energy plans in *Manitoba's Climate Change and Green Economy Action Plan.*[125] This plan included GHG emission reductions compared to 2005 levels of 33% by 2030, 50% by 2050, and to be carbon neutral by 2080. The plan also called for a ban of coal and petroleum coke by 2017. Along with these goals, Manitoba set out plans to implement a carbon cap and trade program and to create a Demand Side Management (DSM) entity. As Manitoba currently generates 98% of its electricity from carbon-free sources, this plan will likely not drive clean electricity imports into Manitoba.

3.3.8 Growth in Electricity Demand

As of March 2016, generation capacity in the MISO market was 180,051 MW and reliability capacity was 194,673 MW. Currently, there are 14,170 MW of wind resources in service with another 15,215 MW of renewable projects in the interconnection queue.[126] Renewables (including hydro) make up 13% of MISOs generating fuel mix and natural gas makes up 42%.

For the MISO planning region, total generation is expected to grow from 684,412 GWh in 2015 to 766,182 GWh in 2025.[127] This is equivalent to a 1.1% compound annual growth rate over the period.

3.3.9 Projected Renewable Growth

For the MISO region, in the business as usual case, 12,600 MW of retirements (mostly coal generators) are projected along with the addition of 5,600 MW of renewable resources.[128]

3.3.10 Projected Gas Generation Growth

For the MISO region, in the business as usual case, projected natural gas capacity additions over the 2014 to 2029 time period are 6,000 MW in combined cycle and 9,600 MW in combustion turbine generators.[129]

Overall energy statistics and projects for MISO, MB, and ON are summarized in Table 14.

Table 14: Overall Energy Statistics and Projections for MISO, MB, and ON.[130]

Overall Statistics	MISO		MB		ON	
Year	**2015**	**2025**	**2015**	**2024**	**2015**	**2024**
Installed Capacity (GW)	180	-	6	6.9	38.6	39.2
Generation (TWh)	684	766	39.8	46.2	170.2	161.2
Peak Demand (GW)	128.5	146.6	-	-	-	-
Planned Retirements	12,600 MW of retirements (mostly coal)		-	-	5,950 MW of nuclear expected	
Energy Efficiency/Demand Response (GW)	-	-	-	-	-	-
Installed Renewable Capacity (GW)						
Hydro	-	(+) 5.6 GW renewable	5.24	5.94	8.95	9.14
Wind	14.7		0.29	0.41	3.38	5.73
Solar	-		0	0.01	1.76	4.6
Installed Natural Gas Capacity (GW)						
NG - CC	42% of generation	(+) 9.2 GW	0	0.1	5.93	7.12
NG - CT		(+) 6 GW	0.13	0.13	1.05	1.05
NG - ST			0.26	0.26	3.06	2.76
Electricity Exchange (GWh)						
Imports	-	-	316	149	3276	5731
Exports	-	-	10512	14016	16644	8760
Net Exports	-	-	9899	13867	13368	3029

3.4 NYISO – Canada International Trade

This section will examine inter-border electricity trade between NYISO and two Canadian entities: Hydro Quebec (HQ) and Ontario IESO. Both HQ and IESO are described in previous sections and only information specific to the NYISO interaction will be discussed. NYISO is also interconnected with MISO, ISO-NE, and PJM areas, but these interfaces are outside the scope of this section.

3.4.1 Market Structure and Regulation

NYISO is the independent system operator for the state of New York. Hydro Quebec is described in the ISO-NE section of this chapter, and IESO is described in the MISO section.

NYISO is responsible for operating wholesale electricity markets, managing electricity flows, and ensuring capacity. As part of these responsibilities, NYISO sets rules for market participants that allow internal and external entities to bid into the NYISO market. NYISO market participants may submit offers in:

- Day-ahead markets
- Real-time markets
- Bilateral transactions - firm or non-firm transactions.
    - Firm transactions agree to pay congestion charges if encountered and non-firm transactions can only be accepted if there is no congestion.[131]

NYISO also offer provides transmission services and ancillary services in compliance with NYISO tariffs. Transmission congestion contracts (TCC) allow market participants to pay a fixed charge for transmission ahead of time and hedge against congestion constraints.[132]

For firm bilateral transactions, external imports into NYISO can be scheduled in the day-ahead market based on economics and limited by the Available Transmission Capability (ATC). If import is uneconomic in the day-ahead market, then it is re-evaluated in the real-time market.[133]

3.4.2 Entities and Jurisdiction

Entities and Jurisdictions are listed in Table 15.

Table 15. Relevant entities and jurisdiction for NYISO and interfaces

Entity	Acronym	States / Provinces	Purpose	Mechanisms that affect international trade	Authority From
New York Independent System Operator	NYISO	NY	Maintain and enhance reliability, operate wholesale electricity markets, and capacity planning	Sets rules for internal and external market participants	FERC
New York State Energy Research and Development Authority	NYSERDA	NY	Promote energy efficiency and renewable energy within New York	Administers state RPS	State of New York
New York Department of Public Service	NY PSC	NY	Acts as the regulator of electrical utilities in New York	Leading New York's Reforming the Energy Vision (REV) to promote renewables and approves rate tariffs of NY utilities	State of New York
Northeast Power Coordinating Council	NPCC	CT, NY, MA, ME, NH, RI, VT NB, NS, ON QC	Responsible for promoting reliability of international and interconnect bulk power system	Establish reliability and compliance standards	NERC
Hydro-Quebec	HQ	QC	Generates, transmits, and distributes electricity	HQ Energy Services created as U.S. subsidiary to facilitate imports/exports. OATT since 1997	Régie de l'énergie, FERC
Independent Electricity System Operator	IESO	ON	Balances electricity system, power system planning, and overseeing wholesale electricity market	Operates energy markets. Active since 2002 and has mechanisms in place that simulate an OATT	Ontario Utilities Board, FERC

3.4.3 System Planning and Operations

As described in the ISO-NE section, ISO-NE, NYISO and PJM participate in interregional system planning through an Inter-Area Planning Advisory Subcommittee. Utilities and system administrators in Canada participate on a limited basis to share data and information.[134]

NYISO leads a Broader Regional Markets (BRM) initiative for collaborating with other ISO/RTOs and counterparts in Canada to maximize resources and address interconnection limitations.[135] BRM projects include Coordinated Transaction Scheduling (CTS) with PJM and ISO-NE[h], sub-hour scheduling with Hydro Quebec and IESO, broader regional markets ancillary services, and coordinating the day-ahead electric market timing at the regional level with the gas nomination timeline.[136] Additionally, NYISO is considering a proposal by Ontario to participate in NYISO's installed capacity (ICAP) market.[137]

Previously, NYISO had scheduled electricity transfers with external participants in hour increments. In order to operate markets more efficiently and protect consumers from volatile prices, NYISO has started programs to schedule in 15 minute increments. This upgrade has already been completed with HQ and is planned for IESO.[138] NYISO plans on upgrading HQ scheduling to 5 minute increments in the future. Shorter scheduling increments can reduce overall system operating cost, provides operators with additional flexibility, and increase market efficiency.[139]

NYISO - HQ interconnection

The interconnection between NYISO and HQ is asynchronous and connected by:

- Chateauguay-Massena line: 765 kV, HVDC, 1500 MW import capacity to NYISO, and 1000 MW export capacity to HQ[140]
    - Import of 1800 MW allowed if certain critical conditions are met and this larger transfer capability will permit wheel through transactions to other markets

NYISO - IESO interconnections

Both interconnections between NYISO and IESO are synchronous. The two areas that connect NYISO to IESO are[141]:

- Niagara Falls
    - Two 230 kV/345 kV circuits, two 230 kV circuits, and one 115 kV circuit
    - Transmission capacity
        - ON to NY - 2080 MW (winter) and 1500 MW (summer)
        - NY to ON - 1570 MW (winter) and 1500 MW (summer)
- St. Lawrence
    - Two 230 kV circuits with 300 MW import and export transmission capacity

Due to NYISO scheduling limits, imports and exports along the Ontario - New York flowgate[i] can reduce the total transfer capacity of the two interconnections to 1650 MW into ON and 1900 MW out of ON.[142] Generators in ON and QC can also wheel through the NYISO market into other service areas (PJM, ISO-NE, etc.). This is done through a Wheels Through bid and is limited by Available Transmission Capacity

[h] CTS involves incorporating prices from neighboring control areas into dispatch to allow market participants to schedule transactions based on price differences between regions.

[i] NERC defines a flowgate as "A mathematical construct, comprised of one or more monitored transmission Facilities and optionally one or more contingency Facilities, used to analyze the impact of power flows upon the Bulk Electric System." From *Glossary of Terms Used in NERC Reliability Standards.*

(ATC).[143] Wheels through transactions account for 2% of Day Ahead Market sales and only 1% of total transactions in the first four months of 2016.[144]

3.4.4 Reliability Standards

NYISO is responsible for compliance with standards set by NERC and the NPCC for system reliability. NPCC's geographic area includes New York, New England, the Maritimes, Ontario, and Quebec. NYISO conducts a Comprehensive Reliability Planning Process over a ten year planning horizon to assess resource adequacy and transmission reliability of the New York power system.[145]

Figure 7: Average Flow of Electricity around Lake Erie. Electricity generally flows as shown in Figure 1 but this can change depending on the physical operating conditions

3.4.5 Known Challenges

According to FERC, there are ongoing issues with transmission congestion in the NYC and Long Island areas, where most of the load in the state resides. Due to this congestion, electricity prices in these regions are often higher than surrounding areas.[146]

In 2008, there was an issue through the NYISO transmission system called Lake Erie loop flow. Electricity sales were scheduled along set transmission routes, but due to physical characteristics of the transmission lines, electricity did not flow along scheduled lines and instead followed the path of least resistance. This phenomenon caused unnecessary costs due to unscheduled wheeling charges through other jurisdictions.[147] Upon review, NYISO identified that scheduling transactions with the PJM and IESO interconnections were likely the cause of loop flow in the Lake Erie region (Figure 7).

With FERC's approval, NYISO has since taken the following steps to avoid loop flow in the future:[148]

- NYISO has placed a ban on external transactions that schedule an indirect path around Lake Erie rather than at the common border between NYISO and PJM
    - Eight specific paths were identified and banned for future scheduling
- NYISO created an internal group to monitor and identify unusual market outcomes in the future
- Lead and participate in the Broader Regional Markets Initiative to address limitations that currently exist between markets and systems that connect with NYISO.

3.4.6 Planned Transmission

There is currently one planned transmission line from Quebec to the New York City area. The Champlain Hudson Power Express is a planned 1000 MW HVDC line that will provide wind and hydro resources to NYC from QC (discussed further in Section 4.7). The project was issued a Presidential Permit in October 2014. This project is part of efforts to reduce transmission congestion into the NYC and Long Island areas. Reduced transmission congestion and access to cheap Canadian hydro and wind power may reduce electricity rates in the region, which currently average the highest in the nation.

In December 2015, Consolidated Edison Energy, Inc. (CEE) applied for authority to export power to Canada. CEE will act as a power marketer for five years and will sell excess power purchased from third party generators. Existing transmission lines will be utilized for power sale.[149] It is at present unclear to whom or what CEE will sell into the Canadian market.

3.4.7 Clean Energy Program and Incentives

The current RPS for New York calls for 30% of generation to be from renewable resources by 2015. Governor Cuomo has directed the PSC to evaluate raising this number to 50% by 2030; this report should be available summer of 2016.[150] As part of this 50% Clean Energy Standard proposed, New YorK Department of Public Service released a white paper that outlined steps to meet these goals which include: addition of 33,700 GWh of renewable capacity by 2030; introducing a third tier in the RPS that allows for nuclear generators to qualify for eligibility (utilities would be required to purchase Zero Emission Credits (ZEC) for compliance); and promote objective from the Reforming the Energy Vision initiative discussed below.[151]

The New York State Energy Research and Development Authority (NYSERDA)is responsible for measuring compliance of the RPS program. NYSERDA has ruled that generators located inside New York count towards the Main Tier of RPS compliance. Canadian hydropower does not currently count towards state RPS compliance. New York also has an energy efficiency standard to reduce electricity use in 2015 by 15% from 2008 projected levels.

New York also participates in the Regional Greenhouse Gas Initiative (RGGI) which is discussed in more depth in Section 6.2.3.

3.4.8 Projected Growth in Electricity Demand

According to NYISO, new and proposed environmental regulations are estimated to cause the upgrade of environmental controls or the retirement of 33,800 megawatts of generation (roughly 80 percent of NYISO's generating capacity).[152]

Peak demand is expected to grow 0.48% annually from 2015 to 2025 to just over 35,000 MW in 2025.[153] However, energy use is projected to remain fairly flat (slightly decreasing) from 2015 – 2025, mainly driven by energy efficiency and distributed resources.

3.4.9 Projected Renewable Growth

In NYISO, total renewable generation in 2014 was 35,756 GWh, of which, hydro accounted for 28,525 GWh and wind accounted for 3,986 GWh. There are roughly 2,300 MW of proposed wind capacity additions.[154]

NYISO estimates that efficiency programs, and distributed energy resources will reduce peak demand by 330 MW from 2015 levels; increasing annually to 2,700 MW by 2025.[155]

3.4.10 Projected Gas Generation Growth

In 2015, natural gas generators account for 56% of NYISO installed capacity.[156] Over 70% of proposed future capacity additions are natural gas and these are driven primarily by fuel switching from coal to natural gas or coal plant retirements.[157]

Overall energy statistics are summarized in Table 16.

Table 16: Overall Energy Statistics and Projections for NYISO, ON, and QC.[158]

Overall Statistics	NYISO		ON		QC	
Year	2015	2024	2015	2024	2015	2024
Installed Capacity (GW)	39	-	38.6	39.2	44.4	47
Generation (TWh)	160	160	170.2	161.2	194.9	210.2
Peak Demand (GW)	33.6	35	-	-	-	-
Planned Retirements	-	-	5,950 MW of nuclear expected		-	-
Energy Efficiency/Demand Response (GW)	1.12	2.7	-	-	-	-
Installed Renewable Capacity (GW)	6.26	-	-	-	-	-
Hydro	-	-	8.95	9.14	40	40.9
Wind	1.75	(+) 2.3 GW	3.38	5.73	3.28	4.84
Solar	-	Goal: (+) 3 GW	1.76	4.6	0	0
Installed Natural Gas Capacity (GW)						
NG - CC	21.84	(+) 3.2 GW	5.93	7.12	0.51	0.51
NG - CT			1.05	1.05	0.28	0.28
NG - ST			3.06	2.76	0	0
Electricity Exchange (GWh)						
Imports	-	-	3276	5731	1165	1165
Exports	-	-	16644	8760	26280	26820
Net Exports	-	-	13368	3029	25115	25115

3.5 WECC – Canada International Trade

This section will analyze the trade of electricity between U.S. states and Canadian provinces within Western Electricity Coordinating Council (WECC) (Figure 8). The main area of focus will be Oregon, Washington, Alberta and British Columbia. See the CAISO section for an analysis of California's electricity trade with Canada and Mexico.

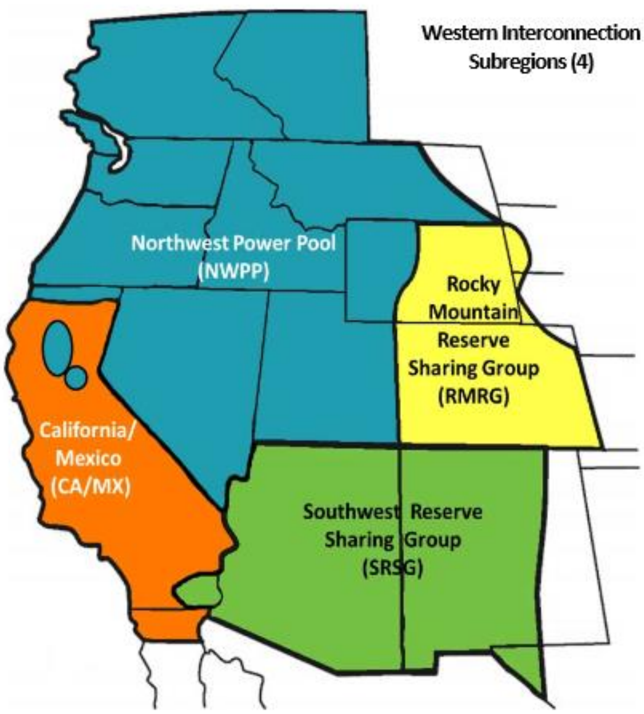
Figure 8: Map of the Western Interconnection and WECC NERC, "Regional Entities."

3.5.1 Market Structure and Regulation

WECC is a non-profit created with the goal of increasing the reliability of the bulk system in the Western Interconnection. The Western Interconnection does not contain any ISO or RTO. The operation of the bulk power system in the Western Interconnection is the responsibility of a collection of balancing areas and the PEAK and AESO reliability coordinators. The Western Electric Coordinating Council (WECC) is responsible for promoting system reliability in the western United States, Canada, and Mexico. WECC is the largest of the eight regional reliability entities that receive authority from NERC and FERC and has jurisdiction over reliability in the western interconnection.[159]

The WECC includes four subregions: the Northwest Power Pool (NWPP), Rocky Mountain Reserve Sharing Group (RMRSG), Southwest Reserve Sharing Group (SRSG), and California/Mexico (CA/MX), as shown in Figure 10. Of most relevance to U.S.-Canadian interactions, the Northwest Power Pool (NWPP) is non-profit organization focused in coordinating operations among its voluntary members. Members include system operators and major generating utilities serving the Northwestern U.S., British Columbia and Alberta.[160] Members operate autonomously, but voluntarily share transmission planning and reserve-sharing responsibilities.[161] NWPP has applied to FERC to operate a voluntary 15-minute trading market in the region.[162]

Figure 9: Map of WECC subregions FERC, "Electric Power Markets - Northwest."



A unique aspect of the Pacific Northwest power system is the dominant role of Power Marketing Administrations (PMA). The federal government started marketing excess power from federally owned dams in the early 1900's and created the first PMA in 1937; the Bonneville Power Administration (BPA) to deliver and sell power from Bonneville Dam.[163] Between the 1940s and 1960s, PMAs built and assumed control of high voltage power lines to market power in their respective regions.[164]

The Bonneville Power Administration (BPA) is one of four federal PMAs that markets and transmits wholesale power produced by federally owned dams in the Northwest. BPA is also the balancing authority for the region and owns roughly three quarters of the high voltage transmission lines in the Northwest, including the transmission lines that connect British Columbia and Washington.[165,166]

On the Canadian side of the border, British Columbia Hydro (BC Hydro) is a vertically integrated utility owned by the province of British Columbia. BC Hydro operates 33 power plants (hydropower represents 95% of their energy mix) and owns a network of over 78,000 kilometers of transmission and distribution lines.[167] BC Hydro buys 25% of the energy it sells from independent producers and it provides access to its transmission system for third parties.[168]

The Alberta Electric System Operator performs the duties of an ISO, including system planning, market operation, and transmission open access management. AESO's wholesale market includes real-time energy and ancillary services trading. AESO is the only North American system operator, besides ERCOT, that does not have a capacity market. AESO does not have a Financial Transmission Rights market, either. AESO is also in charge of guaranteeing open access to transmission in its territory.[169]

3.5.2 Entities and Jurisdiction

Entities and jurisdictions are listed in Table 17.

Table 17. WECC main entities and jurisdiction

Entity	Acronym	U.S. States / Provinces / Mexican States	Purpose	Mechanisms that affect international trade	Authority From
Western Electricity Coordinating Council	WECC	AZ, CA, CO, ID, MT, NM, NV, OR, SD, TX, UT, WA, WY / AB, BC / Baja California	Promotes bulk electric system reliability in the Western Interconnection	Sets reliability standards	FERC, NERC
Northwest Power Pool	NWPP	CA, ID, MT, NV, OR, UT, WA, WY / AB, BC	A sub-reliability region within WECC that is responsible for coordinating balancing authorities in the region	Performs seasonal assessment of reliability and is coordinating electricity market in the region	WECC
Peak Reliability	Peak	AZ, CA, CO, ID, MT, NE, NM, NV, OR, SD, TX, UT, WA, WY / BC / Baja California	Provides real time monitoring of the Western Interconnection	Acts as Reliability Coordinator for the region	NERC, WECC
Bonneville Power Administration	BPA	CA, ID, MT, NV, OR, UT, WA, WY	Non-profit power marketing administration in the Pacific Northwest	Owns hydropower generators and transmission lines. Oversees and schedules international power flows	U.S. Department of Energy
United States Army Corps of Engineers	USACE	United States	Operates and owns hydroelectric dams in the Unites States	Owns some of dams within BPA jurisdiction	U.S. Government
United States Bureau of Reclamation	BOR	United States	Operates and owns hydroelectric dams in the Unites States	Owns some of dams within BPA jurisdiction	U.S. Government
Western Area Power Association	WAPA	AZ, CA, CO, IA, KS, MN, MT, NE, ND, NM, NV, SD, TX, UT, WY	Market and deliver federal hydroelectric power and related services	Owns Montana-Alberta tie line and markets power internationally	U.S. Department of Energy

Entity	Acronym	U.S. States / Provinces / Mexican States	Purpose	Mechanisms that affect international trade	Authority From
British Columbia Power and Hydro Authority	BC Hydro	BC	Responsible for generation, transmission, and distribution in BC	Oversees and schedules international power flow. OATT since 2006	BCUC
British Columbia Utilities Commission	BCUC	BC	Regulator of BC natural gas and electrical utilities	Regulates BC Hydro operations	Provincial Government
Alberta Electric System Operator	AESO	AB	ISO for the province of Alberta, Canada	Balance authority and market administrator. Transmission planning.	Provincial Government

3.5.3 System Planning and Operations

The Columbia River Treaty, implemented in 1964, calls for the collaboration of U.S. and Canadian authorities to manage the flows of the river to provide flood control and power generation benefits. Under the treaty, Canada built three storage dams in British Columbia to control spring runoff and lessen seasonal water flow fluctuations, which benefitted U.S. hydropower generation. [170,171] In exchange, Canada received upfront cash payments and British Columbia receives electricity imports under the Treaty's Canadian entitlement.[172] The treaty is administered by the Bonneville Power Association (BPA), the U.S. Army Corps of Engineers, and British Columbia Hydro and Power Authority (BC Hydro). Roughly 50-60% of electricity imports to British Columbia are comprised of entitlements from the Columbia River Treaty.[173] Hydropower from the Columbia River Basin represents more than 40% of total hydropower in the United States.[170]

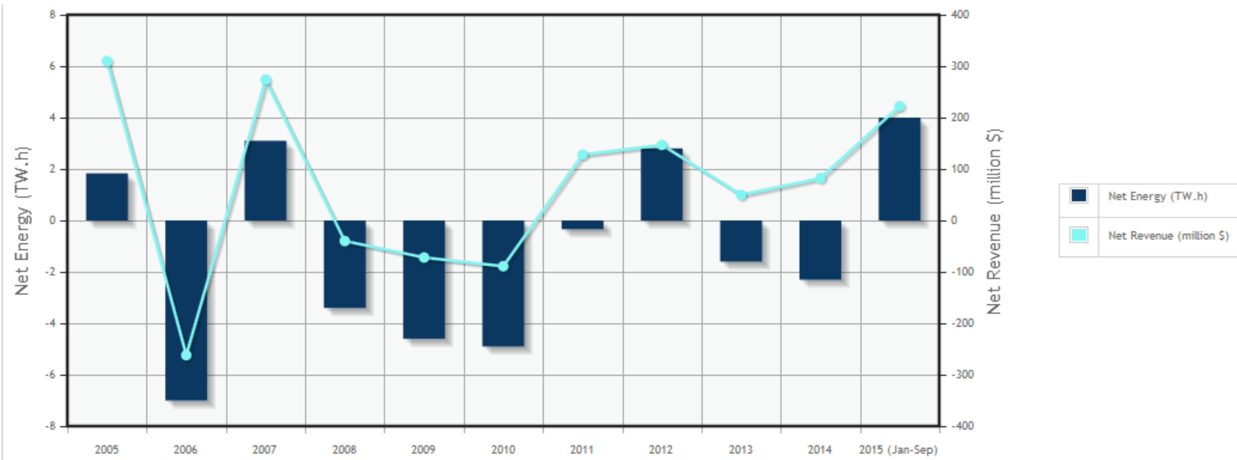
Resources within NWPP are geographically diverse. The northwest portion contains most of the hydro resources and is winter peaking, while the eastern portion contains most of the thermal generation and is summer peaking.[174] When there are more than adequate water supplies for generation, excess electricity generated can be sold to British Columbia. This synergy reduces the need for dam spillover and also defers capacity investments in British Columbia.

Some operators participate in the CAISO energy imbalance market as well (discussed in CAISO section).[175]

BC Hydro has two synchronous interconnections with the United States that provide 3150 MW of transfer capacity from Canada to the United States, and 3000 MW from the United States to Canada.[176] One interconnection is a two circuit 230kV line while the other is a two circuit 500 kV line.[177] One of the 230 kV circuits is normally open and cannot be operated in parallel with other interconnection lines. BC Hydro Control Centre and BPA's Dittmer Control Centre are responsible for dispatch coordination in emergency situations.[178]

Between 2011 and 2015, British Columbia had a positive electricity trade revenue balance despite being a net importer of electricity in three of those years (Figure 9). This is because British Columbia can store water in dams and buy electricity from the United States when prices are low or negative, and produce hydropower for export when prices are high.[179] British Columbia's hydropower counts as a low carbon power source in California's carbon market which has increased its competitiveness in this market. Between 2011 and 2014, British Columbia exported twice as much energy to California than the Pacific Northwest.[180]

Figure 10: British Columbia Net Electricity Imports and Revenue NEB, "Feature Article: British Columbia Uses Its Hydro System to Maximize Gains from Electricity Trade."



3.5.4 Reliability Standards

BC Hydro is responsible for administering the reliability standards for the power system in British Columbia. The British Columbia Utilities Commission issued an order in June 2009 that adopted reliability standards from NERC and WECC for all of British Columbia.[181]

Peak Reliability fulfills the duties of Reliability Coordinator as defined by NERC for the entire Western Interconnection; with the exception of Alberta, Canada, where AESO is the reliability coordinator.[182]

3.5.5 Known Challenges

BPA experienced a rapid increase in wind capacity between 2008 and 2012. This has led to the curtailment of wind power when balancing reserves are exhausted. Curtailments are exacerbated by excess hydro generation during spring. Although hydropower can assist balancing wind output and load, its balancing capability is limited by the number of hydro power plants in a balancing region, the capacity of their reservoirs, and their downstream water commitments. Two strategies that could reduce wind curtailment include sub-hourly resource scheduling and the coordination of operations with neighboring balancing authorities under a regional imbalance market (EIM).[183] Currently, BPA does not participate in CAISO's EIM, the only one WECC's region.

3.5.6 Planned Transmission

There are currently no new proposals for cross-border transmission lines that have applied for a Presidential Permit. The most recently-constructed line was the Montana-Alberta Tie Line project which is a 230 kV AC line with 600 MW of transfer capacity, with 300 MW each way to and from Canada.[184] The project came online in 2013 and seeks to facilitate wind development and increase reliability in the area.

3.5.7 Clean Energy Program and Incentives

The RPS standards for states within the NWPP are shown in Table 18. Along with these RPS standards, Alaska, California, Oregon, Washington, and British Columbia are all members of the Pacific Coast Collaborative to establish cooperative channels to promote sustainability and green energy in the region. As part of this collaborative, Washington and Oregon are considering carbon policies similar to those enacted in California and British Columbia.

Table 18: RPS Standards of NWPP States NC Clean Technology Center, DOE, and NC State University, "Database of State Incentives for Renewables & Efficiency® - DSIRE," 2016.

State	RPS Requirement	Target Date	Hydro Provisions
ID	-	-	-
MT	15%	2015	Existing projects less than 10 MW and new capacity additions at existing facilities count
NV	25%	2025	Capacity additions allowed, but not from new dams or impoundments
OR[j]	50%	2040	Capacity additions from efficiency upgrades on or After January 1, 1995 count towards RPS, small (<50 MW) generators, and facilities operational after January 1, 1995 if installed outside of a protected area
WA	15%	2020	Only increased capacity from efficiency upgrades at current dams count. No new impoundments or diversions allowed
WY	-	-	-

Since 2007, British Columbia has enacted a carbon tax and clean energy mandate. The carbon tax, initiated in 2008, covers roughly 77% of residential, commercial, and industrial GHG emissions in British Columbia and was designed to be revenue neutral.[185] According to independent analysis, the tax has driven reduction in per capita emissions with little to no impact on the province's GDP.[186] In 2010, British Columbia followed up on a carbon tax with the Clean Energy acts that calls for 93% of electricity to come from clean or renewable technologies, to reduce electricity demand by 66% by 2020, and to reduce emissions by 80% by 2050 compared to 2007 levels.[187] More discussion on this program is included in Section 6.2.1.

Alberta plans to phase out generation from coal (currently 39% of generation) by 2030, with two-thirds of this generation replaced by renewable energy and one-third by natural gas.[188] A goal for 30% renewables by 2030 was also included in Alberta's energy strategy, along with a $30/MWh surcharge on coal generation to increase profitability of other generation resources.

3.5.8 Growth in Electricity Demand

Table 19 shows the generation and capacity projections for the Unities States portion of the NWPP area according to the Annual Energy Outlook from EIA. Installed capacity is projected to remain flat over the 2015 to 2025 time period and increased generation is likely due to efficiency upgrades.

According to the NEB, electricity generation in Alberta is expected to grow from 87 GWh in 2015 to 109.7 GWh in 2025, while generation in British Columbia is grow from 71.3 GWh in 2015 to 81.3 GWh in 2025.[189]

[j] Only includes large investor-owned utilities (>3% of state load). There are lesser requirements for smaller utilities.

