2015 Trilateral Energy Outlook Project

Introduction

Context & Motivation

The energy markets of Canada, Mexico, and the United States are becoming increasingly interdependent as physical infrastructure continues to be built across North America. With free trade treatment of many energy commodities, the three neighboring countries include each other's largest import and export markets for many of these commodities. Geographic proximity has also led to some degree of market integration—for example, regional electricity markets extend across the U.S./Canada border, broadening the market in both countries. Conversely, North American geographic isolation creates trade barriers to the rest of the world for energy commodities like natural gas and electricity, while other commodities such as crude oil and petroleum products travel more readily over water. As a result, Mexico, Canada, and the United States can be understood as a single (semi-integrated) regional energy market with internal commodity flows and external links to the rest of the world. For example, most of the crude oil exported from Mexico and Canada finds its way into U.S. refineries, and much of the U.S. demand for crude oil imports is satisfied by its neighbors. The United States also exports relatively large volumes of petroleum products to both Canada and Mexico. Net trade in crude oil and refined petroleum products between these three countries and the rest of the world is relatively modest by comparison. Natural gas generally follows a north-to-south flow pattern on a net basis from Canada to the United States and into Mexico.

In understanding and anticipating the future of energy markets within their borders, the governments in these three countries produce forward-looking energy outlooks. Each outlook makes explicit or implicit assumptions about other North American energy markets, including prices, infrastructure growth, and commodity trade flows. Some of these assumptions are based on historical data that Canada, Mexico, and the United States submit to the International Energy Agency (IEA), or with reference to the other nations' published outlooks. Nevertheless, national energy outlooks have usually been prepared independently, despite the important connections between the physical markets across the three countries. In the Trilateral Memorandum of Understanding, one of the subgroups was created with a mandate to improve coordination and understanding of the national outlooks and modeling systems (Subgroup C).

Outlooks and Modeling Systems

Canada: The National Energy Board (NEB) has been producing long-term energy supply and demand projections regularly since 1967. Its latest outlook, *Canada's Energy Future 2016: Energy Supply and Demand Projections to 2040*[1] (EF2016) projects energy supply and demand for Canada to the year 2040. These outlooks are created using the NEB's Energy Futures Modeling System, which contains various supply and demand modules that interact to produce the outlook at a provincial and territorial level. The supply modules include oil sands, non-oil sands crude oil, natural gas, and natural gas liquids

[1] Available at www.neb-one.gc.ca.

production models that are developed within the NEB. ENERGY 2020, an integrated energy model developed by Systematic Solutions Incorporated, creates the demand and electricity projections. Demand projections are made across four general sectors, each of which has several sub-sectors: residential, commercial, industrial (including oil and gas production), and transportation. An external macroeconomic forecaster, Centre for Spatial Economics (C4SE) provides the macroeconomic outlook.

Mexico: Mexico's Energy Ministry is responsible for the publication of annual energy outlooks, which project approximately 15 years into the future (currently to 2029). A number of agencies participate in the development of demand and supply forecasts for hydrocarbons and electricity. Comision Nacional de Hidrocarburos (CNH), the national Hydrocarbon Commission, is responsible for oil and gas production projections based on estimations provided by Petroleos Mexicanos (Pemex). Mexico's refining model includes details on the transportation of petroleum-derived products to provide projections of logistics and processing capacities, crude processing, and oil products imports, and production. Mexico's Natural Gas Transportation System model uses inputs of prices, demand, capacity, infrastructure, and specifications to obtain results for logistics and processing capacities, and liquids-gas balances.

Specific models are used for each demand sector—transportation, industrial, residential, electricity self-supply, services, air transport, rail demand, and agriculture—in order to project fuel demands by product, region, and industry.

The national electricity company, Comision Federal de Electricidad (CFE) uses a set of models to provide electricity demand forecasts by sector–residential, commercial, public lighting, water pumping, irrigation, large and medium industries–and region. Mexico also uses the PLEXOS for Power Systems Capacity Expansion modelling to estimate the capacity expansion, associated generation reliability of the system, environmental impacts, unit commitment and economic dispatch, revenue adequacy and uplift, transmission lines expansion, reserve margin and intermittent energy sources impact.

United States: The U.S. Energy Information Administration (EIA) produces the Annual Energy Outlook (AEO) using the National Energy Modeling System (NEMS). The most recent AEO was released in April 2015, with projections to 2040.

Overall, NEMS represents the behavior of energy markets and their interactions with the U.S. economy. The model achieves a supply/demand balance in the end-use demand regions, defined as the nine Census divisions or model specific regions (i.e., refining regions), by solving for the prices of each energy type that will balance the quantities producers are willing to supply with the quantities consumers' demand. The system reflects market economics, industry structure, and existing energy policies and regulations that influence market behavior.

NEMS consists of four supply modules: oil and gas, natural gas transmission and distribution, coal market, and renewable fuels, two conversion modules: electricity market and petroleum market, four end-use demand modules: residential, commercial, industrial, and transportation, one module to reflect

macroeconomic activity, one module to simulate international energy markets, and one module that provides the mechanism to achieve a general market equilibrium among all the other modules.[2]

Scope of Current Effort

Activities during the first six months of the Trilateral effort for Subgroup C included regular meetings of the member parties in order to gain a better understanding of the respective modeling frameworks. A centerpiece in these discussions was a comparison of each country's current official projections, with a particular focus on understanding cross-border trade. Given certain limitations surrounding outlook results, net exports were used as a proxy where necessary. The discussion results and activities during the first half of the year were documented in a 180-day report, which was shared with each country's ministerial and secretarial representatives.

The current report extends the previous effort by using a common set of assumptions across all three countries while maintaining the same respective models and methods used by each of them to produce their national outlooks. The resulting Trilateral Energy Outlook is presented here for comparison purposes and to identify areas where further coordination and understanding could yield the greatest mutual benefit. The shared assumptions, which were either assumptions or results from EIA's AEO2015 Reference case, were implemented into Canada and Mexico's modeling frameworks. They are listed in the appendix. These assumptions include world oil prices, the Henry Hub natural gas price, and U.S. gross domestic product growth.

Although the Canadian and U.S. models support projections that extend to the year 2040, the Trilateral Energy Outlook projection period runs through 2029, which is the last year of Mexico's planning horizon.

Caveats

The 2015 Trilateral Energy Outlook Project provides a compendium of separate results from the national energy models of Canada, Mexico, and the United States which are used to produce each country's official energy outlook. The Canadian and Mexican model runs are based on a common set of assumptions, largely assumptions or results from EIA's AEO2015. It is important to note that the use of these common model input assumptions does not represent implicit, or explicit endorsement of the assumptions themselves by any of the three countries, and the individual country-level results presented in this document may differ significantly from nationally published outlooks.

This exercise was undertaken in order to gain insight into the dynamics of each country's energy modeling systems using a common set of assumptions, but it does not reflect results of an integrated North American energy model. The results should not be construed as an official outlook for any of the Trilateral members. Additionally, since the individual energy models were not linked to provide feedback from one model to another, some of the model results, including trade flows, are inconsistent across models.

Although the common set of assumptions used in the Trilateral Energy Outlook 2015 were based on EIA's AEO2015, results for Mexico and Canada may differ from their respective outlooks and should not

[2] For complete NEMS overview: www.eia.gov/forecasts/aeo/nems/overview/pdf/0581(2009).pdf.