3.5.9 Projected Renewable Growth

As of 2016, Washington produces roughly 70% of all U.S. hydro power.[190] As shown in Table 19, only minor capacity additions of renewables are projected in the NWPP region, and renewable capacity in Alberta and British Columbia is expected to grow modestly, with primary additions in the wind power sector.

3.5.10 Projected Gas Generation Growth

As shown in Table 19, natural gas generation and capacity are projected to remain flat over the 2015 to 2025 time period.

Table 19: Overall Energy Statistics and Projections for WECC-NWPP, BC, and AB.[191]

Overall Statistics	WECC - NWPP Region		BC		AB	
Year	2015	2025	2015	2024	2015	2024
Installed Capacity (GW)	70.5	71.1	17.8	19.5	16.8	23.1
Generation (TWh)	259.9	292.7	71.3	80.8	87.1	107.9
Peak Demand (GW)	-	-	-	-	-	-
Planned Retirements	-	-	-	-	0.9 GW of coal expected	
Energy Efficiency/Demand Response (GW)	-	-	-	-	-	-
Installed Renewable Capacity (GW)						
Hydro	34.9	34.7	14.8	16.7	0.87	0.87
Wind	9.8	10.3	0.59	0.95	1.47	2.44
Solar	0.1	0.4	0	0.01	0	0.1
Installed Natural Gas Capacity (GW)						
NG - CC	8.7	8.8	0.26	0.26	3.58	7.48
NG - CT	2.8	2.7	0.28	0.49	3.58	5.58
NG - ST	0.6	0.4	1.03	0.08	0.59	0.59
Electricity Exchange (GWh)						
Imports	-	-	7913	7884	175	175
Exports	-	-	8145	9186	175	175
Net Exports	-	-	232	1302	0	0

3.6 CAISO International Trade

This section deals with international electricity trade with California Independent System Operator (CAISO). CAISO's territory and balancing authorities are shown in Figure 10.

3.6.1 Market Structure and Regulation

CAISO performs the duties of an ISO in most of California's territory.[192] CAISO also operates an Energy Imbalance Market (EIM) that balances load and demand with other utilities outside of CAISO. CAISO, PacifiCorp and NV Energy currently participate in the EIM; other utilities are considering participating.[193]

Figure 11: Map of CAISO's Market Area FERC, "Electric Power Markets - California (CAISO)."

As part of the Mexican Energy Reforms mentioned in section 5.2, CENACE (National Center for Energy Control) operates markets for day-ahead and real-time energy, and ancillary services, and plans to add capacity, financial transmission rights, and alternative clean energy compliance certificate markets in the following years.[194] Foreign systems (such as CAISO) and independent power producers are allowed to participate in the Mexican markets under the reforms.[195] Article 67 of the Electric Industry's Law (Ley de la Industria Eléctrica, LIE) allows CENACE to celebrate contracts and coordinate operations with third parties, which would allow Mexico to participate in CAISO's EIM. Mexico is evaluating this option.[196]

Mexico's energy reforms are discussed in greater detail in Section 5.2. BC Hydro's structure is covered in the WECC section.

3.6.2 Entities and Jurisdiction

Entities and Jurisdictions are included in Table 20.

Table 20: Entities and Jurisdictions relating to CAISO-Mexico interactions.

Entity	Acronym	States Provinces	Purpose	Mechanisms that affect international trade	Authority From
Western Electricity Coordinating Council	WECC	AZ, CA, CO, ID, MT, NM, NV, OR, SD, TX, UT, WA, WY AB, BC, Baja	Promotes bulk electric system reliability in the Western Interconnection	Sets reliability standards	FERC, NERC
California Independent System Operator	CAISO	CA	Acts at the ISO for the California and part of Nevada power grid	Manages flow of electricity along transmission lines. Operates electricity market	FERC, NERC
California Public Utilities Commission	CPUC	CA	Acts as the regulator of electrical utilities in California	Sets standards for California utilities	State of California
California Energy Commission		CA	Acts as the state's energy policy and planning agency	Forecasts future generation needs and sets renewable policies	State of California
Western Renewable Energy Generation Information System	WREGIS	AZ, CA, CO, ID, MT, NM, NV, OR, SD, TX, UT, WA, WY AB, BC, Baja	Acts as the independent renewable energy tracking system for WECC	Manages, tracks, and transfers RECs in WECC markets	WECC
Comision Federal de Electricidad	CFE	Tamaulipas, Nuevo Leon, Coahuila, Chihuahua	Generates, distributes, and markets electric power	In control of planning and reliability of electrical system. Reform allows for private sector to participate in generation and sale of electricity	Mexican Government
Centro Nacional de Control de Energia	CENACE	Tamaulipas, Nuevo Leon, Coahuila, Chihuahua	Exercise operational control of the national electrical system. Acts as an ISO	Operates whole electricity maker and can mediate PPAs. Sets reliability standards for Mexico	Mexican Government

Secretaria de Energia	SENER	Tamaulipas, Nuevo Leon, Coahuila, Chihuahua	drive Mexico's energy policy	during reform, will set initial market rules for electricity	Mexican Constitution

3.6.3 System Planning and Operations

In California, CAISO is responsible for transmission planning. In Mexico, SENER and CENACE plan generation and transmission expansions, although SENER ultimately approves and publishes the final plan, known as the PRODESEN.[197]

Scheduling Coordinators (SC) with resources located outside of CAISO balancing area can bid imports into the CAISO market as long as said resources comply with NERC's reliability standards and have a pre-existing operating agreement with CAISO.[198]

There are currently two 230 kV transmission circuits that connect CAISO to Baja: Tijuana – Miguel and La Rosita – Imperial Valley. Both of these connections are synchronous and permanent enabling a transfer capacity of 800 MW.[199] In 2014, CAISO imported 472 GWh and exported 75 GWh with Baja California.[200] The Energía Sierra Juárez, located in Mexico and described in detail in Section 5.6, exports all of its electricity to California.

BC Hydro also has the ability to import electricity to CAISO through its power marketing subsidiary, Powerex Corporation. FERC granted approval for this trade in 2005 and CAISO has agreements with British Columbia Transmission Corporation, Bonneville Power Association (BPA), and Powerex to allow for dynamic scheduling in the CAISO market. BPA acts as an intermediary control area for transmitting power from British Columbia into CAISO.[201] BC Hydro exported 22.2 GWh to the CAISO market from 2011 to 2014.[202]

3.6.4 Reliability Standards

CAISO follows reliability standards set out by WECC and NERC. Mexico's Energy Regulation Commission (CRE) sets the reliability standards for the national electric system.[203]

3.6.5 Known Challenges

Higher RPS goals have led to challenges with transmission planning in CAISO because the ideal renewable resources tend to be far away from load centers. CAISO has implemented a transmission planning process that considers a range of generation development scenarios and allows for out-of-state resource areas to participate in this process.[204]

3.6.6 Planned Transmission

There are currently no planned transmission lines that cross international borders in the CAISO area.

3.6.7 Clean Energy Program and Incentives

California's RPS was amended in 2015 and calls for 50% of electricity generation to come from renewable resources by 2030.[205] There are three categories for RPS-compliant resources. Category 1 includes resources located within California or scheduled into the California Balancing Authority. 75% of total RPS sales by 2017 must come from this category. Category 2 is the procurement of energy and RECS that cannot be delivered directly into California and must be substituted with electricity from another source. Category 3 is the procurement of unbundled RECs.[206] Under the RPS, the requirements for hydropower specify that only hydro generators under 30 MW may count towards RPS compliance.[207]

Energy from facilities located outside California can count towards compliance provided that their first point of interconnection is either to a California Balancing Authority (CAB) or WECC. Facilities located outside the United States must demonstrate compliance with siting and operation standards similar to those applicable in California.[208] Currently, the 155 MW Energia Sierra Juarez Wind Energy Project is the only generator in Mexico that is certified under California's RPS requirements. There are four wind projects in British Columbia with a combined nameplate capacity of 487 MW that are certified to count towards RPS compliance.[209]

Under Assembly Bill (AB) 32, enacted in 2011, California's cap-and-trade rules came into effect in January 2013. This rule applies to electric generators and large industrial facilities and seeks to reduce greenhouse gas emissions by 17% in 2020 compared to 2013 levels.[210] As of January 2014, California's cap-and-trade program is linked with Quebec's carbon market. California is also part of the Western Climate Initiative (WCI) that includes British Columbia, Manitoba, Ontario, and Quebec. The WCI is a nonprofit corporation that seeks to identify, evaluate, and implement emission-trading programs.[211] Currently, British Columbia hydro generation qualifies as a "low-emission" supply under the California carbon market rules.[212] The WCI is covered in greater detail in Section 6.2.4.

3.6.8 Growth in Electricity Demand

According to the California Energy Commission, energy consumption in California is projected to increase from 283,089 GWh in 2015 to 323,628 GWh in 2026 (CAGR of 1.2%). [213,214] The Non-coincident peak is projected to grow from 63,521 MW in 2015 to 69,314 MW in 2026 (CAGR of 0.86%).[215]

Projected growth in electricity demand for Mexico, Baja California, and Baja California Sur is shown in Table 21.

3.6.9 Projected Renewable Growth

EIA projects that the percentage of California's energy that comes from renewable resources will grow from 32.7% in 2015 to 38.8% in 2025.[216] The installed renewable capacity changes from 2015 to 2025 are shown in Table 21.

Over the 2014 to 2029 time period, SENER projects 44,771 MW of installed capacity additions in Mexico, 53% of which will be from clean energy sources.[217] SENER projects that 40% of generation in Baja California and 15% in the Baja California Sur region will come from clean sources by 2029.[218]

3.6.10 Projected Gas Generation Growth

EIA projects that the percentage of California's energy that comes from natural gas generators to grow from 52.3% in 2015 to 53.6% in 2025.[k,219] The installed natural gas capacity changes from 2015 to 2025 are shown in Table 21.

Over the 2014 to 2029 time period, SENER projects 26,443 MW of combined cycle generator additions in Mexico, which accounts for a 40% increase in overall capacity.[220]

[k] Generation may be imported into CAISO from outside of California and will not show in installed capacity.

Table 21: Overall Energy Statistics and Projections for CAISO, Baja, and Baja Sur.[221]

Overall Statistics	CAISO		Baja		Baja Sur	
Year	2015	2025	2014	2024	2014	2024
Installed Capacity (GW)						
Generation (TWh)	283	323	12.6	21.7	2.4	5.7
Peak Demand (GW)	63.5	69.3	1.9	3.2	0.41	0.93
Planned Retirements	-	-	-	-	-	-
Energy Efficiency/Demand Response (GW)	-	-	-	-	-	-
Installed Renewable Capacity (GW)						
Hydro	9.8	10.1		56 % of generation		18 % of generation
Wind	6.5	6.9				
Solar	5.7	7.8				
Installed Natural Gas Capacity (GW)						
NG - CC	18.6	17.3				
NG - CT	10.14	9.9				
NG - ST	12	8.8				

4. Canada-U.S. Interconnection

While U.S.-Canadian electricity integration is already extensive, the mature, highly-functioning system may face challenges integrating further. This is due to a number of factors, including the uneven distribution of benefits of additional integration, local resistance to the construction of new infrastructure, and barriers resulting from regulatory and policy frameworks.[222,]

4.1 The Importance of Hydropower

Potential for Growth

While the United States and Canada trade electricity generated from a variety of sources, the heart of Canadian electricity exports to the United States is hydropower. The United States and Canada have similar levels of installed hydropower capacity (100 GW and 76 GW, respectively), but Canada uses hydropower as a higher percentage of total electricity generated (63% versus 6% in the United States). There is potential to increase Canada's hydropower capacity significantly:[223] the Canadian Hydropower Association (CHA) estimates that Canada could increase hydropower generation capacity two-fold, to 160 GW.[224]

Operational Benefits

Hydropower, as a resource, also has significant advantages over many other energy technologies. It is flexible, reliable, and cost-competitive with other sources of power.[225] Hydro reservoirs can provide energy storage, and hydropower generation can be adjusted quickly, making it a natural complement to variable resources such as solar and wind power. Some dams also serve additional functions, such as managing flood control or storage of potable water.

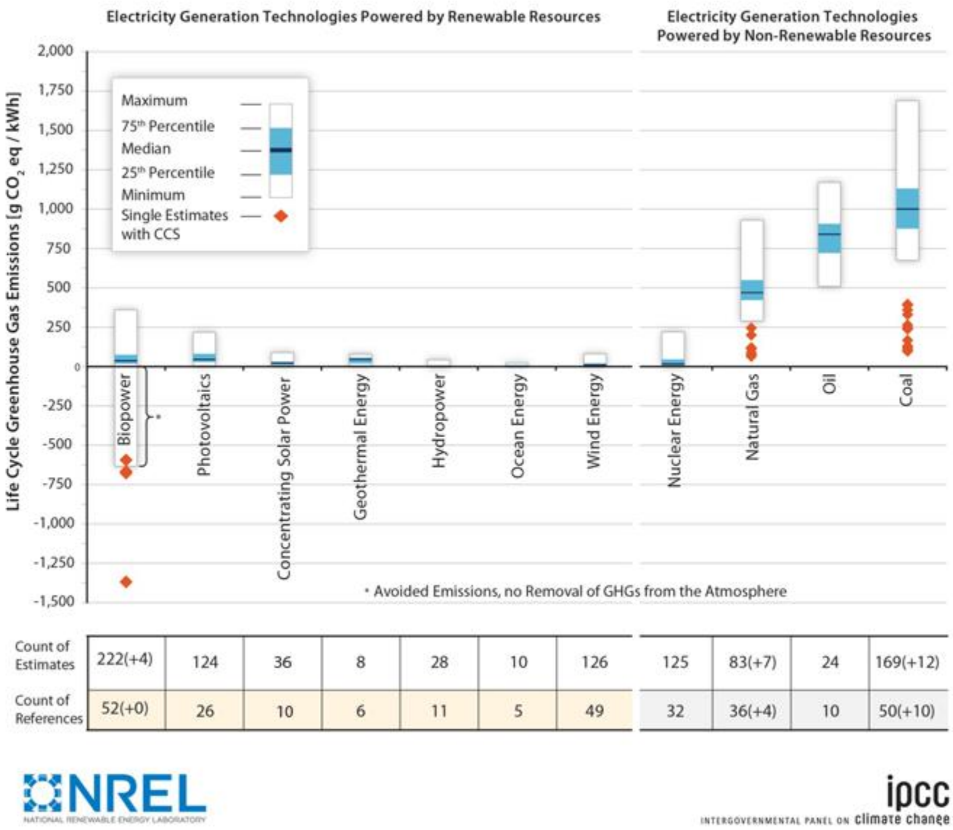
Climate Benefits

Hydropower also has significant climate benefits. By lifecycle calculations, hydropower emissions are roughly equivalent to wind power emissions, and slightly less than solar power emissions (Figure 13).[226] Already, the climate and energy security benefits of Canadian-U.S. hydropower trade may be substantial. For example, there are estimates that trade in hydropower between Quebec and its neighbors (New England, New York, Ontario, New Brunswick) can be credited with 20.6 Mt of avoided emissions (from 2006-2008), or roughly 8% of Quebec's total yearly GHG emissions from all sectors.[227]

Other Benefits/Concerns

The controversies relating to hydropower development generally focus on new large-scale hydropower developments, and concerns over the environmental damage and displacement of communities due to flooding to establish reservoirs, as well as the influence on freshwater marine, bird, and mammalian life, both in the reservoir and downstream of the facility.[228] While the Canadian Hydropower Association estimates that most dams have lifetimes of 100+ years, in some regions of the world this lifetime can be severely reduced by siltification. In an era of climate change, changes in the geographical distribution of water and the greater incidences of drought across the globe may also change the viability of certain hydropower developments.[229] However, while social and environmental concerns have affected a number of hydropower developments globally, Canadian hydropower developments continue to grow robustly: in 2014 alone, Canada installed 1.72 GW of new hydropower capacity.[230]

Figure 12: Emissions from different electricity generation technologies. Hydropower's estimated emissions are very low; in a similar range with wind and ocean energy, and significantly less carbon-intense than nuclear energy, photovoltaics, or biopower. (Sathaye, 2011)



4.1 Brief historical background

A full history of U.S.-Canadian integration is beyond the scope of this Baseline, but specific examples of how cross-border integration developed across the U.S.-Canadian border are discussed below, as well as specific historical events that had important effects on cross-border governance and coordination.

Early Developments at Niagara Falls: Some of the earliest cross-border electricity developments between the United States and Canada originated around Niagara Falls, which supplies hydropower resources on both sides of the border. Hydropower installations were installed on both sides of the river as early as 1893. Due to the industrial growth on the American side of the border, Canadian hydropower was primarily marketed to the United States under bulk, long-term contracts. Most transmission lines between the two countries were strung across the Niagara River and on the underside of the Rainbow Bridge at Niagara Falls. In 1920, the Federal Power Act in the United States established the Federal Power Commission to regulate the interstate elements of the electric power industry. The majority of Canadian hydro developments at Niagara Falls were acquired by Ontario

Hydro in 1925, and, reflecting concerns within Canada that Canadian power was exclusively fueling American industry, Canadian policies were established to ensure some portion of Canadian power was diverted to Canadian development. By the 1960s, interconnections existed across the border from Lake Superior to Quebec, and Ontario Hydro supplied about 90% of Ontario's electricity needs. A 1966 study by FPC identified 500 disturbances in the American power system that were localized thanks to enhanced reliability benefits from the interconnections with Canada.[231]

Establishment of the Bonneville Power Authority: While development proceeded in the Northeast, the Columbia River Valley in the U.S. Pacific northwest experienced a few severe flooding events in the late 1800s that – while less frequent than the flooding incidents on the Mississippi or Missouri rivers – drew scrutiny to the risk of flooding as well as the tremendous hydro potential of the Columbia River.[l] [232] In 1932 the U.S. Army Corps of Engineers and the Federal Power Commission conducted a survey of the nation's rivers, which noted that Columbia floods could be better managed by the construction of dikes near vulnerable zones. In 1935 a Pacific Northwest Regional Planning Commission (with representatives from Idaho, Montana, Oregon, and Washington) recommended the creation of an independent federal agency to more fairly market the power from Bonneville and Grand Coulee dams.[233] In 1967, the United States was the primary exporter to Canada, and trade between the two countries was largely dominated by deliveries by the Bonneville Power Administration to markets in Alberta and British Columbia.[234]

Opening Markets and the Rise of ISOs: From the 1970s through the early 2000s, as electricity demand and supply grew, enhanced coordination among different stakeholders, and the incidence of a number of electricity disruptions, led some regions to create tighter power pools, and in some cases, competitive markets managed by ISOs. The Great Northeast Blackout of 1965, caused by a single transmission-line failure near Toronto, affected 30 million customers over eight states in the Northeast, and demonstrated that interconnected networks could also suffer from reliability vulnerabilities. Partially in response, the New England Power Pool (NEPOOL) was established in 1971 as a voluntary association among six New England States to coordinate transmission outages, undertake joint planning to support reliability, and handle settlements and billing. The Federal Power Commission was recast as FERC in 1977. From the 1970s to the 1990s, vertically-integrated utilities dominated the sector, until the Energy Policy act of 1992 created a new category of "exempt wholesale generator", which opened the door to more independent power producers to operate. Orders 888 and 889 (discussed in Section 2.4.3) opened transmission systems to fair and nondiscriminatory access in 1996, leading NEPOOL to propose the creation of ISO-NE.[235] PJM became the first ISO in 1997; MISO and NYISO followed in 1998 and 1999 (and MISO upgraded to an RTO in 2001). Through the 1990s, Canada's exports to the United States were also increasing, and the following two decades also saw a significant rise in Canadian exports rise from approximately 15 million MWh in 1992 to over 60 million MWh in 2013 (Figure 6).

Northeast Blackout of 2003: On August 14, 2003, a cross-border blackout of unprecedented scale occurred in the Northeast, affecting large portions of Ohio, Michigan, Pennsylvania, New York, Vermont, Massachusetts, Connecticut, New Jersey, and Ontario. For worse than the Great Northeast Blackout, an estimated 50 million people were affected, implicating a loss in 61,900 MW of electric load. Power was not restored for up to four days in some areas, and the province of Ontario suffered rolling blackouts that continued for an additional week. It was estimated that the total costs of the outage in the United States ranged from USD$4-10 billion, and Canadian GDP fell by 0.7% in the month of August.[236] In response to the disaster, the United States and Canada formed the U.S.-Canada Power System Outage

[l] Some older buildings in downtown Portland have marked the high water levels on buildings – some five feet above the sidewalk – to demonstrate the depth of the Wilamette River flood of 1894. Most of those buildings market were hundreds of feet from the shore. (Harrison, Floods and Flood Control, 2008)

Task Force to understand why the outage occurred, and make recommendations to prevent a similar disaster from occurring in the future. The Task Force, in a final report, identified a combination of human error and equipment failures, and established a set of 46 recommendations to avoid such outages in the future.

Following the report's recommendations, a number of policy and regulatory changes took place to strengthen system reliability. Congress passed the Energy Policy Act of 2005, which increased FERC's responsibilities in system reliability by requiring it to solicit, approve, and enforce new reliability standards from the North American Electricity Reliability Corporation, effectively making NERC's reliability standards – which had been voluntary -- mandatory. FERC also established an office of Electric Reliability in 2007.[237] Since that time, no outage of similar magnitude has occurred; however, some mathematicians and power engineers believe such blackouts reflect an inherent weakness in the power system, and are likely to continue occurring in the future regardless of ambitious policy and regulatory measures.[238]

4.2 The Structure of the Canadian Electricity Sector

Due to the Canadian Constitution's Act 1867 (Section 92A), Canada's provinces have near-complete control of the power sector, to the extent that federal discussion of power sector reform is considered politically sensitive. A powerful example of this was the Pierre Trudeau Administration's attempt to create a National Energy Program in 1980, which was "so badly received in the Western provinces that politicians still fear to use the words "national" and "energy" in the same sentence." [239]

The lack of integration across Canada can be partially explained by geography, as the distribution of Canada's population and power resources is irregular. An estimated 75% of the population lives within 100 miles of the Canada-United States border.[240] Power resources and market structure also vary by province in a non-contiguous fashion: three provinces utilize vertically-integrated systems and regulated pricing because a high portion of generation comes from hydropower resources (British Columbia, Manitoba, Quebec), three underwent market restructuring and have more diversified energy mixes (Alberta, Ontario, New Brunswick), and others maintain their traditional vertically-integrated structure (Saskatchewan, Prince Edward Island, Nova Scotia). As a result of these provincial jurisdictions, asymmetric market structures, and the geographic distribution of the Canadian population, it has been economically attractive for major Canadian power exporters (such as Manitoba and Quebec) to build short transmission extensions south from Canadian population centers to the United States border. Therefore, transmission lines in Canada have evolved to run primarily north-to-south, with Canada-U.S. trade far exceeding inter-provincial trade. [241]

There were also political reasons for this evolution: extensive trans-Canadian integration – especially integration into a cross-provincial competitive market structure – would require a rolling-back of regulated electricity prices in hydropower-exporting provinces, increasing their tariffs, while potentially affecting vested energy providers and local jobs in the importing provinces.[242] Many industry and academic commentators have noted the value in greater trans-Canadian integration,[243] but efforts to implement these recommendations have been generally unsuccessful. History details a number of failed trans-provincial agreements to analyze transmission options, including the Clean Energy Transfer Initiative between Manitoba and Ontario, the Churchill Falls project between Quebec and Newfoundland, and HydroQuebec's proposal to purchase New Brunswick Power.[244]

In 2008, international trade (78,800 GWh) exceeded interprovincial trade (52,900 GWh) in Canada, with 60% of interprovincial trade deriving from Labrador's Churchill Falls generating station, which supplies the Quebec electricity system.[245] This emphasis is also reflected in the fact that the National Energy Board, which is the federal agency responsible for international and inter-provincial electricity regulation, publishes annual statistics on Canadian electricity exports and U.S. destination states, but not on inter-provincial trade.

4.3 Governance Entities in the Canadian Electricity Sector

Federal Government

- **National Energy Board (NEB):** The NEB is an independent federal organization that was created in 1959. It regulates cross-border elements (interprovincial and international) of the oil, gas, and electricity sectors, including the granting of electricity export permits. It is similar to the U.S. equivalent FERC, but with less authority. For example, FERC has the authority to require that all U.S. States (and, by voluntary compliance, Canadian provinces that export to the United States) provide open access to transmission lines.
- **Natural Resources Canada (NRCan):** NRCan is the federal ministry that manages topics relating to energy, mining, forests, earth sciences, and the environment. The energy division of NRCan leads in Canadian energy policy, including through engagement *with "other government departments, the provinces and territories, and other Canadian and international partners to address energy needs and potential while considering new policies, practices, and technologies."*[246]
- **Environment and Climate Change Canada (ECCC):** Recently renamed from "Environment Canada", ECCC is the primary environment ministry, with a mandate to preserve and enhance the quality of the natural environment, conserve renewable and water resources, and coordinate environmental policies and programs for the federal government. If national GHG emission constrains were established, this ministry would likely play an important role in energy sector governance. With its mandate to coordinate environmental policies and programs on behalf of the federal government, this department could play an integrating role in the electricity sector if national constraints on GHG emissions are established.[247]

Relevant Non-Governmental Organizations:

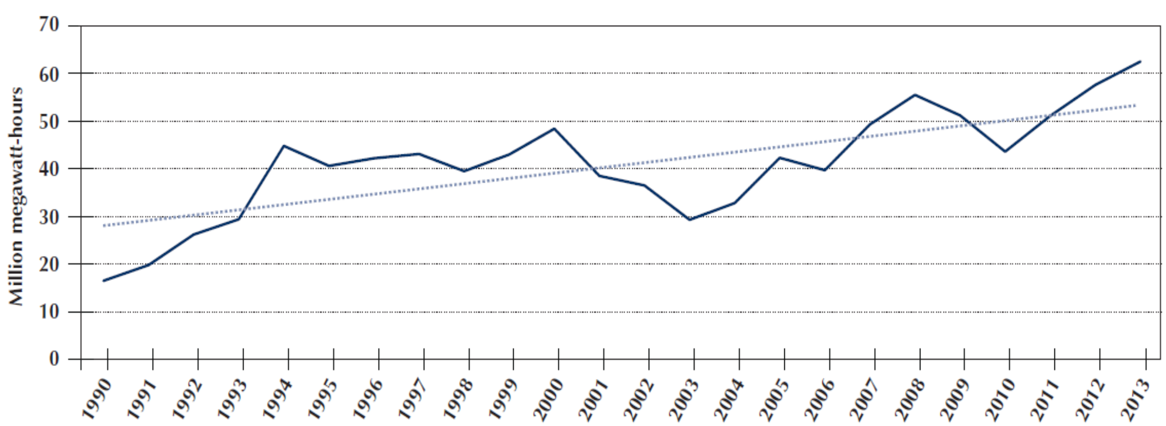
- **Canada's Energy and Utility Regulators (CAMPUT)**: a self-supporting, non-profit organization that convenes federal, provincial, and territorial boards and commissions that are responsible for the regulation of electric, water, gas, and pipeline utilities in Canada,[248] similar to the U.S. National Association of Regulatory Utility Commissioners (NARUC).
- **Industry Associations:** A number of industry associations play a prominent role in the electricity sector, including the Canadian Electricity Association (CEA), the Canadian Hydropower Association (CHA), the Canadian Gas Association (CGA), and Smart Grid Canada.
- **North American Transmission Forum (NATF):** A forum focused on promoting best practices in the reliable operation of the electric transmission system. It includes broad membership

in the United States and Canada that includes investor-owned, state-authorized, municipal, cooperation, U.S. federal, and Canadian provincial utilities.[249]

4.4 Illustrative trade statistics

Canadian Exports Increasing: Following the economic slowdown in 2008, Canada experienced a drop in electricity demand, which has steadily increased through 2016. In spite of the slowdown, in 2014, more than 1 GW of wind and hydro capacity came online in Ontario and more than 800 MW of wind in Quebec. [250] Together, all these factors – temporarily lower domestic demand, additional capacity coming online -- have fueled an increase in electricity exports to the United States by a factor of four since 1990 (Figure 14). Monthly electricity trade, in both directions, is plotted in Figure 15, and summarized in Figure 16. Figure 17, 18, 19, and 20 provide different breakdowns of the destination of Canadian exports. Figure 21 shows existing cross-border transmission infrastructure.
Primary Exporting Provinces: The three largest power-exporting provinces in Canada are Quebec, Ontario, and Manitoba, which all rely on significant hydropower potential. The Canadian Hydropower Association estimates that Canada could further increase its hydropower capacity from 76 GW to 160 GW – 61 GW of which would be located in these three provinces (Figure 22).

Figure 13: Canadian Electricity Exports to the United States, 1990-2013. *A demonstration that Canadian exports to the United States have been gradually increasing over this time period. (NEB, 2015)*



Source: National Energy Board of Canada, "Commodity Statistics: Electricity: Electricity Exports and Imports: Table 2A." February 2015. Available at: https://apps.neb-one.gc.ca/CommodityStatistics/Statistics.aspx?language=english

Figure 14: Monthly Electricity Trade between the United States and Canada, 1999-2015. *U.S. and Canadian binational trade was near equivalent in 2003-2004, but began to diverge in 2004, when Canadian exports to the United States began to increase steadily. U.S. exports to Canada remained roughly constant from 2004- 2008, then began a significant decline from 2008-2015. In November 2015, Canada exported a net of approximately 4,500 GWh to the United States. DOE/EPSA analysis figure (Data from NEB)*

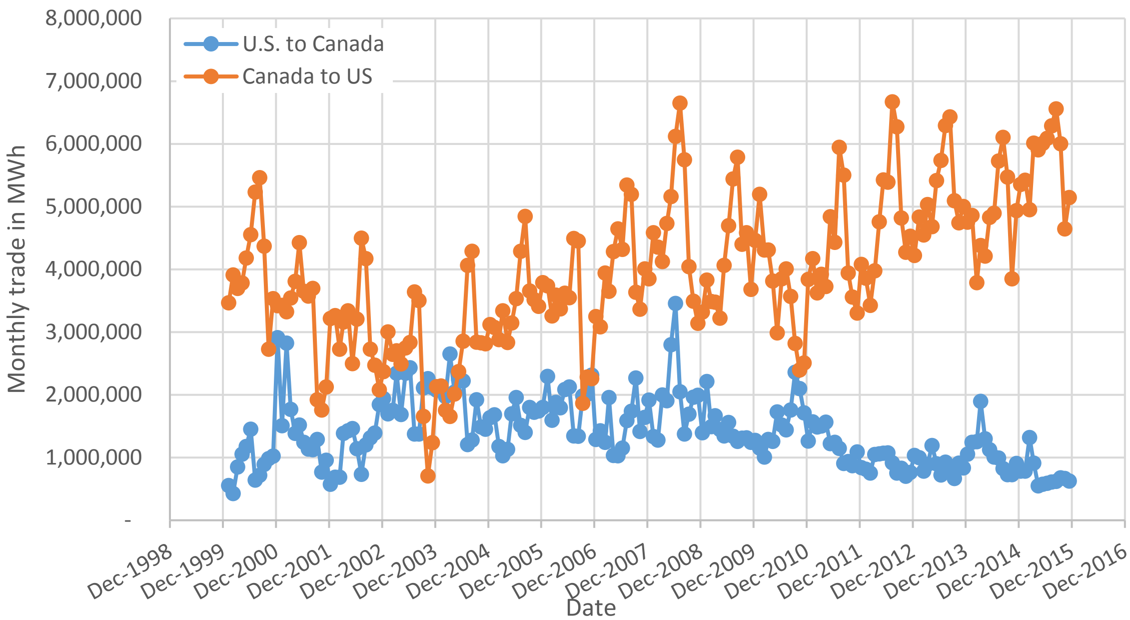


Figure 15: U.S.-Canada net electricity trade. *The primary Canadian exports to the United States come from Quebec (net 23,020 GWh), Ontario (16,553 GWh), and Manitoba (8,061 GWh). British Columbia, though a major hydro producer, is also a significant power importer from the United States due to the Columbia River Valley treaty. All units in GWh. (Canadian Electricity Association, 2015)*

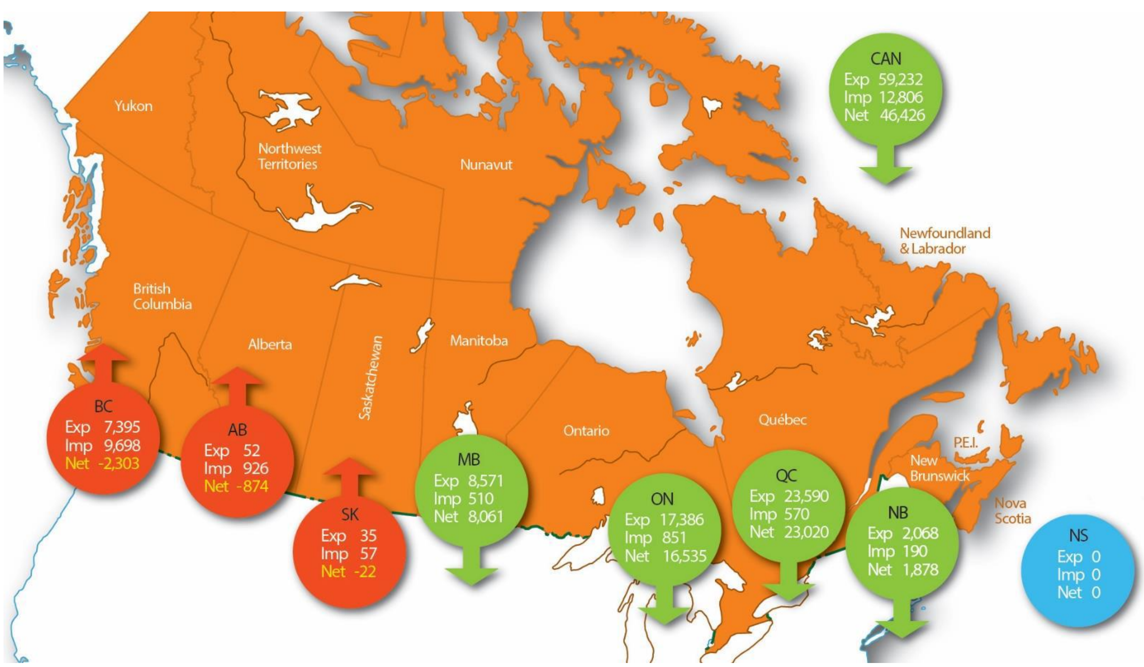


Figure 16. Canadian Electricity Exports by destination region, 2010-2014. *Canadian exports to the United States are greatest in the Northeast region, followed by the Midwest, and the West. From 2010 to 2014, trade in the Midwest and West remained mostly constant, but trade increased significantly in the Northeast. (NEB, 2015)*

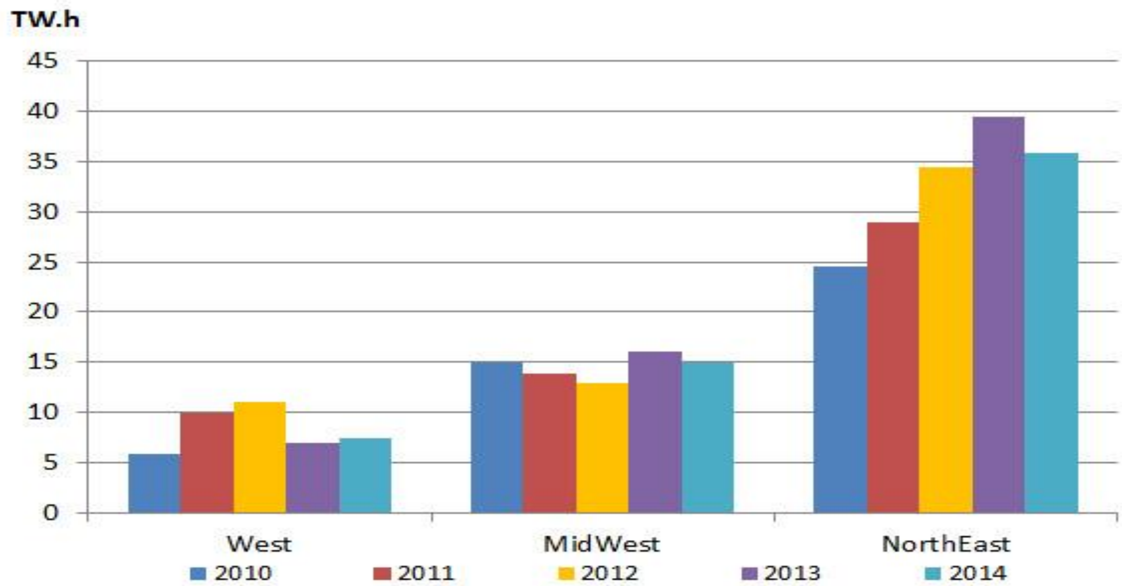


Figure 17. Canadian exports by destination ISO in the U.S. Northeast. *ISO-NE and NYISO are the primary importers of Canadian hydro, but power is also wheeled through to PJM. Power imports have increased year-on-year from 2010-2013, then fell slightly in 2014. As shown in Figure 17, this trend was not as pronounced in the Midwest or Pacific Northwest regions. As shown in Figure 15, overall U.S.-Canada electricity trade continued to increase in 2015. (NEB, 2015)*

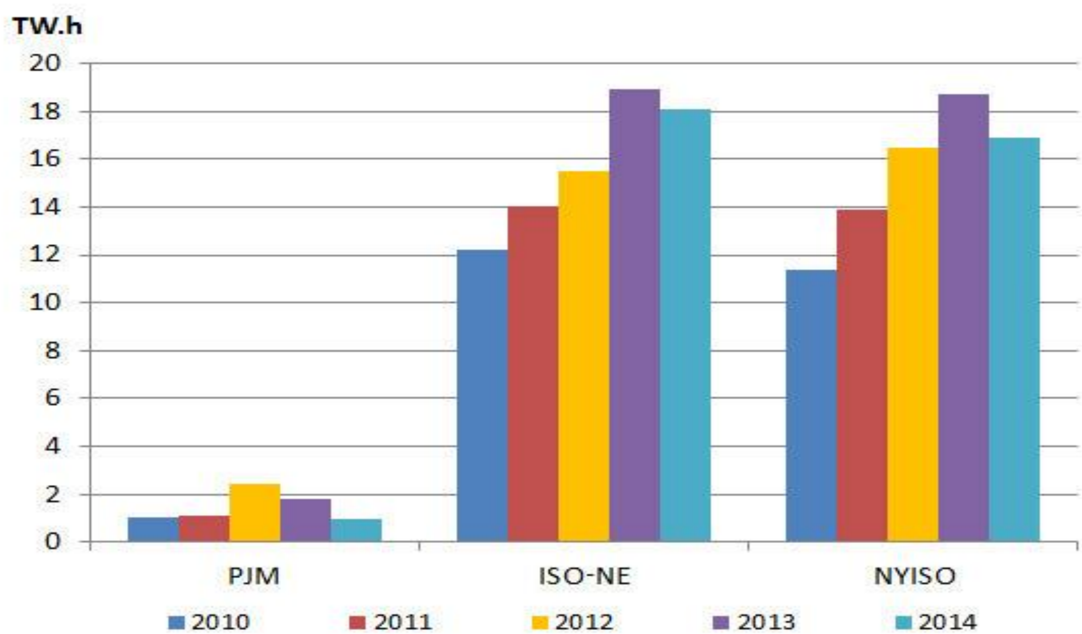
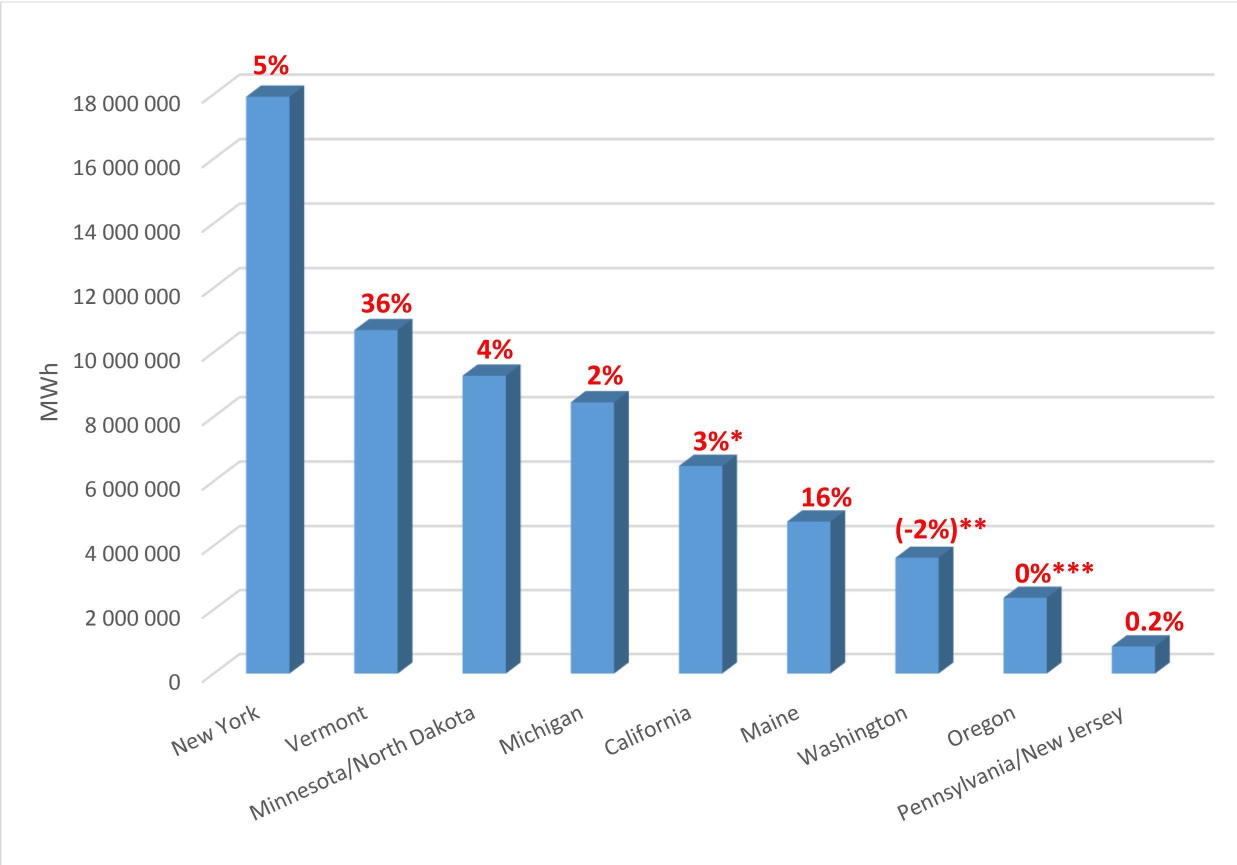


Figure 18: Top Electricity Importers from Canada in 2015: U.S. States and Power Pools. *Blue bars indicate volumes of Canadian electricity sales to each U.S. State/region (NEB Canada); red percentages above each bar indicate the percentage of electricity that net international electricity imports contribute to that State's overall electricity consumption (EIA). While New York is the largest importer of Canadian power, Vermont's sector, which has a power sector that is only 8% the size of New York's, Canadian imports constitute the greatest share of Vermont's electricity (36% in 2013)[251]. DOE/EPSA Analysis figure of NEB and EIA data.*



** California imports electricity from both Canada and Mexico, thus imported electricity contributes to a larger share of in-state consumption.*

*** Washington state exports more electricity to Canada than imports; this creates a "negative" contribution of electricity exports to Washington's in-state consumption.*

**** Different accounting mechanisms for electricity imports between the NEB and EIA, a topic addressed by the NACEI cooperation, are likely responsible for discrepancies in very low-level trade volumes.*

Figure 19. Overall U.S. electricity trade with Canada in four regions: *Northwest, Midwest, New York, and New England. While the Pacific Northwest has been steadily increasing electricity exports to Canada, the Midwest, New York, and New England have been increasing imports overall from 1997 to 2014. (EIA, 2015)*

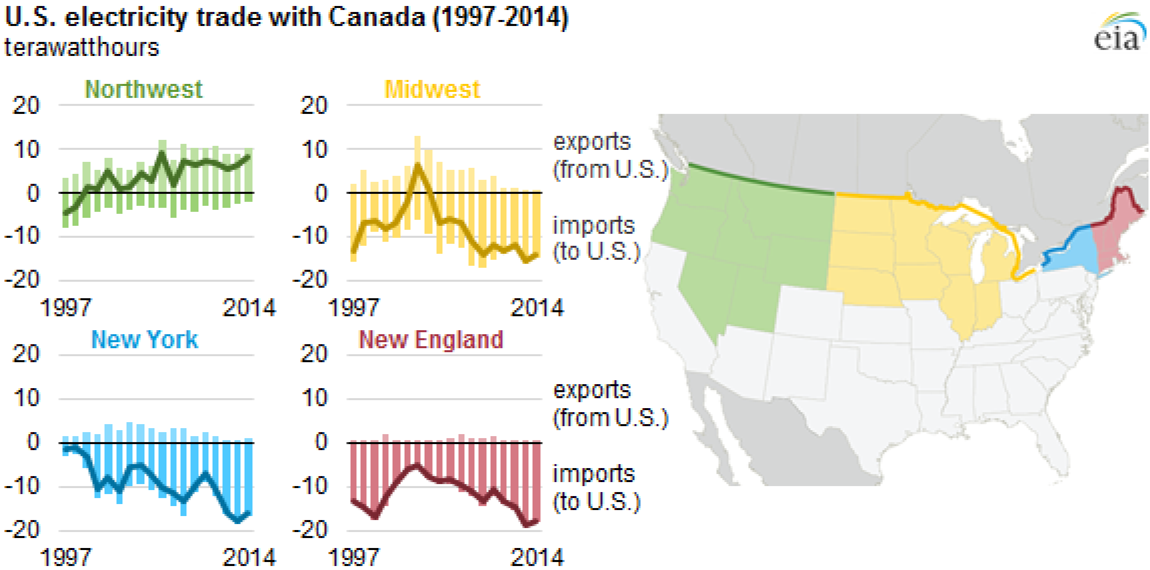


Figure 20: U.S.-Canada transmission infrastructure: *a demonstration of the significant transmission infrastructure linking the United States and Canada. The most infrastructure exists within the midwest (MISO and the Ontario Independent Electricity System Operator), with 17 different transmission lines; and the Northeast (ISO-NE, NYISO, Quebec Hydro) with 10 different transmission lines. (Canadian Electricity Association, 2015)*

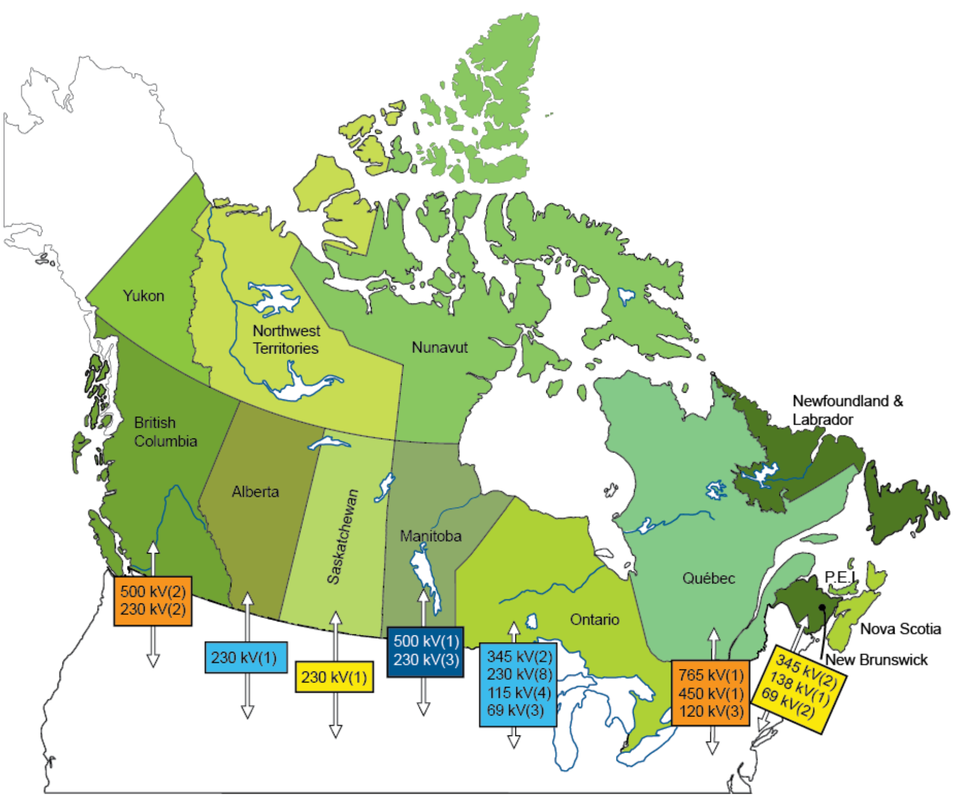
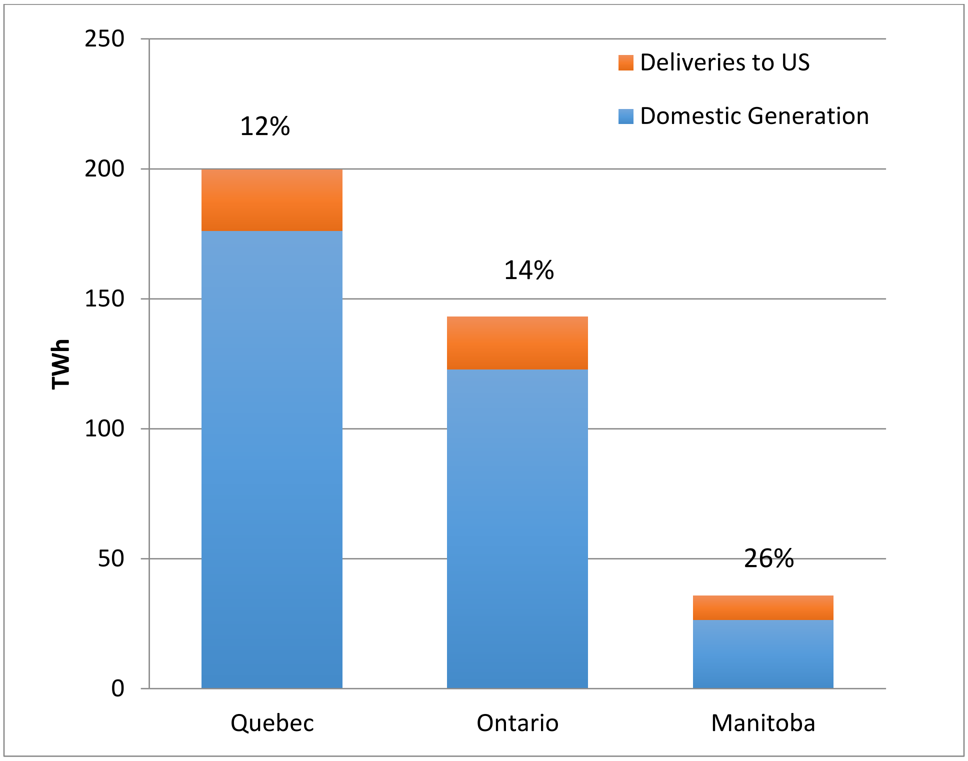


__Figure 21: Total power generation, U.S. exports of top three exporting Canadian provinces.__ Bar height indicates total power generation; orange areas indicate the quantity of power exports to the United States, and blue areas indicate the remaining, unexported power. Percentages above each bar indicate the percentage of total power exported in each province. Quebec is the largest generator in Canada, producing approximately one-third of total Canadian generation (199.7 TWh), and also has the greatest exports to the United States (23.5 TWh). However, Ontario's U.S. exports are of similar magnitude (20.5 TWh) and Manitoba's exports constitute over a quarter of the province's total generation (26%). (EPSA analysis; 2015 StatsCanada electricity data)

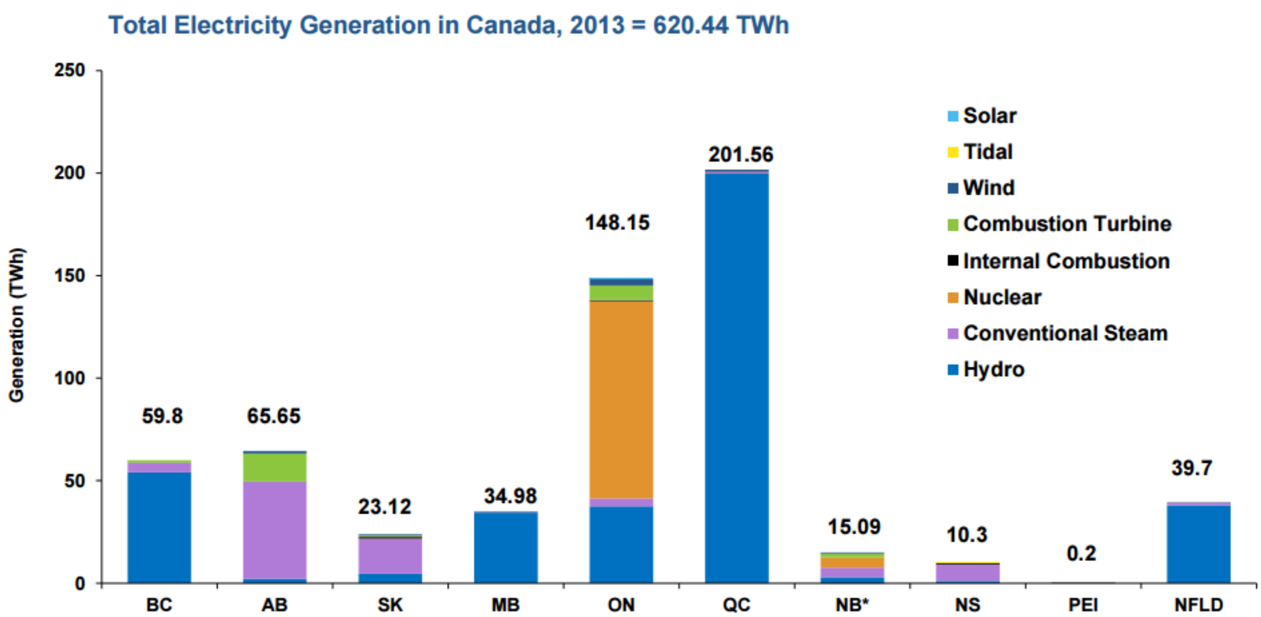


The Dominance of Quebec: Quebec is the largest energy producer in Canada, producing approximately one-third (34%, or 199.6 TWh) of the total generation in the country (592.7 TWh) in 2015.[252] Quebec's sector, managed by the state-owned enterprise HydroQuebec, has access to 41,018 MW of installed power from which 91% is hydropower. [253] HydroQuebec notes on its website that its generation is 99% derived from clean, renewable sources.[254] A testament to its strength as an energy provider, Quebec is also well-interconnected to its neighbors, boasting 15 different interconnections and active trade with New Brunswick, New England, New York and Ontario. Its interregional transmission lines enable a maximum export capacity of 7974 MW and import capacity of 6125 MW.[255] HydroQuebec has also expressed its interest in exporting more hydropower to the United States, but the need for additional cross-border transmission capacity and local concerns over such developments are main bottlenecks (more discussion on this topic in Section 3.6). However, following the permanent closure of the Vermont Yankee Nuclear Plant at the end of 2014, (which accounted for 55% of Vermont's electricity generating capacity and more than 70% of its net generation in recent years), Vermont's sector now absorbs more imports from Canada and ISO-NE.[256] In 2015, Canadian imports accounted for over one-third (36%) of its total consumption.[257]

Unlike Quebec or Manitoba, Ontario's sector is the most highly diversified, and produces a majority of its power from nuclear energy. However, due to its significant size, its hydropower generation was still slightly greater than that that of Manitoba in 2013 (Figure 23), for which hydropower constituted 96% of its total generation.[258]

A note about available statistics: While power sector statistics reporting trade between the United States and Canada are widely available, especially following the establishment of the North American Cooperation on Energy Information, statistics that provide subregional or state/provincial breakdowns of electricity trade and trends were not consistently available.

***Figure 22: Production of electricity by province and by type of production in 2013**. Of note are the hydropower-producing provinces: British Columbia, Manitoba, Ontario, Quebec, and Newfoundland and Labrador, of which all but New Foundland and Labrador are significant electricity exporters to the United States. Alberta, which is the primary hydrocarbons producing province of the region, and Saskatchewan, New Brunswick, and Nova Scotia are more reliant on fossil-fuel driven steam turbines, while Ontario has a significant production from nuclear energy. (Canadian Electricity Association, 2015)*



*Point Lepreau nuclear generating station resumed power production on November 23, 2012, nuclear has been re-established as a major source (about 30%) of electricity in New Brunswick.

4.6 Case Study: Minnesota Power and Manitoba Hydro: Hydro Firming of U.S. Wind Power

Although Canadian hydro provides a significant opportunity for the United States to import affordable, clean power, such imports provide competition to the domestic renewable energy industry, as Canadian hydro is generally produced at a lower cost than renewables, and provides firm power.[259] However, in certain cases imports of Canadian hydropower may actually support U.S. clean energy deployment rather than compete with it: as a clean energy resource that can also provide pumped storage capacity, hydropower can provide balancing for variable resources. While this concept is not new,[260] recent years have seen innovative examples that suggest firming variable renewables resources with hydropower as storage has untapped potential in North America.

A collection of efforts to explore this model have been undertaken by Minnesota Power and Manitoba Hydro. This cooperative economic model could be informative for other developments. The multi-project business model includes a contract that allows Minnesota Power to sell wind-generated renewable energy north to Manitoba, and for Manitoba to sell its stored hydropower back to satisfy Minnesota's electricity needs when variable wind energy is not available. Since 59% of Minnesota's current generation is derived from fossil fuels (coal 46%; natural gas 13%), the use of hydropower imports for firming variable resources is expected to reduce carbon emissions.[261] The project requires additional transmission infrastructure between Manitoba and Minnesota, and has been a key driver in proposals for a new 500 kV transmission. Manitoba Hydro had also indicated plans to build two new hydraulic generators (totaling 2180 MW) in the next 15 years if such a line was built.[262]

To estimate the benefits of additional transmission for the specific purpose of hydro-wind balancing, Midcontinent Independent System Operator (MISO) completed a study in 2013 that explored the costs and benefits of a new transmission line to support a wind-hydropower balancing scheme. [263] The study explored two different possible routes for a new 500 kV transmission line that would connect Dorsey, Manitoba to cities in Minnesota (Figure 24). Using the PLEXOS production cost model, the study was able to analyze wind/hydro balancing potential with simulations of sub-hourly (5-minute) dispatch (an impressive feat for the industry) and concluded that both Manitoba Hydro and MISO would benefit from dynamic real time Manitoba Hydro market participation,[m] through production cost savings, load cost savings, reserve cost savings and wind energy curtailment reductions. More specifically, the study estimated the annual modified production cost savings would range from $228 to $455 million for 2027, while annual load cost savings would range from $183 to $1,302 million for 2027.[264]

The study's concluded that such an arrangement could lead to economic and renewable energy benefits on both sides of the border – spurred the initiation of proposals for the construction of the Great Northern Transmission Line.

On March 31, 2016, the Minnesota Public Utilities Commission issued a route permit for the Great Northern Transmission Line, which serves as the "eastern" transmission option consistent with the MISO study. Minnesota Power has signed a Power Purchase Agreement (PPA) with Manitoba Hydro that requires a transmission line be in service by June 1, 2020.

Other proposals using the wind/hydro balancing scheme have been reported, including a new proposal from Invenergy called "Wind and Hydro Response" that would bring wind power from generation

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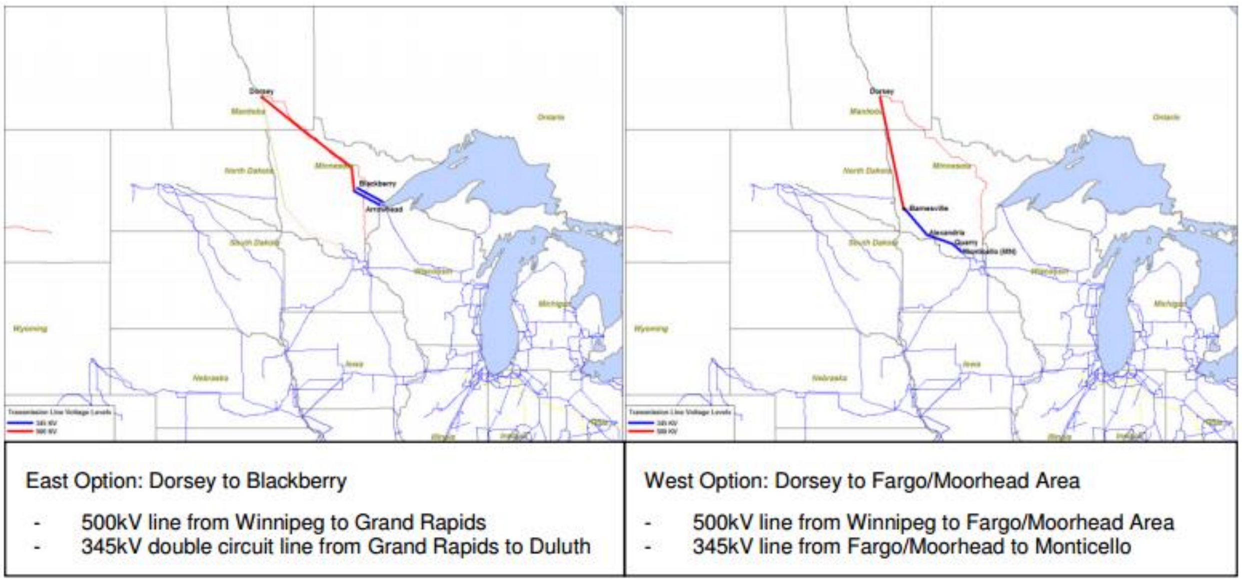
[m] Per the recommendations in this report, in 2015, MISO implemented "bi-directional external asynchronous resources", enabling Manitoba Hydro to import or export energy on a dynamic schedule. (Matlock, 2015)

facilities in New York to Rhode Island, Connecticut, and Massachusetts, with supplemented hydropower from HydroQuebec for firming.[265] However, the extent to which this model could be expanded to other markets is not yet well-understood.

Figure 23: MISO/Manitoba Hydro route analysis[266]



4.7 Case Study: The Champlain Hudson Power Express: Engagement with Stakeholder Groups

Stakeholder engagement, including local consultation, is an important element of the planning, siting, permitting, and development of electric infrastructure. Thorough and complete evaluations of environmental impacts must include strong involvement from stakeholder groups, including the public. Early, transparent, and rigorous local consultation processes, which in some cases may require greater upfront capital commitments to a project from the applicant, lead to better environmental and community outcomes.

A common challenge to new electricity infrastructure development is sometimes competing interests of citizen concerns regarding safety, aesthetics, sustainability, economic impacts, eminent domain, and property value implications of new developments, which can be at odds with the renewable energy objectives of states. In some cases, local stakeholders have expressed concern that projects would not provide local benefits (i.e., the project would provide power to another part of the state or country but would create negative local impacts) or would not adequately protect the natural environment, on which stakeholders often place great value.

In December of 2015, New York Governor Mario Cuomo directed the Department of Public Service to develop and enact a Clean Energy Standard, ensuring that 50% of all electricity in New York State be derived from clean energy.[267] Greater Canadian exports could help in achieving the United States' climate objectives under State programs[n] or the Clean Power Plan; but increasing trade would require greater cross-border transmission capacity.[o]

The Champlain Hudson Power Express (CHPE) was a large-scale transmission project designed to bring Canadian hydropower to New York. A large, long project that assumes greater infrastructure costs, the CHPE project proposes a $2.2 billion, 1,000 MW HVDC transmission line that would originate in Montreal, Canada and bring clean power to New York City. Taking advantage of different geography in Vermont, the project includes two cables that would largely bypass a number of common opposition concerns by passing underwater or underground for nearly all of the 333 mile route: under Lake Champlain and the Hudson River, then underground along railroads and other public rights of way (Figure 25).

The developer, Transmission Developers Inc. (TDI), a Blackstone Group, notes the lines could last 40+ years, and estimates that the project could reduce New York's carbon emissions by 2.2 million metric tons annually, while ratepayers would save $650 million per year.[268] The project was first filed with DOE in January of 2010, then in August 2010 and February 2012 based on feedback from New York stakeholders and other agencies, and received its Presidential permit on October 6, 2014;[269] all required federal permits were received in April of 2015.[270] It still awaits acceptance of its interconnection application from NYISO.

In 2013, TDI also announced it would pursue approvals for a second transmission line, the "New England Clean Power Link" (a $1.2 billion, 1,000 MW line from Canada to Ludlow, Vermont), that would share the same underwater path with the CHPE project before cutting east through south-central Vermont.

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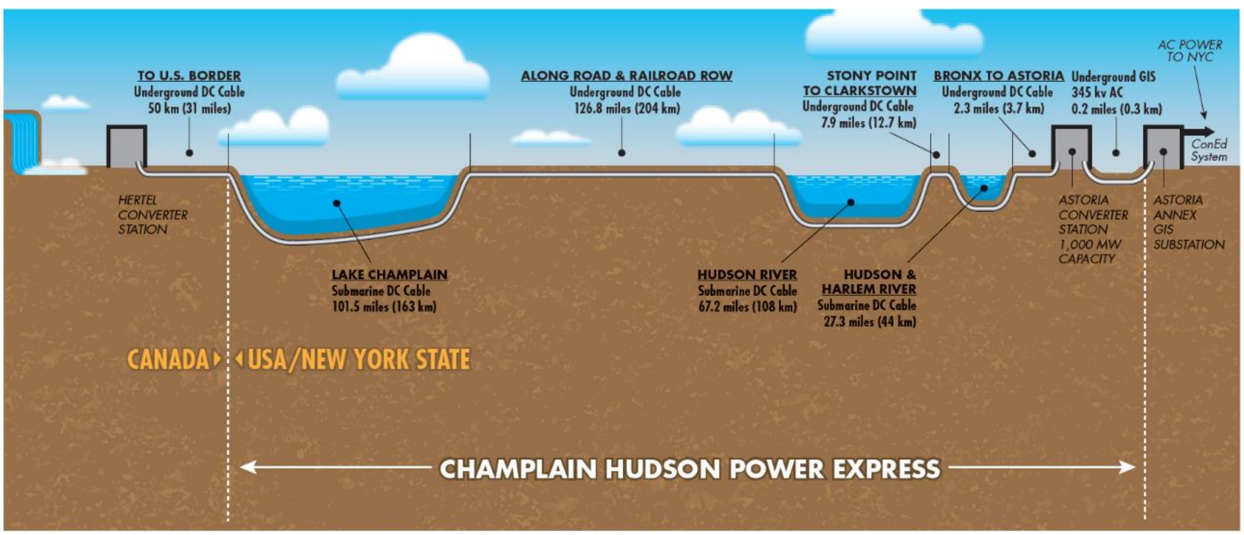
[n] Some State RPS standards were designed to foster in-state development and jobs, and therefore exclude power imports, as discussed further in Section 6.2.3.

[o] More discussion of Canadian hydropower exports and the Clean Power Plan are included in Section 6.2.3.

The Northern Pass transmission project is an example of the challenges of implementing such developments. The original project, announced in October 2010, proposed to bring 1,200 MW of Canadian power to the New England Power Pool along 187 miles of above-ground cable. Groups expressed their concerns that the project would swamp ISO-New England with Canadian hydropower, undermine in-state energy development within New England, and cause environmental damage along the route, which included portions of the White Mountain National Forest, the Franconia Notch area, and a portion of the Appalachian Trail.[271]

Northeast Pass LLC, the project applicant, eventually abandoned the original route and its private land acquisition strategy, and announced a new route in June 2013. The new route avoids private property as much as possible, using existing transportation corridors for 160 miles of the project's path, and burying 60 miles of the route underground, and lowers the size of the project from 1,200 MW to 1,000 MW. The company currently estimates that the project would come online in May 2019.[272] As of July 2016, the project still requires the New Hampshire Site Evaluation Committee Certificate of Site and Facility, a Presidential Permit from the U.S. Department of Energy.[273]

Figure 24: The Champlain Hudson Power Express Route. *The CHPE project avoids private property and visible transmission lines by using existing transportation corridors and burying the transmission lines for most of the 333-mile route. (Transmission Developers)*

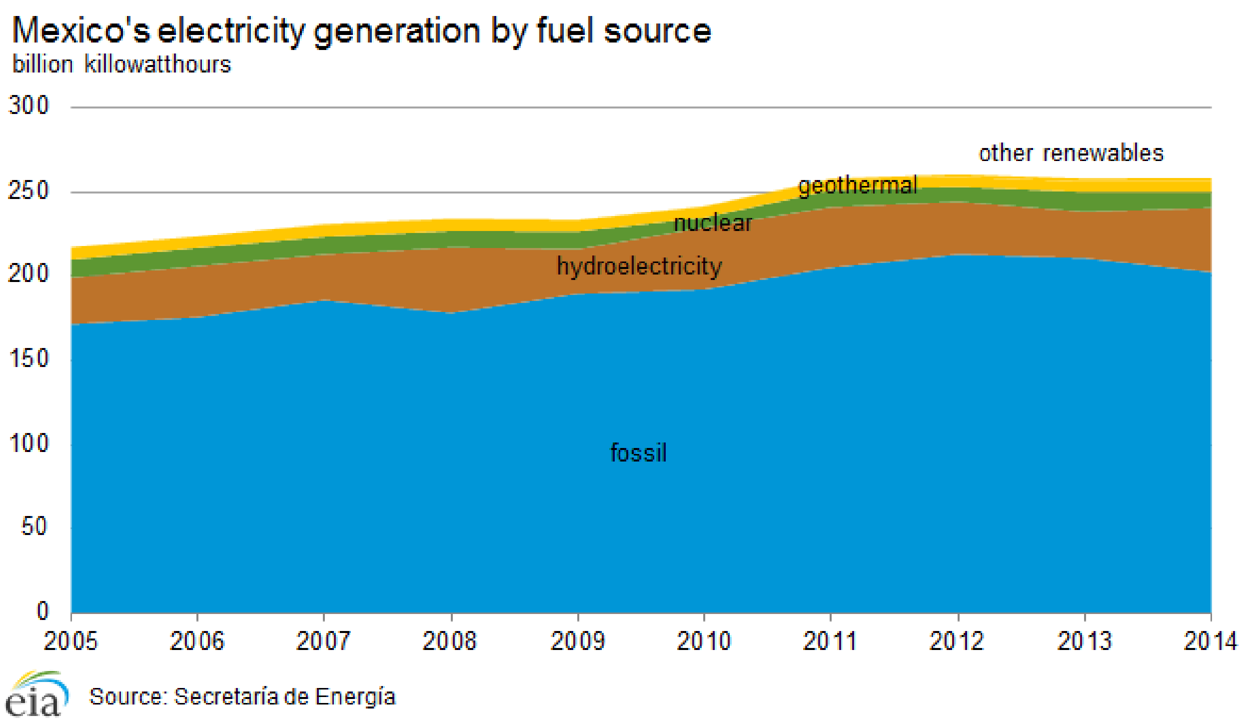


Consultation and negotiation will always be an important element for the development of energy infrastructure, and regional differences will always make these negotiations unique: all involve different communities in different states. Across all types of infrastructure development, including cross-border transmission, time must be taken to ensure that proper assessments of environmental issues. Thorough and complete evaluations of environmental impact take time and resources, and must include strong involvement from stakeholder groups that are directly affected by these projects. Each project will face different challenges, just as all provide different opportunities. Transparent and rigorous local consultation processes, in some cases paired with greater up-front capital costs applied to a project, could smooth the path to identifying a solution that is accepted by local communities - a tradeoff worthy of consideration by developers.

5. U.S.-Mexico Interconnection

Due to a combination of historical, geographical, and resource factors, electricity integration between the United States and Mexico exists at a far lower level than U.S.-Canadian integration. According to the EIA, in 2013, the United States and Mexico traded approximately 2 million MWh total, with the United States exporting 0.68 million MWh and importing 1.27 million MWh. For comparison, total U.S.-Canadian trade in the same year was 73 million MWh.[274] The existing transmission interconnections to California are synchronous; the interconnections to ERCOT are asynchronous.

Figure 25. In contrast to Canada's additional hydropower potential, neither the Southern United States nor Northern Mexico has significant excess electricity supply, and the Mexican electricity grid primarily depends on fossil fuels for generation (Figure 26).



Additionally, while demographically most Canadians live near the border with the United States, the Mexican population is more geographically distributed, with the Mexican border states reflecting some of the lowest population densities of the country.[275]

However, Mexico does have a number of industrial centers in the northern border region, primarily in Ciudad Juarez, Matamoros, Mexicali, Nogales, Nuevo Laredo, Reynosa, Tecate, and Tijuana, which are likely to maintain constant or increasing energy demand.[276]

Another significant factor that reduces the current level of US-Mexican electricity integration is Mexico's former energy sector policy and regulatory framework. Prior to the 2013 Energy Reforms, Mexico's electricity sector followed a vertically-integrated, state-controlled model that left little room for private sector participation anywhere in the oil, gas, or electricity sectors. The energy reforms, which seek to increase private participation, lower energy prices, and implement more renewable energy, included the unbundling of the power sector and establishment of a wholesale electricity market. The reforms have the potential to dramatically change the shape and future of Mexico's electricity sector, and of the North American energy system.

5.1 Brief historical background

History of the Oil Industry

Foreign investment in Mexico's energy sector, especially in the oil industry, has a complex, and at times violent, history. Though this report primarily focuses on electricity and not on the oil and gas sectors, in Mexico both sectors are deeply intertwined.

Oil was discovered and originally developed in Mexico at the turn of the 20th century by foreign investors (primarily Royal Dutch Shell), and the country became the world's second-largest oil producer by the early 1920s. However, largely mirroring the ballooning of the oil industry's wealth and influence, and oil-nationalism movements around the globe, the Mexican revolution in 1910-1920 put national attention on the foreign control of the country's valuable assets. Mexico established a new constitution in 1917 that explicitly specified national ownership of all hydrocarbon resources.[p] Another two decades of fraught relations between foreign oil companies and Mexican governments unfolded, including bitter labor disputes between Mexican workers and U.S. oil companies. In 1938, indicating the end of fruitless negotiations between U.S. oil companies and Mexican workers, President Lázaro Cárdenas signed an order that expropriated the assets of nearly all foreign oil companies operating in Mexico, and established the national oil company, Petróleos Mexicanos (Pemex). Pemex quickly became a symbol of national pride and "rallying point" for the national party that came to be known as the Institutional Revolutionary Party (PRI), as well as for broader Mexican society. Though Pemex continued to pursue service contracts with certain U.S. oil companies, a regulatory law was passed in 1958 that banned this practice as well.[277]

The Mexican oil sector subsequently experienced periods of explosive growth in the 1970s, including the discovery of the enormous Cantarell oil field. However, the 1980s saw the beginning of a decline in production that continues to the current day. As Pemex's main production wells lagged, depriving Pemex of the necessary capital to invest in new reserves or maintain its infrastructure, losses mounted, worker productivity reduced, and production continued to fall. Burdened by high taxes and pension liabilities, Pemex operated at a loss between 1998 and 2013.[278] From 2000-2013, even significant increases in exploration and production investment were insufficient to stop the decline (Figure 27).

History of the Electricity Industry

Though the electricity sector was not as politically prominent as the oil sector in the Mexican revolution, it underwent a similar, though slower, transformation. The Comisión Federal de Electricidad (CFE) was established in 1934, initially with a mandate to regulate the private, vertically-owned energy monopolies that were active in Mexico, as well as to provide electricity to areas that were not considered profitable by the private sector.[279] Through the 1940s and 1950s, CFE steadily acquired new concessions

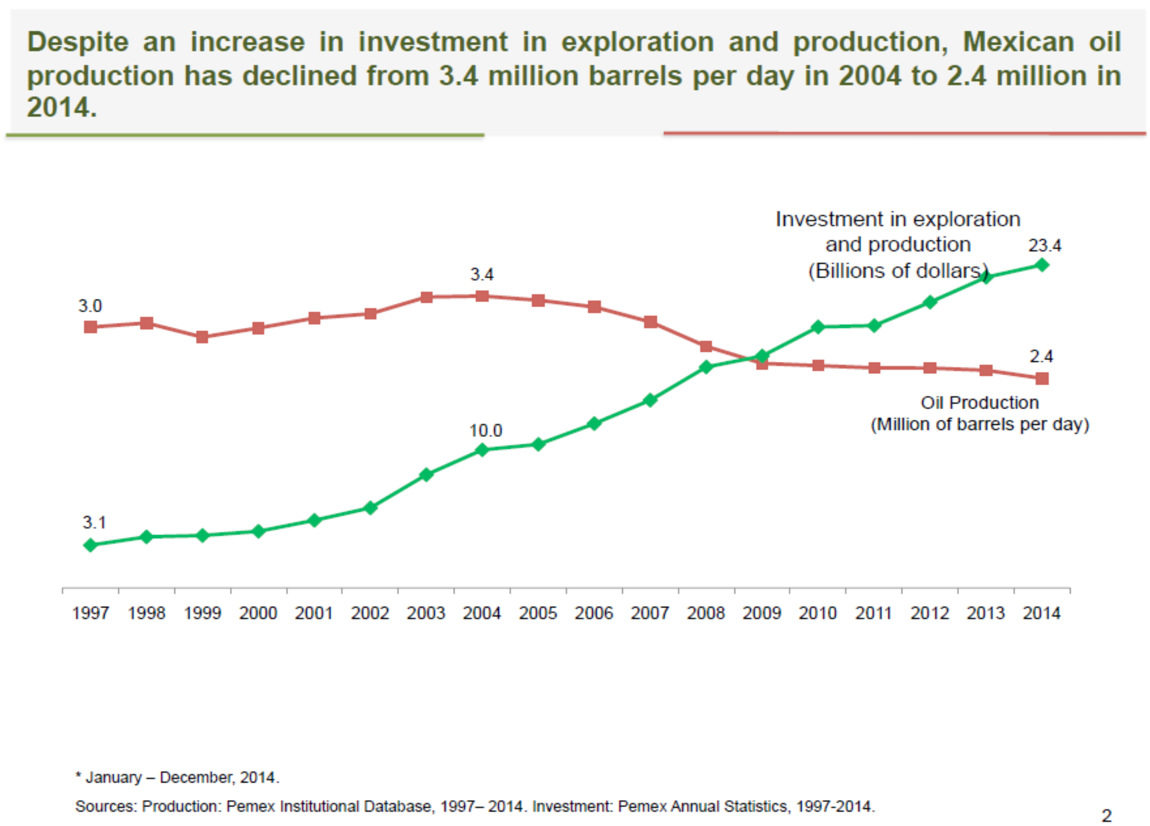
[p] The constitution's Article 27 gives the Mexican government the "exclusive legal authority to exploit, distribute, and process hydrocarbons in the country and states that the government may not, per the regulatory law, grant private concessions for their exploitation." (Congressional Research Service, 2015)

throughout the country, and by 1960, it controlled just over 50% of the market. In September of 1960, the government fully nationalized the electricity sector, requiring the state to take responsibility for being the "sole producer, provider, and distributor of electricity in Mexico." CFE, as a result, became the national monopoly.[280]

The boom in the Mexican oil sector in the 1970s enabled the Mexican government, through CFE, to underwrite the expansion of power sector infrastructure. Primarily relying on diesel-fired generation sources, CFE expanded access to electricity to a greater portion of the Mexican population, roughly doubling the number of households with access to electricity.[281] At the same time, the state also started subsidizing costs for end-users, reflecting a political philosophy to ensure access to and the affordability of basic services. Though these subsidies were intended to support the needs of lower-income users, they resulted in significant subsidies for higher-income households as well.

Recognizing that some industrial facilities were limited by inadequate electricity services, in 1992, through the Electrical Energy Public Service Law, the Mexican government opened the door for independent power producers (IPPs) to operate through cogeneration and self-supply arrangements, which avoided constitutional restriction by producing electricity that was not classified as a "public service". In 2014, approximately 17% of electricity was generated by private sources.[282]

Figure 26: Mexican oil production falls even as investment in exploration and production increases (Source: SENER presentation, Lourdes Melgar, February 2015)



Signs of Strain

However, by 2013, the electricity sector, like the hydrocarbons sector, showed signs of strain. CFE's budget required approval by the Mexican congress, and its gross revenue was just sufficient to cover operational costs, making new investments difficult.[283] Other commentators have noted that labor unions were major beneficiaries of the system and opponents of change, leading to inefficiencies in CFE's management, significant pension liabilities, and an inefficient workforce. Outmoded electricity and natural gas infrastructure became overtaxed, and the distribution system exhibited a high level of losses, including from electricity theft. As of early 2016, technical distribution losses were estimated at 15%; including billing and collections processes, 21% of generated energy is unpaid.[284]

These inefficiencies, the lack of new infrastructure investment, and the sector's continued reliance on oil-fired generation in turn led to higher electricity costs, which were further exacerbated by high oil prices from 2006-2013, which additionally burdened the government's subsidy program. As of 2013, the average subsidy in Mexico was 30%, while the average residential electricity subsidy was 50% of the electricity cost.[285]

With the reforms, the Mexican government identified a number of strategic changes to the sector that could improve its bankability and functioning. For example, the power sector's then high dependence on liquid fuel-based generation makes the country more susceptible to volatile oil prices. And though the dramatic fall in oil prices from 2014-2016 provided some relief to CFE, it also affected Pemex's bottom line, creating a net loss in revenue for the government.

There are a number of tools CFE could use to reduce costs, including the deployment of more natural gas-fired generation, additional renewable energy generation, enhancing efficiency, and improving the environmental footprint of the sector. McKinsey estimates that Mexico could save 20% in energy costs by addressing these issues, which it describes as "issues of supply and demand."[286] However, such changes also require significant infrastructure investment, especially in the case of increasing gas-fired generation. In spite of Mexico's easy access to the United States gas market, in early 2013, the limitations in natural gas pipeline capacity from the United States resulted in severe gas shortages, which were blamed for a loss of 0.3 percent of GDP in the second quarter of 2013, and resulted in Mexico turning to boost supplies from more expensive overseas markets.[287] On infrastructure more broadly, McKinsey notes that Mexico will require an estimated $71 billion in development per year through 2025, just to keep up with current economic growth. Figures 28, 29, and 30 describe Mexico's natural gas import trajectory.

In an interview in 2010, CFE's Communications Director, Estéfano Conde, noted that energy security was "a main challenge", and that Pemex did not have an adequate supply of natural gas to support the Mexican power sector; also, that Mexico "must determine whether the state can continue to be the dominant energy provider or whether radical reform is needed in which the private sector takes a more prominent role."[288]

5.2 The Mexican Energy Reforms

In 2012, Mexican President Enrique Peña Nieto introduced major structural reforms, known as the "Pacto por México" to improve governance, combat corruption and accelerate economic growth. Energy was a major part of that reform package and by 2013, with its power demand projected to grow by 4 percent annually from 2012-2026,[289] a greater political consensus came together to support overhaul of the sector. For the power sector, the government focused on reform with two main objectives: to increase private investment in order to lower electricity costs for users (also unburdening government subsidy programs) and enhance investment in natural gas and renewable energy development.

After months of passionate political debate, driven by the deep-rooted belief of many Mexicans that natural resources, oil in particular, belong to the Mexican people, President Peña Nieto signed the historic constitutional reforms on December 20, 2013. Amendments were made to Articles 25, 27, and 28 of the Mexican Constitution; and the implementing legislation was passed on August 11, 2014. The secondary laws governing the electricity sector took more time to develop, and are listed below.

Figure 27: Mexico's Dry Natural Gas Production and Consumption: In recent years, Mexico's consumption of natural gas increased, even while production stagnated, leading to a greater number of imports. SENER estimates that power sector demand will grow by annually by 2.5% from 2014- 2029, due to plans for new natural gas transmission infrastructure and new demand centers.[290]

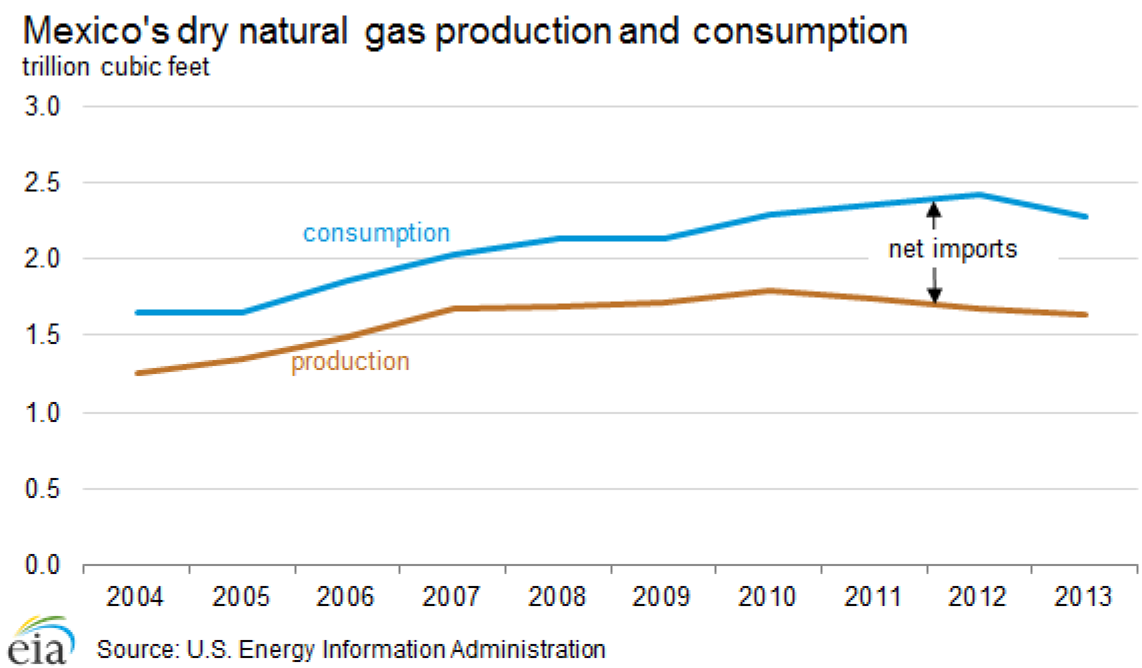


Figure 28: SENER'S projections of Mexico's natural gas consumption.

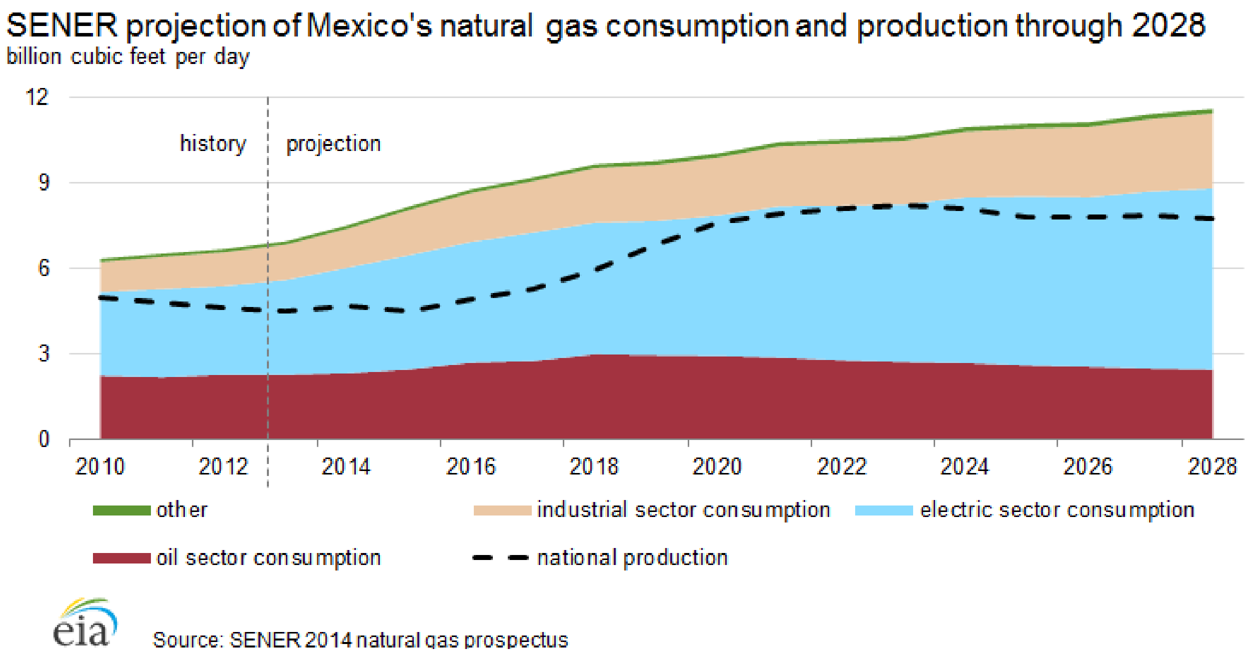
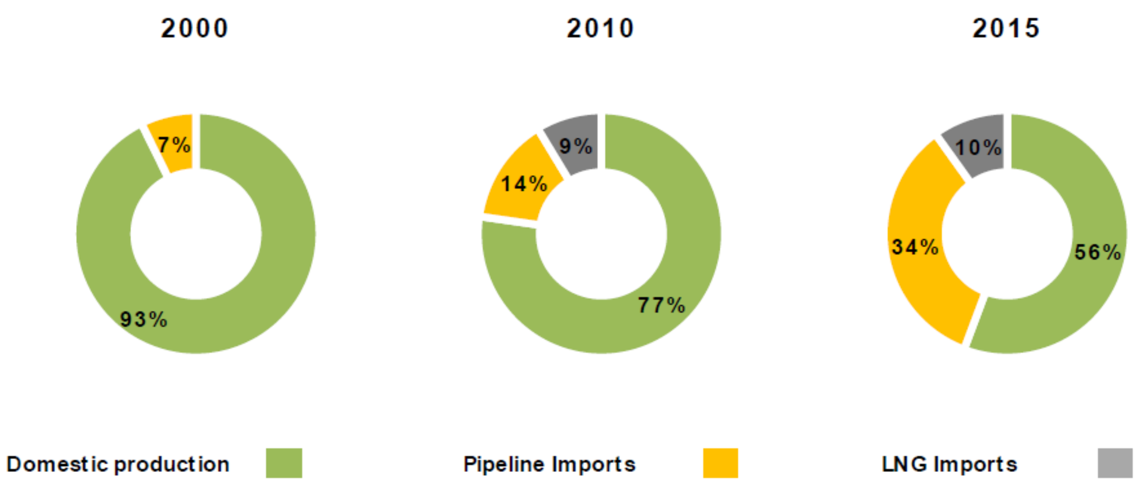


Figure 29: Mexico's natural gas production and imports by source. From 2000 to 2015, the declines in domestic natural gas production led Mexico to import increasing quantities of natural gas from pipelines (from the United States) and LNG, rising from 7% of total consumption to 44%. (International Energy Agency, 2016)



5.2.1 The Structure of the Reforms

The restructuring of the electricity sector took place through the passage of a number of interrelated laws. The primary elements include the following:

1. **The Energy Reform Law** (August 11, 2014);
2. **The Law of the Electricity Industry** (Ley de la Reforma de la Indústria Eléctrica, abbreviated "LIE"), which came into effect August 12, 2014;[291]
3. **The Energy Transition Law** (Ley de la Transición Eléctrica, or "LTE"), which came into effect on December 24, 2015;
4. **Guidelines for the Wholesale Electricity Market** (Sept 8, 2015). The Guidelines are divided into 19 sections and cover various aspects of the Market structure and operation.[292]
5. **Publication of the Guiding Criteria for the Issuance of Clean Energy Certificates** (Certificados de Electricidad Limpia, or "CEL"s)[293]
6. **Publication by CRE/CENACE of initial CEL Market Rules** (June 2015)
7. **Ley del Servicio Público de Energía Eléctrica ("LSPEE").**

Through these laws, the reforms accomplished the following changes[294] (summarized in Figure 31):

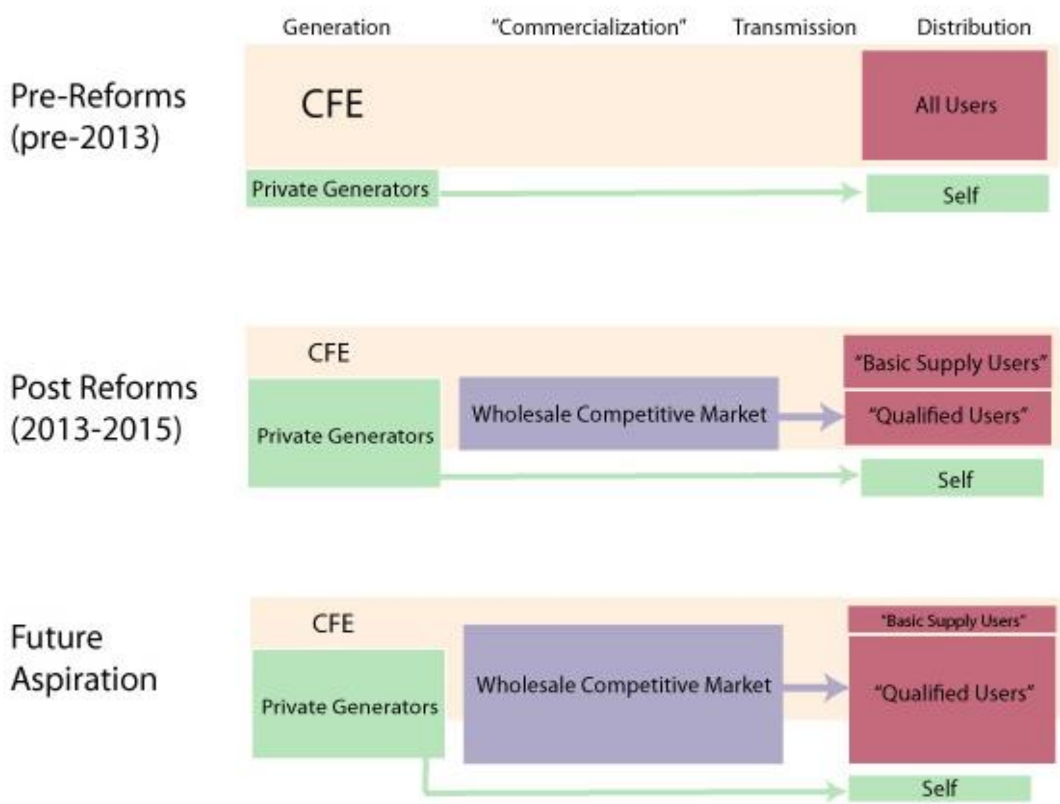
1. CFE was unbundled, separated into subsidiaries for generation, transmission, distribution, basic supply, other forms of Power Marketing, and provision of primary inputs. and considered a "productive state enterprise" permitted to participate in all market activities (none of CFE's assets were privatized) – *LIE, LTE*;[q]
2. The private sector is now free to participate in the generation and sale of electricity, while CFE maintains operational control of transmission and distribution, but may establish agreements or joint ventures with private investors to finance, install, maintain, manage, operate, and expand T&D networks;
3. No one company may participate in more than one of the following areas: generation, transmission, distribution, power marketing, supply of electricity, or basic resources for the electricity industry.
4. A wholesale competitive electricity market was established, operated by a newly independent system operator, CENACE, and regulated by the Electricity Regulatory Commission (CRE) and Ministry of Energy (SENER);
5. Wholesale market participants were divided into new categories: generators, suppliers, power marketers, customers with aggregate load points under 3 MW ("basic users"), customers with aggregate load points over 3 MW ("qualified users"), transmission providers, and distributors. Over time, the threshold to qualify as a "basic user" is reduced;[r295]
6. Generators and qualified users may establish private power purchase agreements (PPAs), mediated by CENACE.
7. Basic users may only purchase power from retail providers, such as CFE, and CFE-generation remains the sole provider to residential users with regulated tariffs;

[q] The unbundling of CFE is based on articles 25, 27, and 28 of the Mexican Constitution, articles 8, 11, Section VII and XVII, Transitional Third, Fourth, Sixth and Eighteenth of the Law on Electric Industry (LIE) and Section I, 5, 10, 57, 60 and the Transitional Fourth and Fifteenth of the Federal Commission of Electricity Law. (International Energy Agency, 2016)

[r] The division between basic users and qualified users reduces over time; at the time of the reforms, the division was drawn at 3 MW; at the time of drafting this report, it had been reduced to 2 MW; and it is expected to fall to 1 MW in August 2016.

8. A new incentive scheme for renewable energy development will enter into force in 2018, requiring power retailers and consumers to consume set percentages of clean energy or purchase "clean energy certificates" (CELs), which are sold by clean energy producers;
9. A number of other institutional responsibilities were established: SENER is responsible for issuing the initial market rules; CRE issues permits and form contracts to participate in the wholesale market, setting tariffs for transmission, distribution and basic retail services, issuing interconnection contract forms, managing the CELs.

*Figure 30: **Structure of the Mexican Electricity Sector.** Prior to the 2013 Energy Reforms, the State vertically-integrated utility, CFE, managed all aspects of the market, with the exception of some private "self-generation". Following the reforms, CFE maintains some generation operations, sector-wide transmission management, and the provision of power for residential users, but a new wholesale competitive market was established with an independent system operator, CENACE, to stimulate private sector investment and competition for the industrial sector. (EPSA Analysis).*



5.2.2 Governance entities, roles, and responsibilities

Under the new reforms, the primary governing entities in the Mexican electricity sector, and their current responsibility descriptions, are the following:

- **Secretariat of Energy (SENER):** The lead energy policy ministry in charge of designing Mexico's national electricity policy, with a mandate to guarantee competitive and sufficient supply of high-quality, affordable, and sustainable energy to the public. Is responsible for a number of specific areas, including the publication of the PRODESEN, oversight of the wholesale electricity market, oversight of other CFE activities, such as transmission development. SENER will also be responsible for establishing CEL criteria.
- **Regulatory bodies:** Both regulatory institutions have technical, operational, and management autonomy in their specific areas of expertise, and are responsible for a number of regulatory functions, including: the publication of acts, resolutions, directives, and regulations; conducting audits; issuing permits and authorizations, documenting inspections; and providing accreditation to third parties that conduct regulatory activities.
    - **Energy Regulatory Commission (CRE):** Responsible for oversight of the technical, operational, and management of the energy sector, including the midstream oil and gas sector, and the electricity sector. Includes regulation and development of transportation, storage, distribution, compression, gas liquefaction and regasification, retailing of fossil fuels and petrochemicals, electrical generation, transmission, and distribution.
    - **National Hydrocarbon Commission (CNH):** Responsible for regulation of the upstream oil and gas sector. Includes regulation and supervision of the exploration and extraction of hydrocarbons.
    - **The Safety, Energy, and Environmental Agency (ASEA):** Provides additional regulation and supervision of the hydrocarbon sector, with a focus on industrial safety and environmental protection.
- **The National Center for Energy Control (CENACE):** Formerly a part of CFE, CENACE was made an independent system operator of the national electric system. It has a mandate to guarantee impartial access to the national transmission and distribution grid and manage the wholesale electricity markets under conditions that "promote competition, efficiency, and impartiality, through optimal dispatch." It is also responsible for establishing expansion and modernization programs for national transmission and distribution infrastructure, when authorized by SENER.[296]
- **Secretariat of Environment and Natural Resources (SEMARNAT):** The primary environmental ministry, responsible for conservation, prevention and control of pollution, integrated management of hydro resources, and addressing climate change. SEMARNAT is responsible for Mexico's Climate Change Strategy, and issues reduction obligations for electric power industry.
- **The Energy Sector Coordination Council (CCSE):** A council to assist in the coordination between CNH, CRE, and SENER and other government ministries. The CCSE membership includes the head and undersecretaries of SENER, Presidents of the CRE and CNH, the Director General of CENEGAS, and the Director General of CENACE. [297]
- **National Commission for the Efficient Use of Energy (CONUEE):** a sub-agency within SENER, CONUEE promotes energy efficiency and serves as a technical body for the sustainable use of energy.[298]

5.2.3 Current Status

Although the reforms are still extremely new, and will continue to evolve in the coming years to fulfill regulatory and policy functions, the initial private sector and international response to the reforms is very positive, with interlocutors from governments, private sector, and academia acknowledging that the challenge is daunting, but Mexico's rapid implementation has been admirable.[299]

The country is already seeing results. Government plans for increasing generation capacity are shown in Figures 30-32. By switching from fuel oil to natural gas (primarily for the power sector), the consumption of fuel oil fell 47% in 2015 (in the January-September timeframe), compared to the same timeframe in 2013 (Figure 33). The government has also established plans to increase natural gas pipeline infrastructure to support additional natural gas imports (Figure 34), and current trends show imports have increased steadily since 2010 (Figure 35). As a result, December 2014 to December 2015, electricity tariffs have also fallen between 30-42% for industry and 13-27% in the commercial sector. The wholesale electricity market also began to operate in January of 2016, and renewable energy generation capacity increased by 7.6% from 2013-2014 alone. [300]

In accordance with a Constitutional requirement and a number of implementing laws (LIE, LSPEE), SENER is required to forecast energy demand present a (non-binding) Development Plan for the National Electric System (known by its Spanish acronym, PRODESEN). Updated annually, the latest PRODESEN was released in 2015. It details plans for new generation (60 GW by 2029 country-wide) as well as transmission expansion planning, including a general mention of studies exploring the diverse options to interconnect the national grid to Baja California and enhance interconnections with North America. SENER estimates that for 2015-2029, transmission system investments will require MXN $138 billion (USD $7.5 billion) in investments.[301] The Mexican government is also exploring the establishment of an East-West transmission line across Northern Mexico parallel to the U.S. border, with the objective of connecting industrial centers and facilitating cross-border flows.

Lower natural gas prices have continued to incentivize Mexico's transition from oil to gas for power generation. The future uncertainties in oil and gas prices could influence the pace at which oil-to-natural gas switching and renewable energy deployment takes place, as well as the business case for increasing cross-border electricity trade.

Commentary from power sector stakeholders

While most power sector stakeholders commend the Mexican government's efforts and many implementing regulations are still in development, some parties have noted challenges with the current structure specified by the reforms. Some commentators have pointed to CFE's "imperfect unbundling" -- its continued control over some aspects of transmission development and regulated residential users – as a potential distortion that provides it with considerable market power over new market entrants. Private sector entities, especially, voiced concern about certainty in transmission access. As elaborated in section 5.2.2, the current structure also relies on multiple ministries for many regulatory and planning processes, which will require extensive and complex inter-ministry coordination and communication for success. Others have noted that CFE's extensive and fungible workforce is likely to permeate CENACE and other relevant Ministries, causing a delay in those institutions' ability to establish of complete independence and a new workforce culture.[302]

Figure 31: Current generation capacity by State. While the Northern Mexican states have some of the lowest population densities in the countries, in part due to their large size, they also house significant industrial centers, resulting in some of the highest levels of electricity generation. [303]

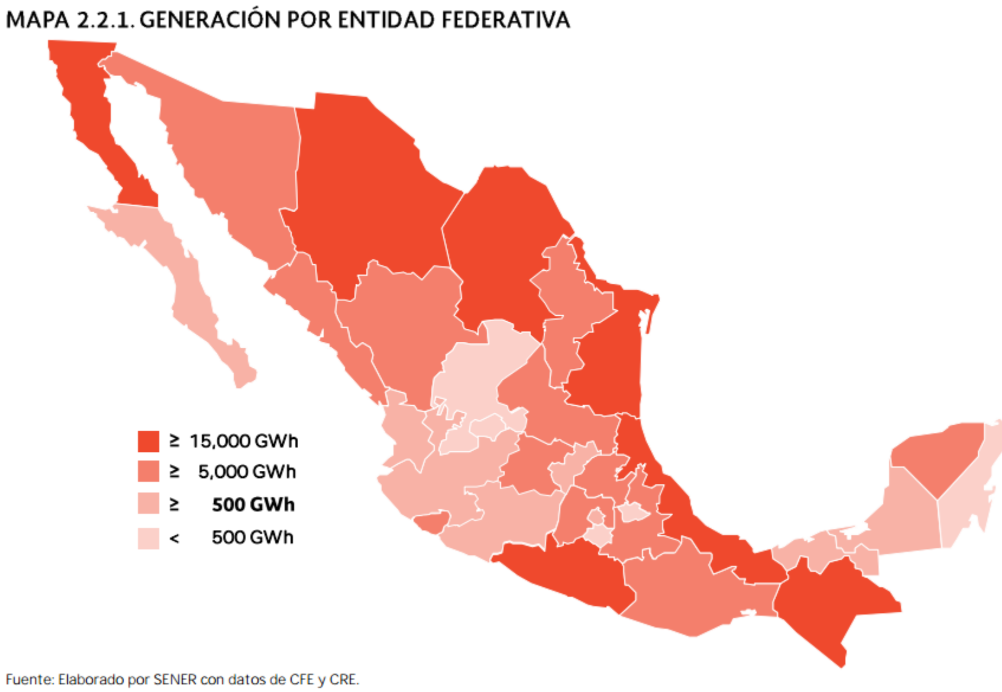


Figure 32: Planned generation capacity additions for 2015-2029 by State. The Mexican government estimates that approximately 60 GW of capacity will be required by 2029. Primary capacity growth is expected in Northern and Western states.[304]

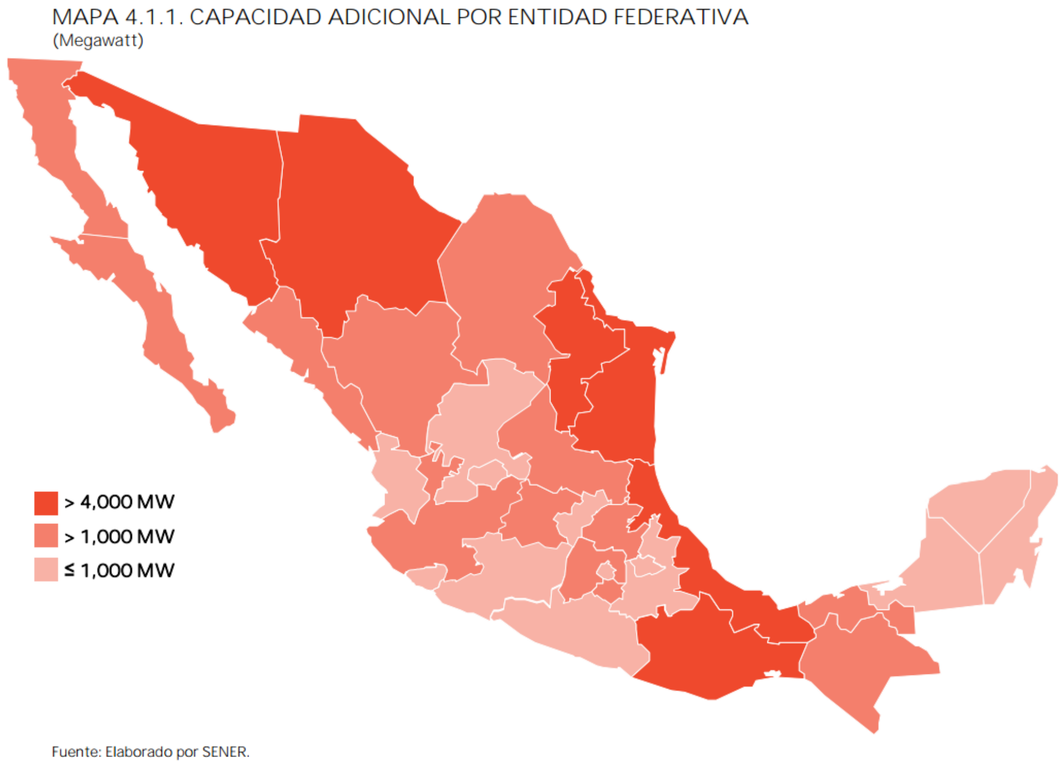


Figure 33: Distribution of marginal pricing estimated by transmission region (based on 2015 data). Transmission regions are colored based on percentile of marginal annual pricing, with green regions in the lowest 35%, yellow regions between 35%-65%, and red regions at 65% and above. The map for 2015 assumes a marginal pricing index based on the 2015 value; the 2020 map assumes the marginal pricing index will be reduced to 81.12% the 2015 index value.[305]

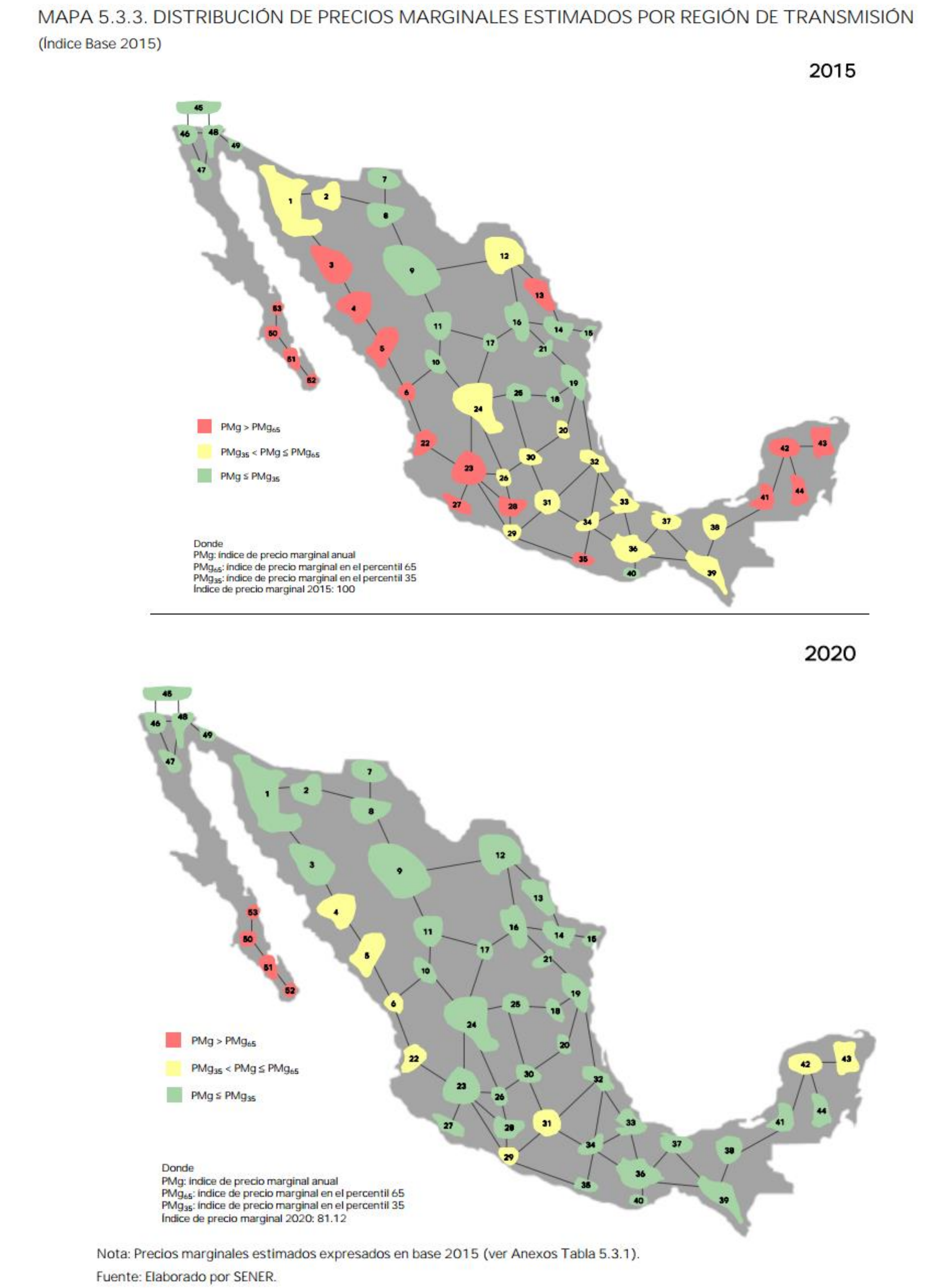


Figure 34: CFE's accounting of Mexico's consumption of fossil fuels for electricity generation.

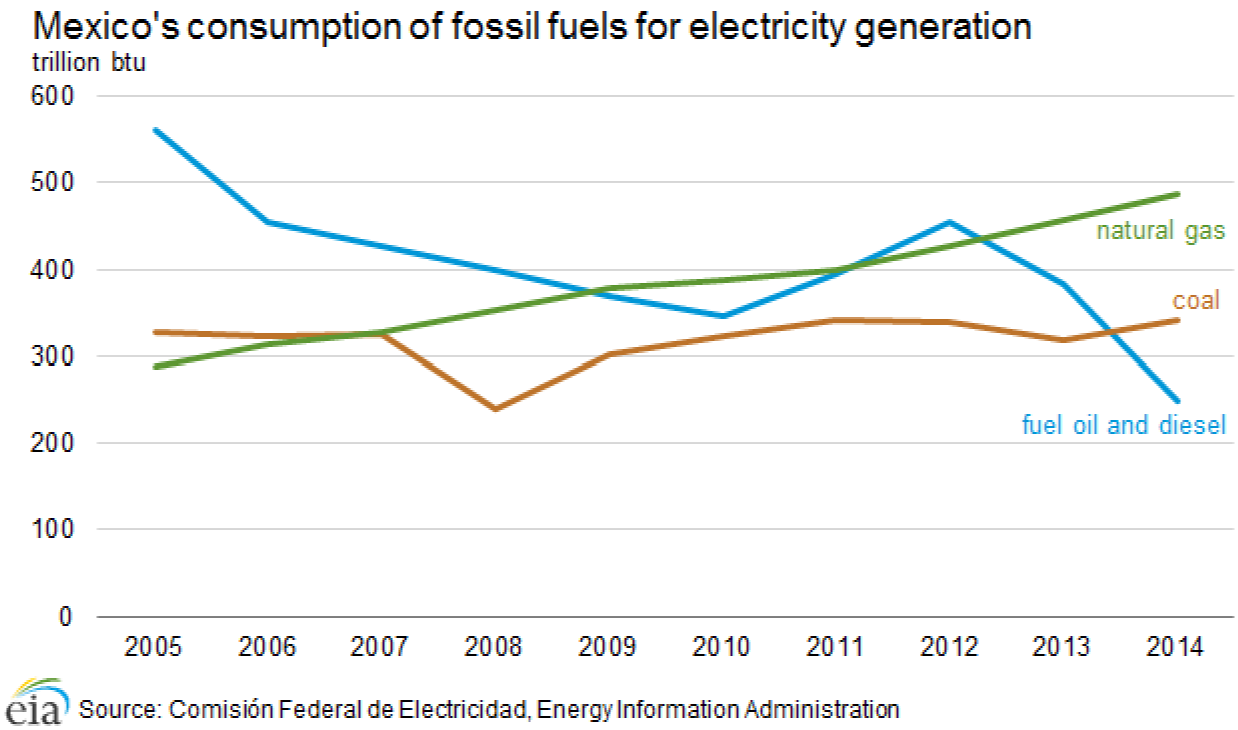


Figure 35: Natural gas transport infrastructure plans 2014-2018 (Source: SENER Presentation, Lourdes Melgar, Feb 2015)

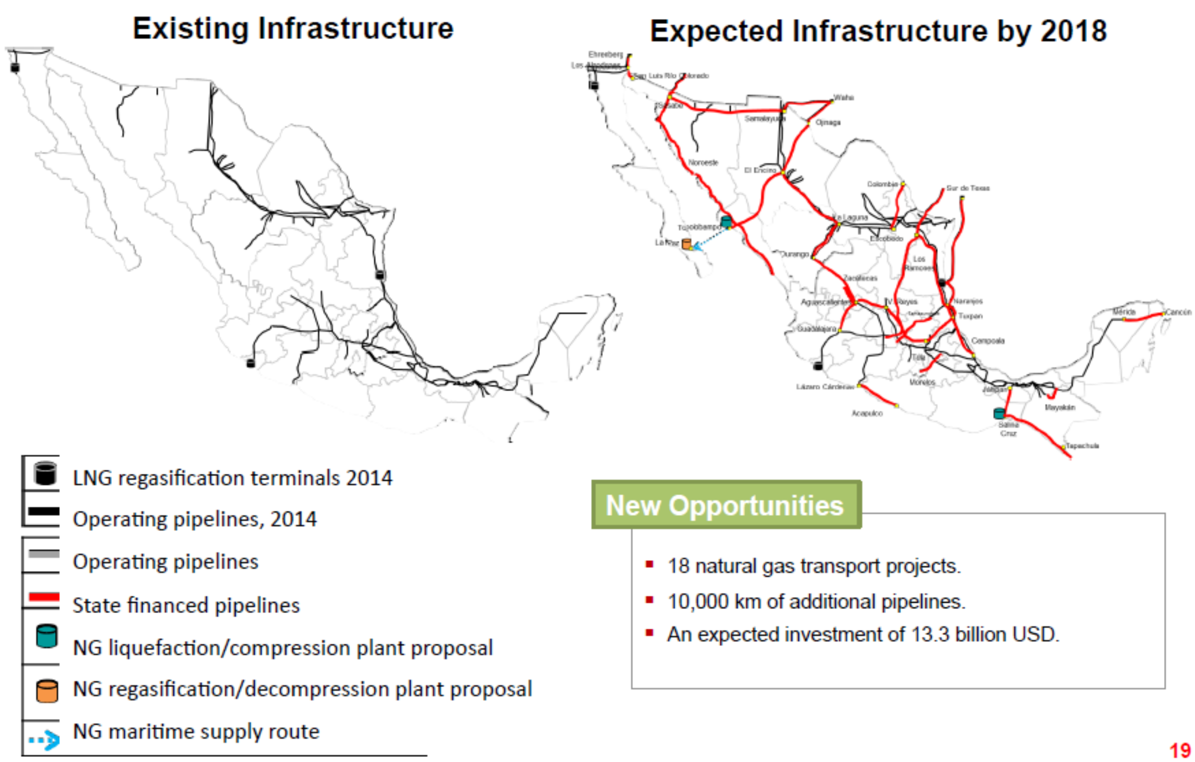
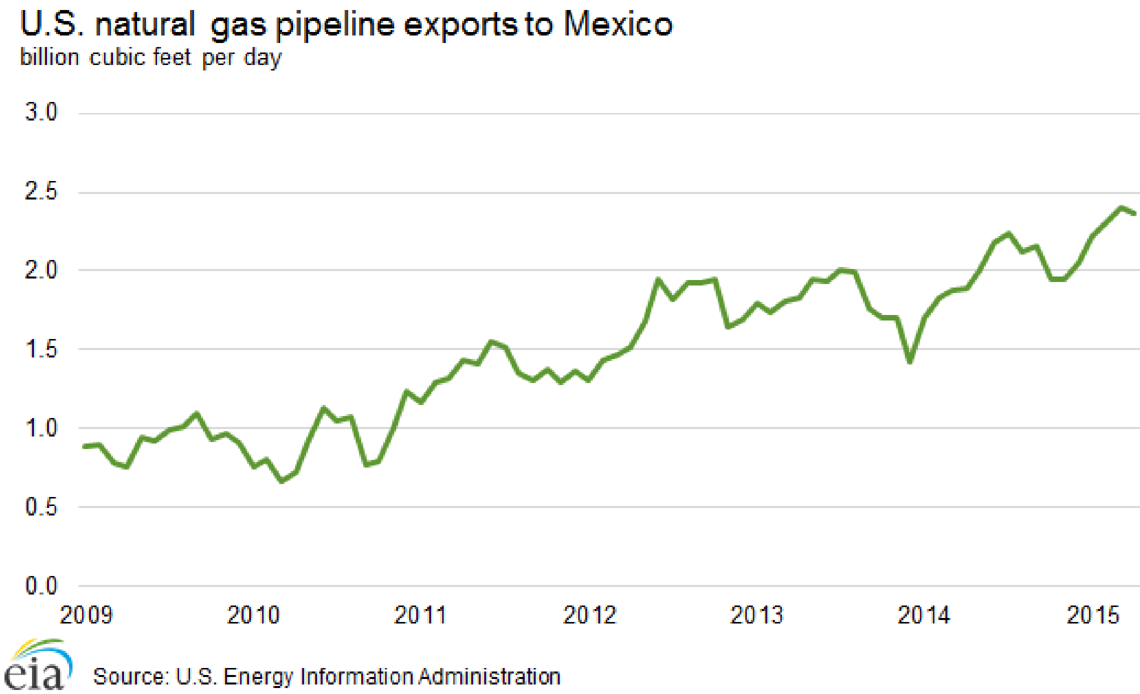


Figure 36: U.S. Natural Gas Pipeline Exports to Mexico (in billion cubic feet per day). The graph demonstrates the steady increase of U.S. natural gas exports to Mexico, roughly doubling from 2011 to 2015.



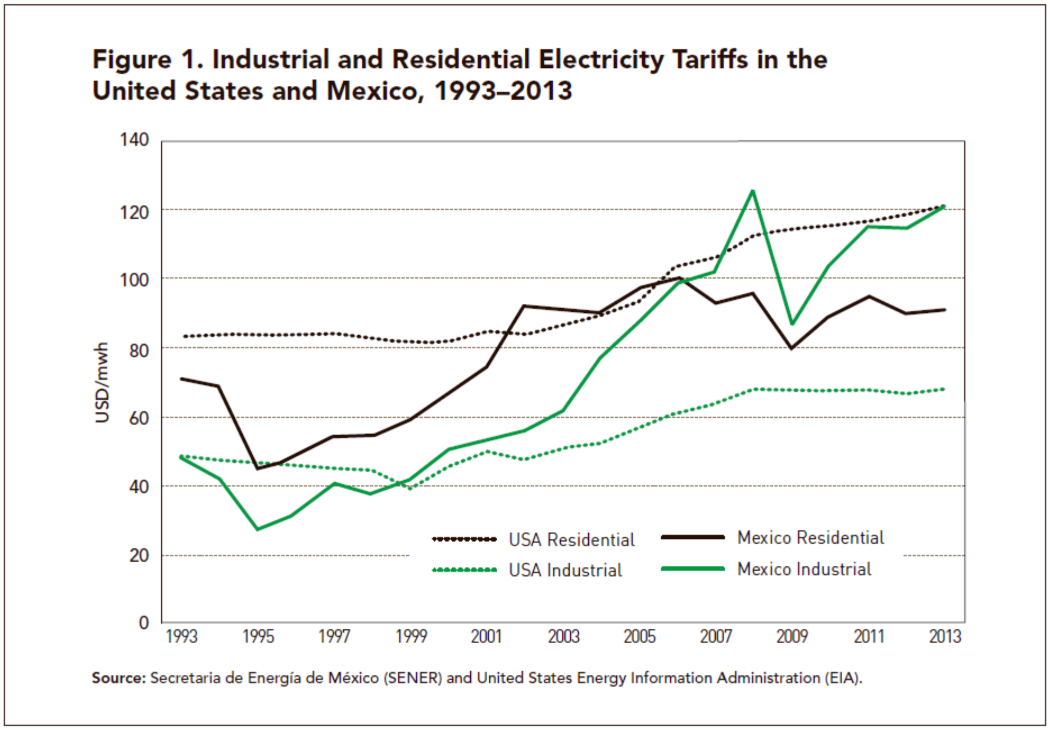
In a demonstration of international private interest, on March 29, 2016, Mexico held its first clean energy auction, which awarded 18 wind and solar projects, with a total capacity of 1,720 MW, in a round expected to generate $2.6 billion in investment. Mexico's Deputy Electricity Minister, Cesar Emiliano Hernandez, called the results "better than some of the most successful auctions in the world," and celebrating the participation of "top-level international companies".[306]

On integration, the Mexican government continues to express strong support for enhanced integration. Mexico recommends significant new transmission infrastructure in its PRODESEN, and Mexico's SENER continues to estimates that 6000 MW of new interconnections could produce net savings of USD$125-300 million per year on both sides of the border.[307]

5.3 The Economic Benefits of Reforms: the Mexican Industrial Sector

While cross-border electricity integration between the United States and Mexico could create impacts for all elements of Mexican society, the industrial sector has much at stake, and would directly benefit from greater access to natural gas and electricity. The industrial sector has a large economic footprint for Mexico: it employs a quarter of Mexican workers and accounts for 93 percent of Mexico's exports.[308, 309] The sector includes the significant manufacturing facilities in Northern Mexico that developed after the signing of NAFTA in 1994. In the six years from 1994-2000, Mexico also experienced an impressive average annual growth of 5.6 percent in manufacturing output, and exports increased from 15 percent of GDP (pre-NAFTA) to over 30 percent in 2012. Likely due to its access to the North American market, Mexico's northern states began to outperform the south economically, a trend that continued through the last two decades.[310]

Figure 37: Industrial and Residential Electricity Tariffs in the United States and Mexico, 1993-2013. In addition to the global rise in tariffs in both countries, the data indicate different strategies for electricity tariff-setting: while Mexico subsidizes residential rates relative to industrial rates, in the United States industrial rates are considerably lower than residential rates in the United States. U.S. industrial tariffs are also significantly lower than Mexican industrial tariffs, which has implications for the competitiveness of each sector.



Electricity and natural gas, critical elements for industrial production, are also two key factors limiting additional output growth in Mexico. Both are limited in terms of reliability and access – electricity prices alone in the industrial sector increased nearly threefold from 2002-2014.[311] An IMF white paper estimates that natural gas accounts for 35.8 percent of industrial energy consumption (measured by energy units), and electricity for 34.5%.[312] In the United States, a Manufacturing Energy Consumption Survey from 2010 reports that natural gas accounted for a similar percentage (35%), but electricity accounted for only 15% of energy consumption. Given the higher electricity rates in Mexico, this implies a relative reduction in Mexican industrial competitiveness.[313] A 2014 McKinsey report identified high and volatile electricity costs as one of the three primary barriers to further growth in the Mexican economy, noting that electricity costs 73 percent more for commercial users in Mexico than the United States, and that Mexico ranks 79 out of 144 countries in the World Economic Forum's rankings on the cost and quality of industrial electricity.[314] Additionally, while CFE provides generous subsidies for residential electricity, industrial electricity rates are not subsidized. The resulting gap between residential and industrial electricity rates is the opposite of the trend seen in the United States, where larger industrial consumers in competitive markets can access lower prices through economies of scale (Figure 36). As a result, electricity rates for any given "client category" have been nearly double for industrial producers in Mexico compared to the United States, lowering competitiveness and growth.[315]

5.4 Illustrative electricity trade statistics

In contrast to cross-border trade with Canada, U.S. electricity trade with Mexico is small and often irregular, representing a small fraction of U.S. electricity use (less than 0.01%) and approximately 100 times less than trade with Canada, which is reflected by the low levels of cross-border transmission infrastructure. Only three U.S. states trade electricity with Mexico (California, New Mexico, and Texas), and the power is not passed through to other states, as occurs with Canadian power in the Northeast. California trade with Mexico primarily takes place between Southern California and the Mexican Northern Baja California region, which also participates in the NERC Western Electric Coordinating Council (WECC). At lower voltage levels, a few asynchronous interconnections connect southern and western Texas and New Mexico with Mexico (Tamaulipas and Chihuahua states), and are primarily used for emergency power trades.[316] A map summarizing of cross-border interconnections is included in Figure 37. A full map of the Mexican grid system is in Figure 38.

Electricity trade statistics, which take place at nearly two orders of magnitude less than U.S.-Canadian trade, is shown in Figure 39, and regional-specific breakdowns of this trade are in Table 22.

5.5 Case Study: Export Opportunities for ERCOT

Even within the United States, the Electric Reliability Council of Texas (ERCOT) system is unique. In order to avoid federal regulation by FERC under the Federal Power Act, ERCOT has established a sector that avoids cross-border relationships, by maintaining all grid operations within the state of Texas, and interconnecting to the rest of the U.S. grid through a small number of asynchronous interties. [317] Though California and New York also have power grids fully contained within the state, they do not follow the same model: California relies on imports (in-state and international) for nearly a quarter of its power,[318] while New York engages in significant imports and exports with its neighboring ISOs.[319]

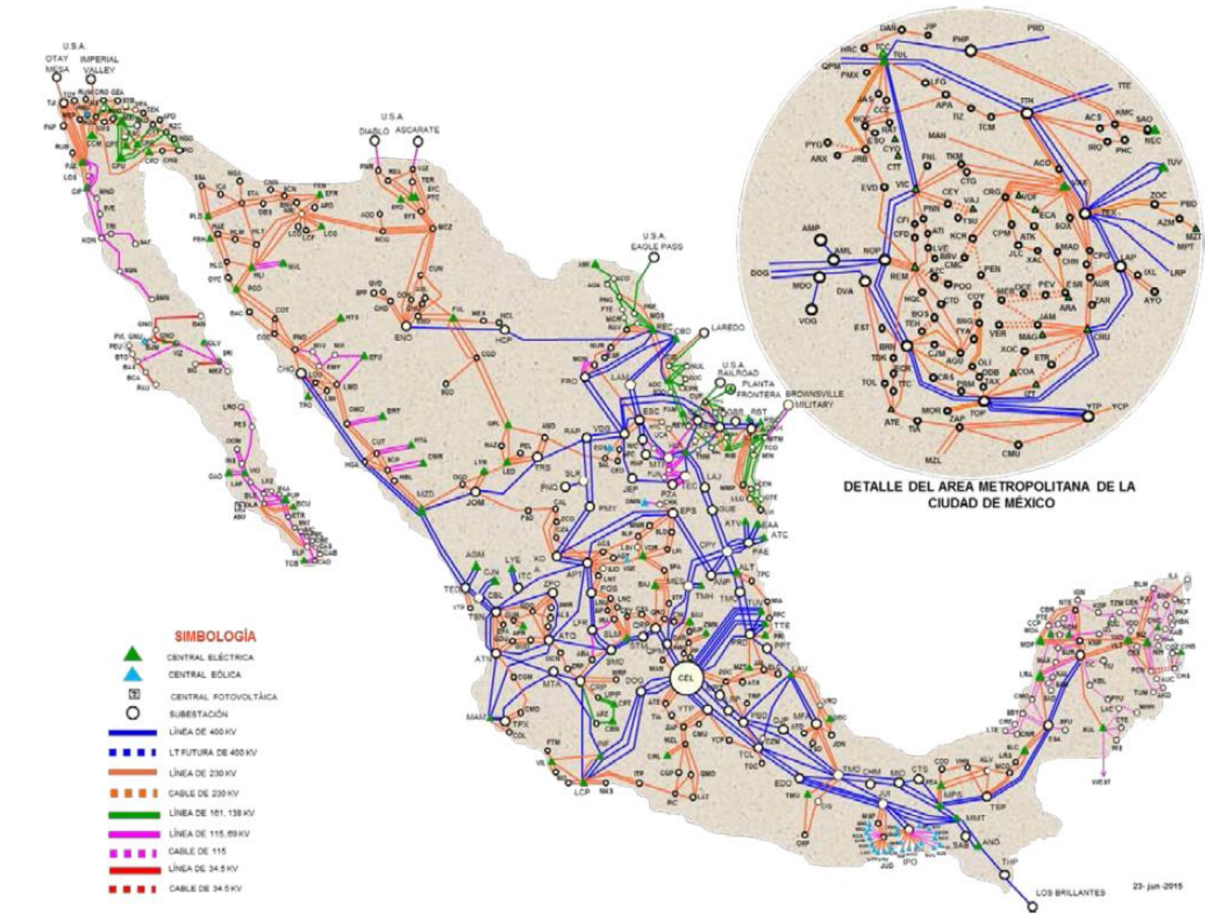
ERCOT's isolation from the rest of the U.S. grid, and resulting regulation under exclusively state authorities, is popular with the industry and some state lawmakers, and does prevent it from being vulnerable to cascading disruptions that originate out-of-state.[320] However, in times of stress, such as unexpectedly high or low temperatures, ERCOT forgoes access to some of the reliability benefits that could come from increasing power imports from its neighbors (including non-ERCOT Texas generators in El Paso, for example).

ERCOT does have a few small interconnections with Mexico, which are primarily used for commercial transactions or emergency power and do not trigger greater FERC regulation in the system: Eagle Pass (30 MW), Sharyland Railroad (150 MW), and Laredo Variable Frequency Transformer (100 MW) (also discussed in Section 3.2). Though ERCOT has found that Mexico's emergency power is not always available when requested,[321] the history of ERCOT-Mexico electricity trade suggests that Mexican imports were beneficial in a number of cases. Additionally, the significant price differential between ERCOT and Mexican electricity tariffs (electricity tariffs were estimated to be 74% higher in Mexico than in ERCOT in 20XX[322]) suggests a business opportunity for Texas generators.

Figure 38: Cross-Border transmission lines to Mexico, 2014. No 400 kV lines interconnect the United States and Mexico; larger (synchronous) interconnections exist between California and Baja California, while intermediate, asynchronous connections exist between Mexico and Texas. Two emergency 69/115 kV lines interconnect Mexico and New Mexico. (International Energy Agency, 2016)

Source: CENACE.

Figure 39: The Mexican electricity transmission system. (International Energy Agency, 2016)



Source: CENACE.

Figure 40: Electricity Trade between the United States and Mexico: Monthly cross-border electricity trade demonstrates that U.S.-Mexican trade is two orders of magnitude less than trade between the United States and Canada, but appears to be increasing in both directions from 2013 to the present. While Mexican exports to the United States were dominant from 2002-2005, bidirectional flows appear to become more balanced from 2013-2016. (EPSA analysis, data from CRE-CENACE)

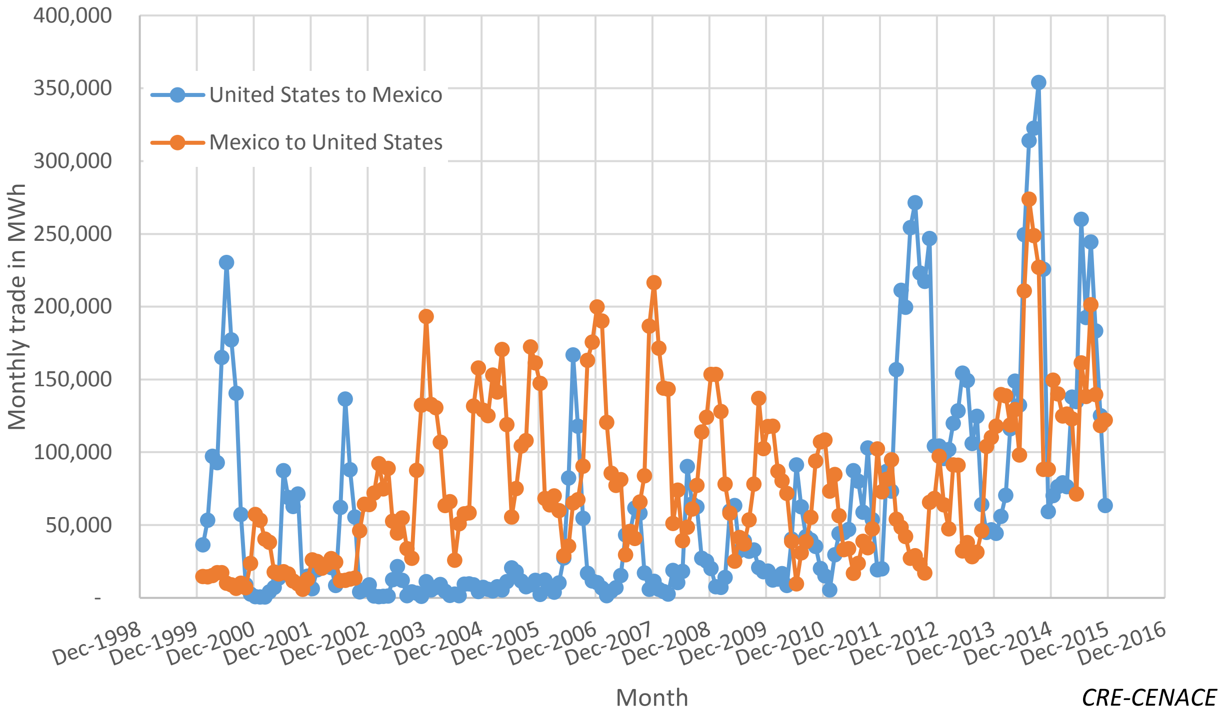


Table 22: Electricity Exports and Imports from Mexico by territory, 2004-2015. Primary trade takes place between Chiapas and Guatemala, Baja California and California (San Diego Gas and Electric, Arizona Public Service, Imperial Irrigation District, Sempra Energy Trading, CAISO), and Quintana Roo to Belize. Baja California trade with California was significantly skewed towards U.S. imports in 2014, but was nearly neutral in 2015. Trade with Texas (especially from Tamaulipas) is heavily weighted towards exports. (International Energy Agency, 2016)

Electricity Exports and Imports

State	(GWh)											
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Exports												
Chiapas [1]	0	1	2	2	3	22	349	504	231	204.4	508.7	361.2
Baja California [2]	770	1,037.00	1,072.00	1,211.00	1,197.00	984	830	600	643	792.7	1,897.90	1,575.4
Chihuahua [3]	0	0	0	0	0	0	0	0	0	0.1	0	0.0
Tamaulipas [4]	0	0	16	13	4	27	10	18	5	8.9	12.9	3.0
Quintana Roo [5]	236	253	209	225	248	216	160	170	238	233.9	233.2	255.0
Total	1,006.0	1,291.0	1,299.0	1,451.0	1,452.0	1,249.0	1,348.0	1,292.0	1,117.0	1,240.1	2,653.0	2,194.6
Imports												
Baja California [2]	39	75	514	266	340	280	221	261	341	494.6	5	1,410.4
Sonora [6]	6	6	6	6	6	6	6	4	3	2.8	1,704.4	2.5
Chihuahua [7]	2	6	3	3	3	3	3	59	278	9.3	1.1	1.1
Tamaulipas [4]	0	0	1	3	3	57	168	269	1,517.00	674.2	411	215.6
Chiapas [1]	0	0	0	0	0	0	0	3	30	28.9	2.6	20.4
Total	47	87	523	277	351	346	397	596	2,169.00	1,209.80	2,124.00	1,650.0
Trade balance	**959.0**	**1,204.0**	**776.0**	**1,174.0**	**1,102.0**	**904.0**	**951.0**	**696.0**	**- 1,052.0**	**30.3**	**529.0**	**544.6**

1/ Guatemala
2/ San Diego Gas & Electric, Arizona Public Service, Imperial Irrigation District, Sempra Energy Trading y CAISO (EUA)
3/ American Electric Power (AEP) (EUA)
4/ American Electric Power (AEP) y Sharyland Utilities (SU)(EUA)
5/ Belize Electricity Limited (BEL) (Belice)
6/ Trico Electric Cooperative, Inc y Unisource Energy Services (EUA)
7/ El Paso Electric Co , Rio Grande Electric Cooperative, Inc y American Electric Power (EUA)
Fuente: SENER with CFE data

The interplay of ERCOT's avoidance of FERC regulation and the opportunities relating to greater trade with Mexico are well-demonstrated by a recent case from the Lower Rio Grande Valley (LRGV) region (Figure 40). The LRGV region is one of the fastest-growing regions in the country – its population is currently an estimated 1.5 million, and is expected to grow by another 1 million by 2020. The region is also geographically clustered along the U.S.-Mexico border and isolated from neighboring population centers. As a result, current transmission and generation infrastructure is barely sufficient for the region's needs, straining reliability. [323] The peak demand in the LRGV was 2,300 MW in 2014, and is expected to grow to 2,900 MW by 2020. The region has approximately 2,300 MW of electric generation capacity available and two high-voltage transmission lines to provide 1,100-1,500 MW of transmission capacity for power imports (from elsewhere in ERCOT), and a 170 MW direct current line for sending power to or from Mexico.[324] Due to its low excess capacity, the region has experienced a large number of planned and unplanned electricity shortages in recent years, including a need to implement rotating outages in 2006, 2011, and 2014. ERCOT Director of Systems Operations, Daniel Woodfin, commented in 2014 that "until current efforts to increase transmission and generation capabilities to serve the growing Valley region are complete, even minimal unplanned outages during high electricity demand periods can create challenges."[325]

To compound these challenges, in 2014, the owners of one of the large LRGV natural gas facilities– Frontera Generators - announced plans to discontinue providing for the ERCOT market, and instead send power to Mexico, ramping from exporting 170 MW to the full 500 MW (over 20% of the LRGV's current generation capacity) in a few years. [326] Though ERCOT is already planning for new generation and transmission infrastructure to shore up the region's reliability, including two large transmission projects that are expected to be active in the summer of 2016, the request has important reliability implications. [327]

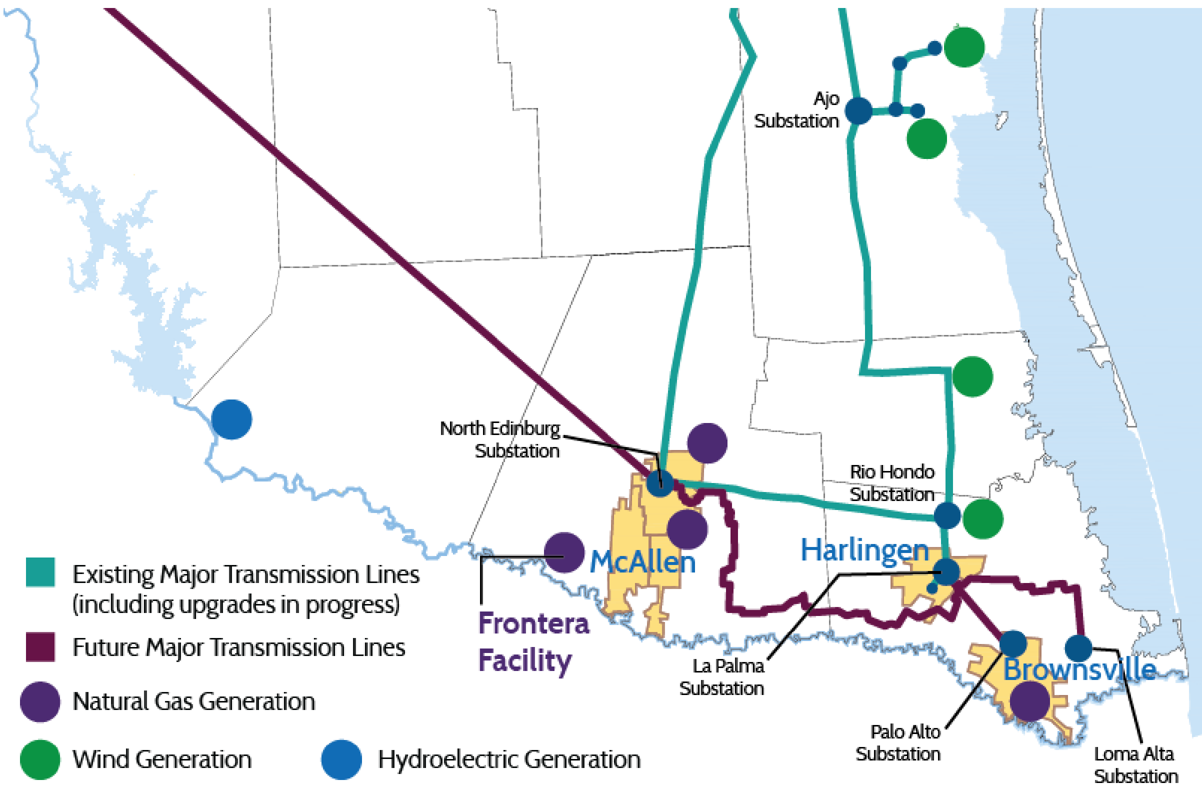
ERCOT studied the issue, and concluded that, though the ERCOT system could run without the additional capacity during normal circumstances, the loss of Frontera's capacity during emergency situations, especially prior to the completion of ongoing transmission projects, would cause reliability challenges in 2015-2016. According to ERCOT, the loss of Frontera's generation would also create the inability of ERCOT to comply with 2016 NERC reliability requirements.[328] Such concerns are also considerations for DOE's provision of a Presidential Permit for electricity exports. In the end, the solution was straightforward – ERCOT and Frontera worked together to agree on reliability safeguards needed to ensure Frontera's power is available if needed in an emergency, and those provisions were filed with the Department of Energy as part of the export authorization request.[329] However, it is not known whether additional companies in the future will be motivated to pursue similar economic opportunities.

In this example, the interconnection with Mexico can both compromise and strengthen reliability. Just as opportunities to trade power with Mexico may entice American generators to sell outside the ERCOT system, Mexico can also provide emergency power to prevent disturbances within ERCOT.

According to the author of the ERCOT analysis, in addition to economic growth and the increasing development of renewable energy, additional environmental regulations, such as the Clean Power Plan (CPP) and the Regional Haze Federal Implementation Plan (FIP), could lead to additional strains on the ERCOT system. ERCOT has flagged that the implementation of CPP alone would result in the retirement of 4,000 MW of coal generation capacity by 2022, while implementation of CPP and the Regional Haze Federal Implementation Plan would go further, including earlier retirements of coal and gas steam generation, by as much as 7,000 MW by 2030. [330] ERCOT also estimates both rulings would spur greater deployment of renewable energy, which would help the state comply with emissions requirements but result in a host of other challenges, including a shortage of sufficient transmission capacity, difficulty maintaining reliability, and rising electricity retail costs by as much as 18% by 2030.[331] ERCOT also estimates that approximately 143 miles of 345 kV transmission lines, 147 miles of 138 kV transmission lines, 39 miles of 69 kV transmission lines, and 11 transformers will be needed, implying significant new transmission infrastructure costs.[s,332]

As Mexico works to stabilize its supplies of natural gas, strengthen its own power sector, and finalize its energy reforms, the potential for U.S. generators to sell at a premium in the Mexican wholesale market and the potential for the Mexican market to provide reliability benefits to a burgeoning border region, may change the dynamic surrounding ERCOT's traditional policy.

Figure 41: Transmission plans for the Lower Rio Grande Valley Region



[s] ERCOT notes that as a general estimate, new 69 kV and 138 kV lines cost roughly one million dollars per mile and new 345 kV lines cost on the order of three million dollars per mile, and the timeline for new transmission projects to be planned, routed, approved, and constructed is approximately five years.

5.6 Case Study: Energía Sierra Juarez[t]: Cross-Border Renewable Energy for California's Rigorous Renewable Portfolio Standards

While cross-border trade between Mexico and Texas primarily focuses on emergency power and maintaining reliability, California's energy challenges are more deeply rooted in its assertive clean energy policies. In 2002, the State of California implemented (and subsequently strengthened) a rigorous Renewable Portfolio Standard (RPS) requiring that utilities ensure 33% of energy is derived from clean energy sources by 2020. This has had two main effects: first, it creates a business opportunity for renewable energy developers in Mexico that want to sell into the California market; second, it increases California's need for ancillary services to balance its increasingly variable energy mix, while reducing its ability to establish those services (which are often fossil fuel-derived) in-state.

The Baja California state of Mexico has low population density, a GDP per capita (USD$11,365) that is less than one-fifth that of California (USD$54,000).[333] It is also home to some of the best-known wind resources in North America. Cross-border trade is lucrative; outside of renewable energy development, there already exist projects in Baja California near Mexicali for exclusive export to the California market, including Intergen's 1,065 LNG plant, and Sempra's 600 MW LNG plant.

International developers are often interested in their projects' access to renewable energy incentives in other countries. The Energía Sierra Juárez (ESJ) project, managed by IEnova (the Mexican unit of Sempra Energy), is the only example of a completed renewable energy project that qualifies for in-state renewable energy incentives; in this case, California's Renewable Portfolio Standard. The ESJ project is a multi-phase wind project in the Sierra Juárez mountain range, a region that boasts some of the strongest wind resources on the west coast of North America (Figure 41). Phase I of the project, which installed 155 MW of capacity (47 turbines of 3.3 MW each) with a USD$300 million investment, came online on June 9, 2015. The ESJ project would establish a total capacity of 1,200 MW of wind power when all phases are complete, all for export to San Diego Gas and Electric (SDG&E), which is also a Sempra company.[334] The project is located in the Mexican Baja Peninsula, in a small Mexican region that is well-connected to the California grid but not connected to the main CFE-managed federal grid, and which is the only portion of Mexico that complies with the Western Interconnection's (WECC) NERC standards. Baja California's deep integration with the State of California is such that it has considered formally joining CAISO, though these discussions were largely stalled by the Mexican energy reforms.

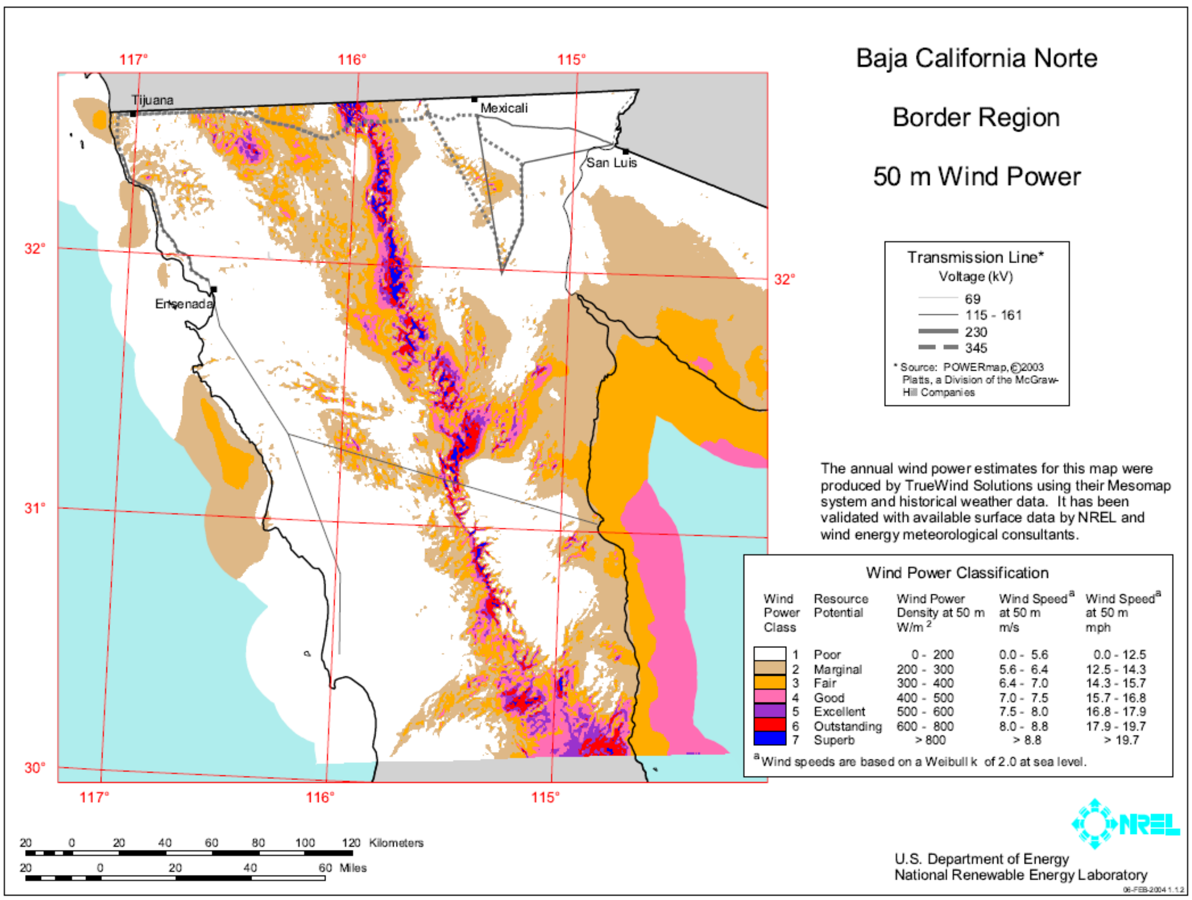
The Energía Sierra Juárez (ESJ) project included the construction of a new transmission line that interconnects it directly with the Southwest Powerlink transmission system at SDG&E's East County (ECO) substation east of San Diego. Given Baja California's complete grid isolation from the rest of the Mexican power system, the ESJ project does not connect to the rest of Mexico, although the company appears to be open to that possibility for the future,[335] and the Mexican government has stated an intention to connect the Baja region to the rest of Mexico's federal grid in the near future.

As in the Northeast United States, a key challenge for building cross-border projects in the California-Baja region is transmission infrastructure. Transmission limitations exist on both sides of the border: in Mexico, there is limited transmission infrastructure to move power to California, and once in California,

[t] DOE's approval of Presidential Permit No. 334 for the ESJ electrical transmission line is being challenged in federal district court. Plaintiffs alleged that DOE violated NEPA, the Endangered Species Act, the Migratory Bird Treaty Act, and the Bald and Golden Eagle Protection Act. DOE has to date prevailed on all claims, with the exception of two NEPA claims, one on which the court ruled in plaintiffs' favor, and the other of which remains pending.

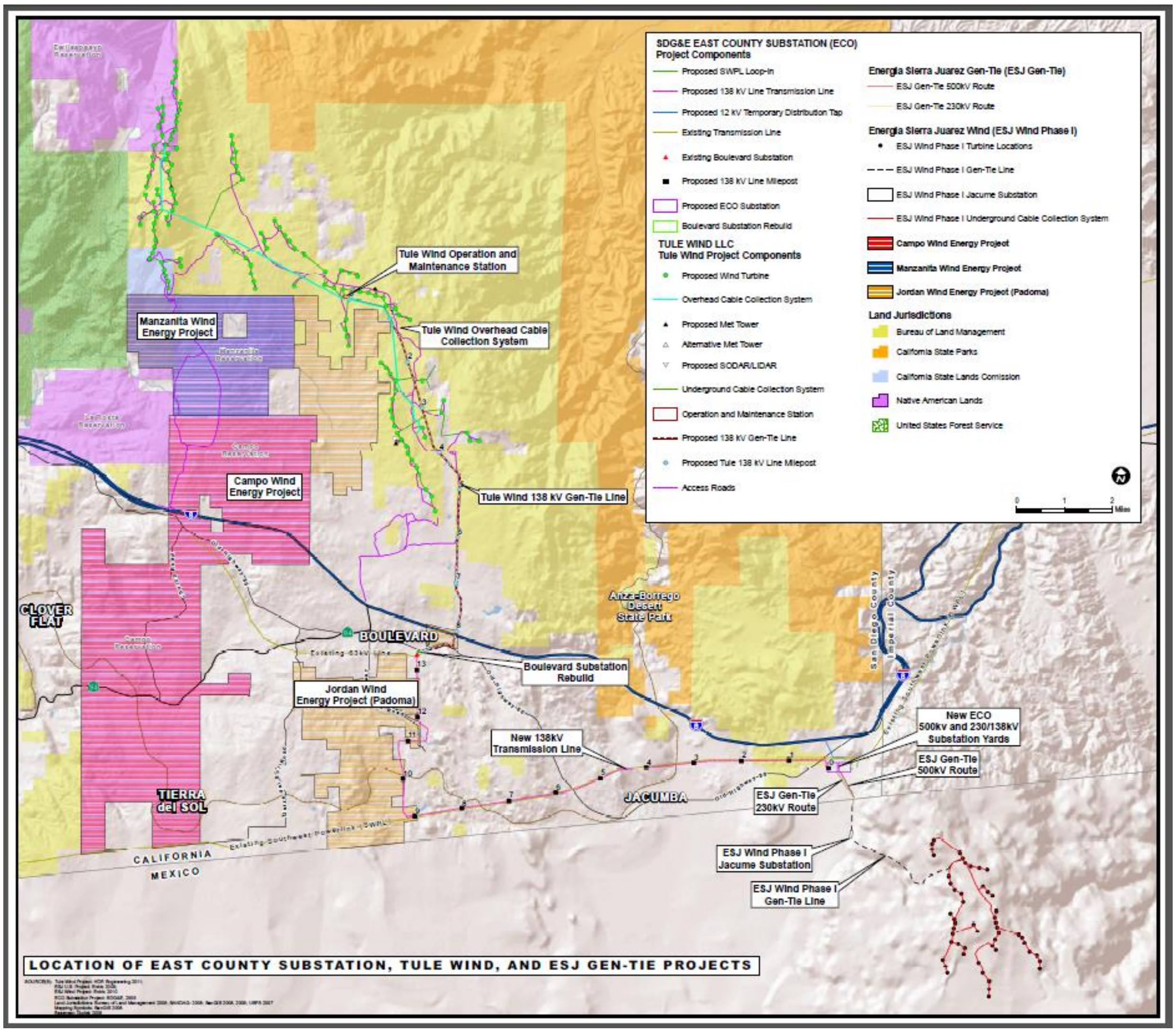
there is congestion on the lines required to move power to urban centers. Within the Mexican federal grid (i.e. everything except Baja California), all transmission lines are owned by CFE; on the California side, they are owned by SDG&E. Developers in the Baja region that want to export to California's sizeable market have two main choices: to construct a transmission line directly to the California grid, or to connect to one of two 230-kV lines jointly referred to as Western Electricity Coordinating Council Path 45, which are owned on the Mexican side by CFE and connect to the Southwest Powerlink in the Imperial Valley. While the second option has 800 MW of capacity, most of which was largely unused in 2009, the transaction with CFE would require the company to acquire an export permit from the Mexican government and pay wheeling charges.336 Like the Sempra and Intergen LNG plants, the ESJ project opted instead to establish its own, direct interconnection into a SDG&E substation on the California grid, bypassing the regulatory requirements of the Mexican government, but assuming the responsibility for construction of the line itself. The ESJ connection line, known as Energia Gen-Tie, is under a mile in length.

Figure 42: Mapping Wind Resources in the Northern Baja Peninsula of Mexico: the figure shows a strip of "superb" wind resources in the Northern Baja region. The Energia Sierra Juarez project is located on the wind corridor, very near the 116° latitude, one mile from the U.S.-border. (NREL)



Sempra applied for a Presidential Permit to export power to the United States for the first Phase of the ESJ project on June 13, 2012, and received approval on August 19, 2014. The State of California allows imported energy to qualify for its RPS, as long as the producer is deemed to comply with California's environmental standards through a certification process. Records from the State of California show that as of 2016, the ESJ project was the only project in Mexico that had received such a certification.

The planning for the full-phase ESJ project development, along with other renewable energy developments in California, led to cascading infrastructure needs within California, especially relating to transmission capacity. The ESJ project, together with a number of other wind projects (the 201 MW Tule project in Southeastern San Diego Country, as well as the Campo, Manzanita, and Jordan wind energy projects), were considered significant factors in the need to construct a new substation, ECO, under a mile from the ESJ Phase I Jacume Substation (Figure 42). The California Public Utility Commission and Bureau of Land Management considered the ESJ and Tule projects to be so closely related to the ECO substation project, that they considered them "connected actions" under National Environmental Policy Act (NEPA) and "whole of action" under the California Environmental Quality Act (CEQA).[u] The ESJ project may have also been a contributing factor in the construction of the Sunrise Powerlink, a $1.9 billion 500 kV transmission line built by SDG&E from the Imperial Valley Substation to the Sycamore Canyon Substation in San Diego County, which was completed in 2012, in spite of significant opposition and controversy. Figure 43: Transmission infrastructure near the ESJ project. Significant other renewable energy investments in the region have led to a need for greater transmission capacity. (CPUC)



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[u] The project included included the construction of a 500/230/138-kilovolt substation in Eastern San Diego County, a loop-in to the Southwest Powerlink line, the construction of a 138 kV transmission line between the ECO substation and Boulevard Substation, and the rebuilding of the existing Boulevard Substation. (CPUC, n.d.)

As discussed in section 3.6, local stakeholder engagement is of importance for all forms of energy development. Small communities in California have complained about the visibility of ESJ turbines from their Californian rural communities, and voiced concerns about the environmental effects of the ESJ projects.[338] However, it is probable that the location of the ESJ project in Mexico expedited development. Sempra Energy Group chairman Don Felsinger was quoted saying that the 600 MW LNG plant that operates near Mexicali took "only six months to license… in California, it would have taken two years."[339] The relative ease of permitting the project in Mexico was likely due, in part, to the less consultative policies that exist in Baja California relative to California,[v] as well as the sub-region's low economic development, which feeds a higher appetite and tolerance for infrastructural projects.

[v] Mexican law does not have provisions for opposing infrastructural development based on the infrastructure's visibility or potential to "ruin the view"; a common complaint for cross-border communities in California.

6. North America Climate and Environmental Policies

Cross-border electricity integration is not guaranteed to be a tool that will enhance climate commitments, but with specific, well-designed policies and project developments, it could provide significant benefits. It is generally understood that cross-border integration could be a valuable tool for governments to achieve climate goals if integration leads to:

- Stronger commitments for climate emissions reductions;
- An increase in the deployment of clean energy;
- A reduction in the deployment of high-emitting energy; or
- A reduction in energy demand (such as through energy efficiency).

However, if integration enhances the deployment or slows retirements of fossil fuel-fired generation, or leads to significant increases in demand (such as by causing a boom in the Mexican industrial sector), such development could increase emissions.

The Administrations of Canada, Mexico, and the United States have all made strong statements on a desire to cooperate to further their individual climate commitments,

6.1 Climate Commitments of Canada, Mexico, the United States

Prior to the November 2015 21st Conference of the Parties in Paris, all three countries announced "Intended Nationally-Determined Contributions" (INDCs), summarized in Table 23. Even before that, back in 2009, all G8 countries committed to cut their GHG emission 80% below 2005 levels by 2050. Each country's ability to achieve their respective INDCs will depend on subsequent policies. In Canada, in particular, provincial-level implementation is critical to success. Current trajectories for emissions for each country are included in Figures 43, 44, and 45.

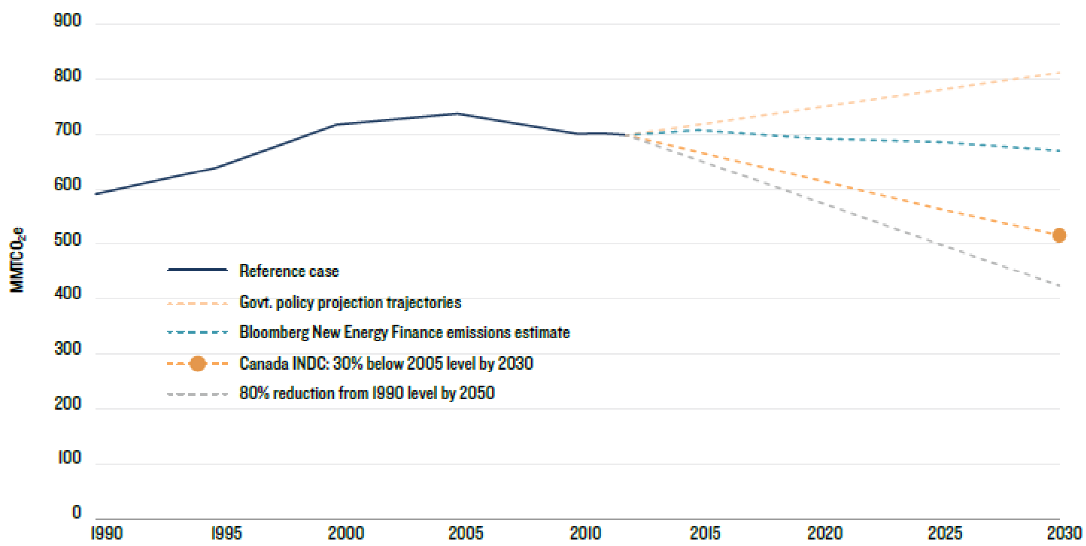
Table 23: Nationally Determined Contributions: A summary of Nationally-Determined Contributions (NDCs) of the three countries. [340]

	Mexico	Canada	United States
NDC	25% reduction in all GHG (22%) and black carbon emissions (3%) by 2030 compared to 2030 emissions predicted under 2013 BAU emissions[341]	30% reduction from 2005 levels by 2030	26-28% economy-wide reduction of GHGs below 2005 level by 2025[342]
Peak emissions information	Net emissions peak by 2026	Canada is currently on a path to increase emissions through 2030, but to meet their G8 commitment would need to cut emissions	Reached

		38% below 2005 levels by 2030	
Other features	Reduction in emissions intensity per unit of GDP of 40% from 2013 to 2030. Also proposed to conditionally reduce emissions by up to 40% by 2030, contingent on certain requirements for global agreements and international support	The new Government of Canada formally met with provinces & territories on March 2-3, 2016 and established a framework for setting a national target & policies for climate change reductions this year.[343, 344] At COP21, Canada's new Prime Minister pledged $1.98 billion U.S. dollars to the Green Climate Fund	The U.S. will make a best effort to reduce emissions by 28%. Long-term path to 80% reductions by 2050.
INDC Submission Date	March 27, 2015	May 21, 2015	March 31, 2015
Domestic federal law for implementation	General Climate Change Law	Currently no federal law for implementing; see Table 24 for complete list of Canadian provincial actions	Clean Air Act (including actions under sections 111b and 111d to cut carbon pollution from new and existing power plants), Energy Policy Act, Energy Independence and Security Act

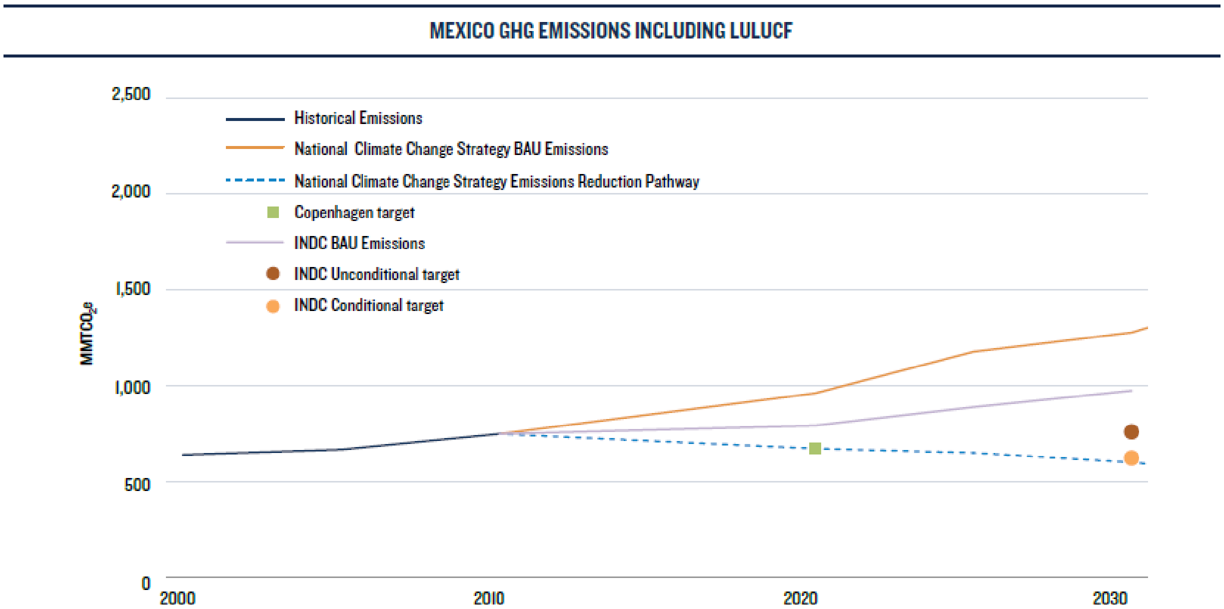
Figure 44: This figure from Natural Resources Defense Council was prepared in advance of the Paris COP21 meeting to demonstrate Canada's targets for GHG reductions as set out the Intented Nationally Determined Contributions. Though Canada's NDC does take it significantly below BAU projections from 2015, according to this source, Canada will not come close to reaching their mid-century commitment to an 80% economy-wide reduction on that trajectory.

CANADA GHG EMISSIONS



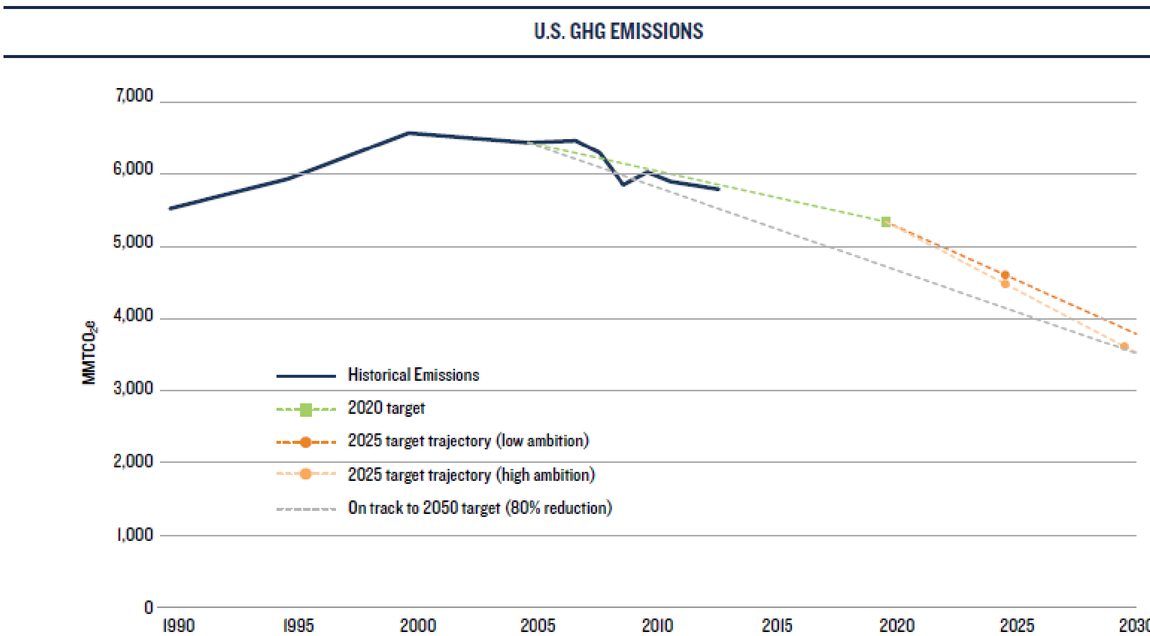
Source: Natural Resources Defense Council, based on Envrionment Canada's report "Canada's Emission Trends 2014", Bloomberg New Energy Finance and Canada's INDC submission to the UNFCCC.

Figure 45: This figure from Natural Resources Defense Council was prepared in advance of the Paris COP21 meeting to demonstrate Mexico's targets for GHG reductions as set out in its Intented Nationally Determined Contributions and domestic National Climate Change Strategy. According to this source, Mexico will need to enhance its national climate change policies to reach its INDC emissions target.



Source: Natural Resources Defense Council, based on Mexico's "National Climate Change Strategy 10-20-40 Vision" and INDC submission to the UNFCCC.

Figure 46: This figure from Natural Resources Defense Council was prepared in advance of the Paris COP21 meeting to demonstrate the U.S. targets for GHG reductions as set out in its Climate Report to the UN from Copenhagen and its Intented Nationally Determined Contributions. According to this source, the 28% reduction target is consistent with a straight line emission reduction pathway from 2020 to emission reductions of 80% or more by 2050.



Source: Natural Resources Defense Council, based on data from the US Climate Action Report to the UN (2010) and US INDC submitted to the UNFCCC (2015).

6.2 Reduction Mechanisms for Carbon Emissions

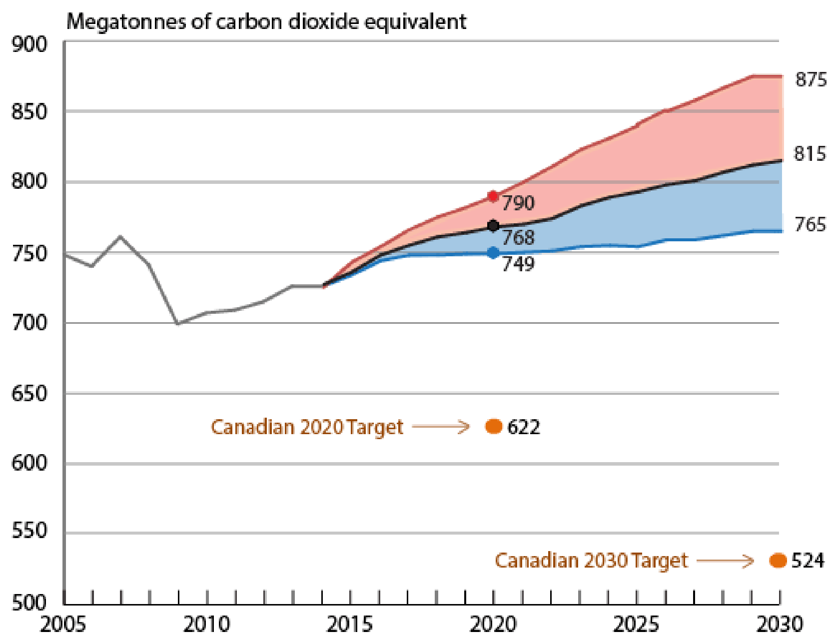
For countries that want to reduce emissions, there exist a number of different policy mechanisms, including source-specific emissions performance standards, carbon taxes, and market-based cap-and-trade (C&T) emissions systems. While market-based C&T mechanisms are generally recognized as one of the most economically efficient strategies to reduce emissions (REF), the relative strength of each policy depends on their implementation, rigor, and specific context. In addition, emissions trading can be a component of all three policy mechanisms, and can increase compliance flexibility, reduce costs, and incentivize new technologies. Examples of GHG reduction policies from all three countries are described below.

6.2.1 Clean Energy and Climate Change Policies: Canadian Provinces

As stated in Table 23, Canada's INDC calls for a 30% reduction of economy-wide emissions by 2030 compared to 2005 emissions levels.[345] This reduction targets also calls for a sector-by-sector regulatory approach to reduce emissions in a cooperative action with the United States. Under the INDC, Canada will ban construction of new traditional-coal fired generators and accelerate the phase-out of existing coal plants. Other actions include: establishing a common North American GHG standards for vehicles coordinated with the United States, regulation of HFC emissions and oil and gas methane emissions, and programs to reduce emissions from natural gas generators and from chemical and nitrogen fertilizer manufacturers.[346]

The Government of Canada presents slightly less optimistic projected greenhouse gas (GHG) emissions than the Natural Resources Defense Council (Figure 43), as shown in Figure 46. These projections include different assumptions for oil and gas prices and economic growth factors along with climate measures enacted as of September 2015[347]. Canadian GHG emissions are projected to be much higher than climate goals with current policies, representing a need for new policies and strategies to reduce emissions while maintaining economic growth.

Figure 47: Historical and Projected Greenhouse Gas Emissions with Measures as of September 2015 - Canada, 2005-2030 [348]



The federal government's limited jurisdiction over provincial energy sectors implies that Canadian provinces must act as the implementers of climate emission reduction policies – a point that was underscored by the fact that Premiers from eight of Canada's ten provinces and two of three territorial leaders accompanied the Primate Minister to the Paris COP 21 conference. On March 3, Prime Minister Trudeau met with provincial and territorial premiers to establish a broad strategy to develop a "pan-Canadian framework on clean growth and climate" by early 2017, in order to meet and exceed Canada's commitment to reduce GHGs by 30% from 2005 levels by 2030. Many provinces already employ a variety of policies to reduce emissions; however, Environment and Climate Change Canada forecasts that, under current measures, Canada's emissions in 2030 would be at least 765 megatons, 46% above the 524 megatons target. While the meeting was deemed successful in its accordance on the importance of a shared strategy and the need to do more, the details of how such a strategy would be achieved were not specified The Vancouver Declaration, which was signed on the same day, noted that pricing carbon may be part of the solution.[349]

However, though the federal government does not have the constitutional authority to regulate industrial emissions within provincial borders, it does manage transboundary issues, which includes atmospheric emissions. As a result, under the government's Taxation Power, parliament does have the authority to impose a carbon tax on the production or consumption of energy – a federal excise tax already exists on gasoline and diesel fuel.[350] At the Vancouver meeting, the Prime Minister committed to having a federal climate change strategy by the end of 2016.

Specific initiatives in certain key Canadian border provinces are described below (a full summary of all Canadian provincial plans is included in Figure 47 and Table 35):

- **British Columbia**: In 2008, British Columbia became the first province (or state) in North America to establish a carbon tax. The carbon tax is considered "revenue neutral" in that it was accompanied by reductions in other taxes elsewhere, and it was increased incrementally every year until 2012. Keeping with its Climate Change Strategy, which aims to reduce GHG emissions by 33% below 2007 levels by 2020, the tax applies to nearly all fossil fuel use (gasoline, diesel, propane, natural gas, and coal), covering 77% of the provinces emissions from residential, commercial, and industrial sources. Since its re-election in 2013, the current British Columbia government has moved more cautiously on climate policy, and established a Climate Leadership Team to move towards and updated policy, which is set to be enacted in 2016.[351] While the carbon tax regime was controversial at the time, it has since been considered a "textbook" success – it reduced British Columbia's consumption of affected fossil fuels by 19% while keeping economic pace with the rest of Canada.[352,353]

- **Alberta:** In 2007, Alberta, the largest fossil-fuel producing province in Canada, established a mandated performance standard for companies that emit over 100,000 tons of GHG annually to reduce emissions intensity by 12 percent (to be raised to 15% and 20% in 2016 and 2017, respectively) or pay into a technology fund, creating a kind of "simulated" carbon pricing.[354,355] However, the new New Democratic Party Administration in Alberta recently increased requirements significantly, with a carbon pricing policy that will apply to 78-90 percent of total provincial emissions. The new approach, which will begin on January 1, 2017, will require a carbon price (starting at $20/ton in 2017, $30/ton in 2018, then face real-term increases in the following years), an emission performance standard, pricing of emissions from transportation and heating fuels, and the reinvestment of carbon pricing revenue into pollution reduction measures. [356,357] The new climate change plan includes calls for the replacement of two-thirds of coal-fired electricity generation with renewables, and the elimination of coal-fired electricity emissions by 2030 – a significant source of emissions, coal currently provides more than 40% of Alberta's electricity.[358]

- **Saskatchewan:** Saskatchewan relies heavily on coal, which provides 44% of the province's electricity, and it has been concerned about compromising economic growth in the pursuit of climate objectives. The Management and Reduction of Greenhouse Gases Act of 2009, which regulates emissions from large emitters and collects a carbon compliance payment for violators, does not include the oil and gas sector. Saskatchewan has instead focused its support on opportunities relating to carbon capture and storage technologies, including at the Crown Corporation SaskPower's Boundary Dam 3 Project. [359]

- **Manitoba:** In 2008, Manitoba enacted the *Climate Change and Emissions Reductions Act*, which provides governments with the authority to use market-based approaches and economic/financial instruments to reduce emissions. While no carbon price is currently in effect, Manitoba has expressed an interest in joining the Western Climate Initiative's Quebec-California carbon market.[360]

- **Ontario:** Ontario recently took strong steps to eliminate coal-fired electricity generation plants, a goal that was achieved in 2014, followed by legislation permanently banning its use in November of 2015. The government is currently enacting regulatory measures to enable its entry into the Western Climate Initiative Carbon Market with Quebec and California, including efforts to implement a C&T system by January 2017, for linking with California/Quebec markets by 2018.[361]

- **Quebec:** Quebec has established aggressive emissions reductions targets, especially for a system in which the electricity portfolio is already largely renewable: a 37.5% GHG emissions reduction below 1990 levels by 2030.[362] This will primarily be achieved through a C&T system for carbon emissions system, established in 2013, which applies to businesses that emit 25,000 metric tons or more of carbon dioxide equivalent a year. From 2013-2014, only industrial and electricity sectors were required to comply with the system, but as of 2014 fossil fuel distributors are also subject.

Canada has nationally committed to other climate actions outside of measures announced in the INDC. These include, but are not limited to:

- Pledging CA$2.65 billion over five years in climate finance to support developing countries. This commitment represents a doubling of fast-start financing levels compared to previous commitments[363].
- Organizing a pan-Canadian conference to establish a national framework on climate goals and ensure that provinces have resources available to achieve climate goals[364].
- Endowing a CA$2 billion Low Carbon Energy Trust to finance projects that reduce carbon emissions[365].
- Phasing out subsidies for fossil fuel producers[366]
- Participating in the Commission of Environmental Cooperation with the United States and Mexico to identifying areas of collaboration on climate change adaption and mitigation[367].

Figure 48: Summary of Climate actions in Canadian Provinces.

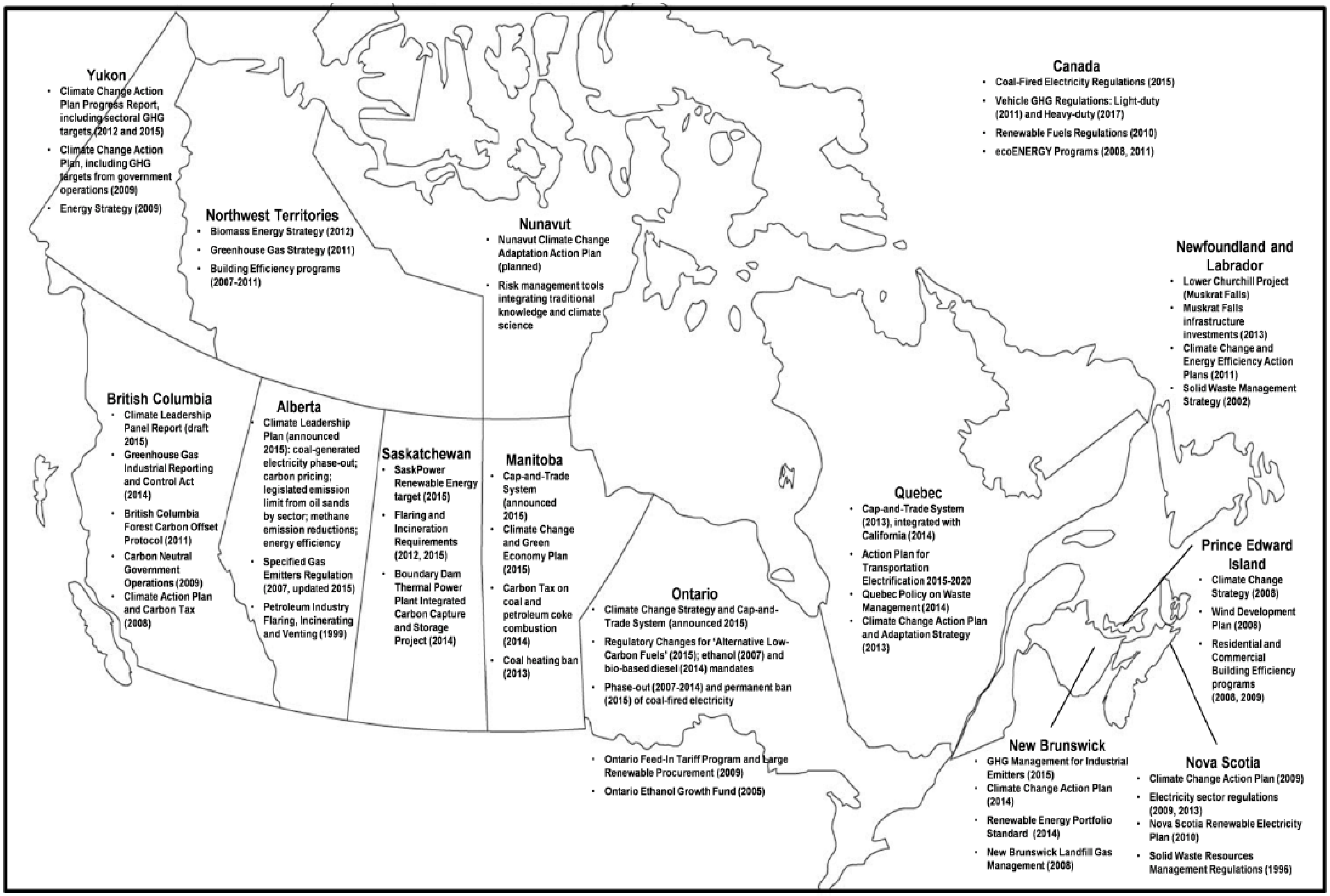


Table 24: Summary of Canadian Provincial Climate Commitments and Implementing Policies.

Province	Emissions Reduction Commitments	Current Implementing policies	Upcoming Changes
Alberta		"Simulated carbon pricing": companies that emit over 100,000 tons of GHG annually required to reduce emissions intensity by 12 percent (to be raised to 15% and 20% in 2016 and 2017, respectively)	Transitioning to a carbon pricing scheme January 1, 2017. Carbon price will start at $20/ton in 2017, $30/ton in 2018, then face real-term increases in years following
British Columbia	Reduce GHG emissions by 33 percent below 2007 levels by 2020.	Carbon tax, applies to nearly all fossil fuel use (gasoline, diesel, propane, natural gas, and coal), covering 77% of the provinces emissions from residential, commercial, and industrial sources.	
Manitoba		2008 Climate Change and Emissions Reductions Act enables financial instruments and market-based approaches to reduce emissions. Emissions reduction target exists, but no carbon price in effect.	Government will announce new Green Plan.
New Brunswick	Source 40% of in-province electricity sales from renewables by 2020	Climate Change Action Plan 2014-2020 mandates increasing renewable energy generation and reducing demand through efficiency measures. Shift to natural gas in medium and heavy-duty vehicles.	
New Foundland and Labrador	2001 objective: Reduce emissions to 1990 levels by 2010 (*objective was met*)	Emissions reduced due to a switch to lower-emissions fuel and reduced output from Holyrood generating station, 27% decline in offshore oil production, lower emissions from Come-by-Chance refinery, lower manufacturing emissions due to newsprint mill closures	Province still committed to expansion of offshore oil and gas assets and measures for economic development

Northwest Territories		Voluntary energy efficiency targets for households and businesses, replacement of fossil-fuel generated electricity with non-emitting sources	
Nova Scotia	2009 objective: Generate 25% of electricity from renewable sources (wind, hydro, biomass) by 2015 *(objective was exceeded)*	Climate objectives were achieved due to a demand drop in 2009 resulted in paper mill closures, and increase in wind energy generation	A new hydro plant, Muskrat Falls, expected to come online in 2018 and displace heavy emission sources.
Nunavut		Climate Adaptation strategies	
Ontario	15% emissions reduction below 1990 levels by 2020, and 37% emissions reduction for 2030 and 80% by 2050	Eliminated coal-fired electricity in 2014.	Working to implement a C&T system by January 2017, to link to Canada/Quebec market by January 2018
Prince Edward Island			
Quebec	37.5% GHG emissions reduction below 1990 levels by 2030	C&T system for carbon emissions that applies to businesses that emit 25,000 metric tons or more of CO2 equivalent a year. Applies to industrial, electricity, and fossil fuel distribution sectors	
Saskatchewan		*Management and Reduction of Greenhouse Gases Act of 2009* regulates emissions from large emitters, but does not include oil/gas sectors	
Yukon Territory	Reduction of Yukon governmental internal operations GHG emissions to carbon neutrality by 2020	Voluntary energy efficiency targets for households and businesses	

6.2.2 Clean Energy and Climate Change Policies: Mexico

Mexico's greenhouse gas (GHG) emissions in 2010[w] were 7.1 metric tons of carbon dioxide-equivalent (tCO_2e) per capita, and 748,252 thousand tCO_2e total. This represents a 33.4% increase with respect to 1990 levels and is equivalent to a 1.5% compound annual growth rate. The major emitting categories in 2010 were transportation (22%), fuel extraction and energy generation (22%), agriculture (12%), fugitive emissions (11%), industrial processes (8%), and manufacturing and construction (8%).[x] Mexico's emissions represent 1.5% of global emissions.[y]

Mexico's national climate change policy is framed mainly in the General Law on Climate Change from 2012, the National Strategy on Climate Change from 2013, and the energy reforms described in Section 5.

Legal Framework, 2000-2012

In 2007, Mexico launched a first **National Strategy on Climate Change (ENACC),** a document that acknowledged climate change and specified the need for climate change adaptation and mitigation measures. Following the 2007 NSCC, Mexico launched the **Special Program on Climate Change (PECC),** which went a step further and specified short, medium, and long-term emissions reductions, including a long-term target of 50% reductions below 2000 levels by 2050.[368] The law was established in 2012 and it was the first of its kind among developing nations.[y] In 2012, Mexico's Congress passed the **General Climate Change Law,** which set a number of ambitious emissions targets (30% emissions reduction below business as usual by 2020; a 50% reduction below 2000 levels by 2050).[369] The same law also established an Inter-Ministerial Commission on Climate Change, which foresees the possibility of establishing an emissions trading system in the future.[z]

Specific to the electricity sector, in 2008, the **Law on Renewable Energy Use and Financing the Energy Transition (LAERFTE)** enabled CFE to use environmental sustainability as one of the factors in determining which generation source would be dispatched. (Prior to this law, CFE was legally required to dispatch the lowest-cost electricity.)[370] **Mexico's Energy Transition Law (ETL)** also stipulates that 35% of the electricity consumed in the country must come from renewable sources by 2024.[371] The law also includes a mandate to prepare and annually update and publish a **National Atlas of Clean Energy Zones (AZEL).** AZEL's main goals are to promote the utilization of the country's renewable energy potential and to guide transmission infrastructure planning.

Legal Framework, post-2012

An updated **National Strategy on Climate Change (ENACC)** was published in 2013 by the Ministry of the Environment and Natural Resources (MENR), with the collaboration of the National Institute of Ecology and Climate Change (NIECC) and the Climate Change Council (CCC), and the approval of the Inter-Ministerial Climate Change Commission (IMCCC). The NSCC outlines the long term strategies the federal government will follow to mitigate the effects climate change. The strategies are aimed at reaching

[w] 2010 is the most recent year for which the GoM produced an emission inventory.
[x] (SEMARNAT 2013)
[y] (Friedman 2015)
[z] Articles 7, 33, and 92 of the law mention economic instruments that could be used to further these efforts, including emissions trading arrangements.

adaptation and low-carbon development milestones in the next 10, 20 and 40 years. Adaptation strategies include protecting the most vulnerable social sectors and increasing social resiliency; protecting critical infrastructure and production systems, and increasing their resiliency; and utilizing natural resources in a sustainable way. Low-emission development strategies include accelerating the use of clean energy resources; increasing energy conservation and efficiency across the sectors of the economy; adopting sustainable city models that reduce carbon emissions from buildings, transportation systems, and waste management; preserve and increase carbon sinks through farming and forestry best practices; and reducing short-lived climate pollutants.

In its **Intended Nationally Determined Contribution (INDC),** the Government of Mexico has set a goal of unconditionally reducing its GHG emissions by 25%, with respect to the business as usual (BAU) scenario, for the year 2030. Mexico also committed to a goal of reducing GHG emissions up to 40% from BAU levels conditionally on a global agreement increasing Mexico's access to low-cost financing, technology transfer and technical assistance.[372]

To develop and implement carbon reduction policies, Mexico instituted the **National System of Climate Change (NSCC)**, a group of diverse government stakeholders. The NSCC enables the collaboration of different government limbs such **as Inter-Ministerial Climate Change Commission (IMCCC), the National Institute of Ecology and Climate Change (NIECC),** the **Climate Change Council (CCC),** state governments, state municipal associations and the climate change commissions in both chambers of the Mexican Congress. The NSCC evaluates national vulnerabilities and establishes critical mitigation and adaptation strategies.[373]

Though Mexico does not currently have a mandatory carbon trading scheme, the government has been setting the stage to initiate such a program. In 2014, Mexico instituted a carbon tax and the **National Emissions and Emissions Reductions Registry**. Mexico imposes a carbon tax on fossil fuels sales and imports on manufacturers, producers and importers. The tax varies according to the type of fuel and is proportional to the additional amount of carbon emissions compared to natural gas.[374] The approximate tax rate is $3.5 (U.S. dollars) per tCO_2e , capped at 3% of the sales price of the fuel, and it is expected to generate a revenue of 1 billion dollars per year.[375] The GCCL mandated the creation of the National Emissions and Emissions Reductions Registry, which track compliance of mandatory emission reductions and also voluntary reductions. All entities emitting more than 25,000 tCO_2e per year must report their emissions. Around 3,000 entities will be subject to compliance. Tracking includes direct and indirect emissions from mobile and stationary sources.[375]

Mexican officials have more recently been **considering a variety of emissions trading mechanisms**, including joining the Western Climate Initiative (discussed below).[376]

Mexico's **Clean Energy Certificate** (CEC) program issues CECs to clean energy generators, and requires energy retailers to comply with minimum percentages of clean energy, as discussed in Section 5.2.1. CECs do not only reward renewable energy generation, but also "clean" sources, such as nuclear power, efficient cogeneration, and large hydroelectric plants.

6.2.3 Clean Energy and Climate Change Policies: United States

The United States has a variety of policies at the federal and state levels that seek to reduce emissions. As published in The President's Climate Action Plan in 2013, the federal plan to reduce carbon emissions focuses on four main areas: deploying clean energy, transforming the transportation sector, cutting energy waste, and reducing other GHGs (such as methane, HFCs).[377]

For a more complete discussion of federal, state, and local policies that mitigate GHG emissions from the U.S. power sector, see the *QER 1.2 Environment Baseline, Volume 1: Greenhouse Gas Emissions from the U.S. Power Sector.*

Clean Power Plan

The Environmental Protection Agency's (EPA) Clean Power Plan (CPP) uses authorities under the Clean Air Act to establish state-by-state targets for carbon emission reductions under a flexible framework, which allows multiple emissions reductions tools, including renewable energy investment, energy efficiency, natural gas, and nuclear power, among others. The final rule is estimated to reduce national electricity sector CO_2 emissions by 32 percent below 2005 levels by 2030.[378] On February 9, 2016, the Supreme Court issued stay on the implementation of the CPP pending further judicial review.[aa] However, in spite of the judicial stay and due to the long-term nature of investment and infrastructure plans, many states continue to move forward in preparing state plans.

States can comply with the Clean Power Plan by implementing mass-based or rate-based mechanisms to reduce carbon emissions. Under a mass-based plan, the state measures total CO_2 emissions generated in-state. To the extent that electricity imports allow a U.S. state to ramp down in-state generation and associated emissions from existing fossil generation, the state's total CO_2 emissions would decline, and the imported low-emissions electricity could potentially help the state with CPP compliance. Under a rate-based plan, the state measures both total CO_2 emission and generation (the rate is lbs CO_2/MWh). Emissions Rate Credits (ERCs) are traded in denominations of MWh. A state could use Canadian hydropower or Mexican solar, for example, to generate ERCs **<u>if</u>** there is some contractual agreement, e.g. a power purchase agreement, which indicates that the actual clean electricity being generated outside of the United States is being consumed in the U.S. state, and connection to the contiguous U.S. grid.[379]

The Canadian Electricity Association, North American Electric Reliability Corporation, and other stakeholders have commented that the CPP could lead to an increase in Canadian exports.[380] The EPA's final rule, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units," the potential for international renewable energy imports to count towards CPP implementation is allowed under the following terms:

> "The EPA will work with states using the rate-based approach that are interested in allowing the use of RE from outside the U.S. to adjust CO_2 emission rates. In these cases, all conditions for creditable domestic RE must be met, including that RE resources must be **incremental and installed after 2012,** and **all EM&V standards must be met**. In addition, the country generating the ERCs must be connected to the U.S. grid, and there must be a power purchase agreement or other contract for delivery of the power with an entity in the U.S. [Renewable energy]

[aa] On February 9, 2016, the United States Supreme Court stayed the rule implementing the Clean Power Plan until the current litigation against it concludes. Chamber of Commerce, et al. v. EPA, et al., Order in Pending Case, 577 U.S. ___ (2016), http://www.supremecourt.gov/orders/courtorders/020916zr3_hf5m.pdf. As of that date, a challenge to the rule was pending before the United States Court of Appeals for the District of Columbia Circuit. The Court's decision was not on the merits of the rule. EPA firmly believes the Clean Power Plan will be upheld when the merits are considered because the rule rests on strong scientific and legal foundations. For the states that choose to continue to work to cut carbon pollution from power plants and seek the agency's guidance and assistance, EPA will continue to provide tools and support.

> generation capacity outside the U.S. that existed prior to 2012 but was not exported to the U.S. is not considered new or incremental generation and, therefore, not eligible for adjusting CO_2 emission rates under this rule. For example, a new transmission interconnection to existing RE in Canada would not be considered incremental, but a new interconnection to RE where the RE was built after 2012 would be considered incremental."[381]

This reinforces a theme present throughout this section: the design of the CPP, like all federal, state, provincial, and territorial efforts to reduce carbon pollution, will have implications for future collaboration with Canada and Mexico. The design of these programs – and the way they account or do not account for international trade of energy -- could affect total GHG emissions from North America.

Federal Renewable Energy Incentives

The Renewable Electricity Production Tax Credit (PTC) and Investment Tax Credit (ITC) are federal policy mechanisms to support the deployment of clean energy in the United States. The White House estimates the credits, which were extended in December of 2015 with a five-year extension and phase-down, could lead to the development of 100 GW of new wind and solar in the coming years, more than doubling the current amount in operation. Bloomberg estimates that the credits will provide a boost of 56% to the industry over this time period, including $73 billion in new investment and 37 GW of new wind and solar capacity.[382] The credits, which can be claimed by taxpayers investing and producing energy from the affected technologies, also vary by technology type. The PTC includes incentives of 2.3 cents/kWh for wind, geothermal, and closed-loop biomass; and 1.2 cents/kWh for other eligible technologies for the first 10 years of operation.[383] The ITC credits include a 30% eligible cost reduction for investment in solar and wind resources that elect to claim the ITC instead of the PTC (geothermal, microturbines, combined heat-and-power receive only a 10% reduction).[384]

State-Level Incentives

Many U.S. states also have some form of state-level clean energy mandates, incentives, or emissions reductions programs that target the electricity sector, including: renewable portfolio standards (found in 29 states and the District of Columbia), public benefit funds (about half of U.S. states), net metering and green pricing (45 states), limits on power plant emissions (California, Montana, Oregon, Washington), incentives for carbon capture and storage (16 states), energy efficiency resource standards (26 states), and enhanced appliance efficiency standards (8 states).[385],[386] The details of these programs in a state-by-state breakdown can be found at the Federal Energy Management Program's Energy Incentive Program website,[387] or the Database of State Incentives for Renewables and Efficiency (www.dsireusa.org). Many of them are also discussed in the *QER 1.2 Environment Baseline, Volume 1: Greenhouse Gas Emissions from the U.S. Power Sector.*

While all renewable energy incentives could have an effect on the economics of cross-border trade, Renewable Portfolio Standards (RPSs) have particular relevance, as they can create market opportunities for cross-border clean energy exporters (as evidenced by the Energía Sierra Juarez project discussed in Section 5.6).Although most RPS standards allow for imports to contribute to satisfying the standard, states can still require eligible resources to be either located in the state, or to be "deliverable to the state". As of 2014, 18 states had RPS provisions that require some portion of in-state generation, including (border states bolded): **Arizona,** Colorado, Delaware, Hawaii, Illinois, Iowa, Kansas, Maryland, Massachusetts, **Michigan, Minnesota,** Missouri, **New Hampshire,** New Jersey, **New Mexico, New York**, Nevada, and **Texas**. [388] State-specific RPS provisions are included in Tables 6, 13, 18, and Figure 46.

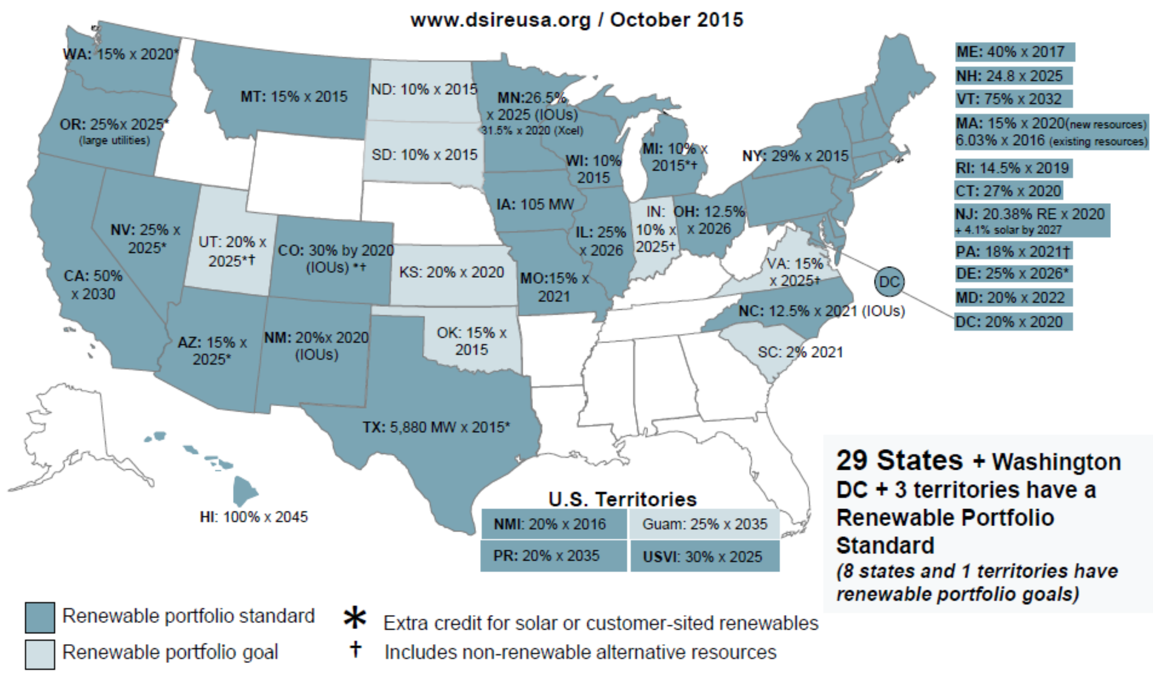
U.S. Subregional Carbon Markets

- **The Regional Greenhouse Gas Initiative (RGGI)** was the first mandatory carbon market in the United States, which includes a cap-and-trade carbon dioxide emissions trading program for power generations with nine northeastern and mid-Atlantic states: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. The RGGI states have reduced power sector carbon dioxide emissions by more than 40 percent since 2005, even as the regional economy has grown 8%. RGGI, Inc., estimates that the investment of proceeds from RGGI has powered an investment of over $1 billion in the energy future of the New England and Mid-Atlantic states, with a strong focus on energy efficiency.[389]

- *(inactive)* **The Chicago Climate Exchange (CCX)**, which launched in 2003, is North America's "largest and longest-running greenhouse gas emission reduction program". From 2003-2010, the exchange was structured as a voluntary, but legally-binding C&T program with an offsets component. The program facilitated trading through the end of its first phase of operations in 2010. CCX launched and continues to operate the Chicago Climate Exchange Offsets Registry Program to support the continued use of any "legacy tonnes".[390]

- **The city of Boulder, Colorado,** has also implemented a tax on carbon emissions at a level of $7 per ton of carbon. The tax applies to the electricity sector, and is estimated to reduce emissions by more than 100,000 tons a year, while generating $1.8 million in revenue. This revenue is focused on enhancing energy efficiency measures, as well as expanding bike lanes and setting up new community-based solutions to reduce energy consumption.[391] Portland, Oregon, is considering similar measures.[392]

Figure 49: Renewable Portfolio Standard Policies in U.S. States (October 2015). A large number of U.S. States have RPSs. While a majority of RPS requirements could technically be filled by out-of-state imports, some states limit RPS qualification for in-state developments, including Texas, New Mexico, Michigan, Minnesota, and New Hampshire. (DSIRE, 2015)



6.2.4 Cross-border Accords

- **The Western Climate Initiative (WCI)** was originally established in 2007 by five U.S. states (California, Arizona, New Mexico, Oregon, Washington), then grew to also include Utah, Montana, and four Canadian provinces (British Columbia, Manitoba, Quebec, and Ontario). The WCI had a regional GHG target to reduce carbon emissions by 15 percent below 2005 levels by 2020. This target was to be reached through market-based multi-sector cap-and-trade mechanisms, applied to six greenhouse gases (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride). The program planned to cover 90 percent of GHG emissions from the region when fully implemented. All parties collaborated to produce the "Design for the WCI Regional Program", which was released in July 2010. However, as the group began to further outline the cap-and-trade system, all of the U.S. states, with the exception of California, withdrew from the agreement. The Western Climate Initiative was rolled over into a non-profit cooperation to continue to provide administrative and technical services to support state and provincial greenhouse gas emissions trading programs.[393]

- Though WCI lost many of its original foundational members, it became the nexus through which **California and Quebec** linked their originally-independent carbon markets. Through AB 32, the California Global Warming Solutions Act of 2006, California established a law mandating a sharp reduction in emissions. To comply with AB 32, the California Air Resources Board (ARB) designed a legally-binding, enforceable California cap-and-trade program. The program was formally launched on January 1, 2012, and compliance obligations went online in 2013.[394] In

2014, Quebec officially linked its C&T system with the California carbon market,[395] creating the largest carbon market in North America, by volume, as well as the first market to be linked bi- and sub-nationally.[396] The joint market has held six auctions for carbon, the latest in February of 2016. Ontario is in the process of establishing its own carbon market, with the intention of joining the accord; Manitoba and Mexico have also expressed interest.

- *(inactive)* **The Midwest Greenhouse Gas Reduction Accord (MGGRA**) was established in 2007 by the governors of Illinois, Iowa, Kansas, Michigan, Minnesota, Wisconsin, as well as the premier of Manitoba. Indiana, Ohio, South Dakota, and the province of Ontario also joined the agreement as observers. Under the Accord, members agreed "to establish targets for greenhouse gas emission reductions that were consistent with states' targets, and to complete the development of a proposed cap-and-trade agreement and model rule". The participants released a final model rule in April 2010, which detailed a cap-and-trade program designed to reduce greenhouse gas emissions by 20 percent below 2005 levels by 2020, and 80 percent below 2005 levels by 2050. However, like the Western Climate Initiative, once the terms were established, the efforts under MGGRA disbanded, and states and provinces chose to pursue their own plans separately.[397]

- *(inactive)* **The North America 2050 Initiative** was launched in March of 2012. It was the successor to the **3-Regions Collaborative**, which facilitated cooperation among the three main regional cap-and-trade efforts: the Western Climate Initiative, the MGGRA, and the RGGI. It was discontinued in 2014.

- **The Pacific Coast Cooperative (PCC)** is an accord among the leaders of Alaska, British Columbia, California, Oregon, and Washington to leverage clean energy innovation and low-carbon development, launched in 2008. While the primary focus of the PCC was on sustainable development, in October of 2013, the PCC signed the "Pacific Coast Action Plan on Climate and Energy", a nonbinding agreement to align climate regulations and market-based measures in each state or province. The plan covers a number of policy, ranging from promotion of clean energy development and low-carbon transportation, but also includes revision of regional GHG reduction targets and carbon pricing.

6.3 The Potential for Cross-Border Cooperation on Climate Goals

From the characterization of climate and clean energy policies in Sections 6.1-6.2, a few basic principles may be extracted:

- While federal governments are responsible for national climate commitments, in the United States and especially in Canada, provincial and state governments have important roles to play to enable implementation.
- Currently, many U.S. States do not allow for Canadian hydropower to count towards state-level RPS goals.
- The commitment of these provincial/state governments to reducing emissions varies considerably, with progressive policies among first-movers (British Columbia, Quebec, California, and New England), and fewer incentives among regions more highly dependent on fossil fuels (the U.S. Midwest, Saskatchewan).

- Mexico's federal commitments do not face the same subregional jurisdictions challenge, however, due to the recent nature of its energy reforms, some methodologies for its clean energy and climate programs have not yet been established, nor their functionality tested.
- While several prior efforts to establish carbon markets in the United States and Canada have failed, the Western Climate Initiative is an exception. The California-Quebec carbon market has functioned smoothly thus far, and is attracting interest in additional linkages (Ontario, and potentially Manitoba). The stated interest of Mexico to join this initiative in 2017 could open a new era for subnational, trilateral climate cooperation.

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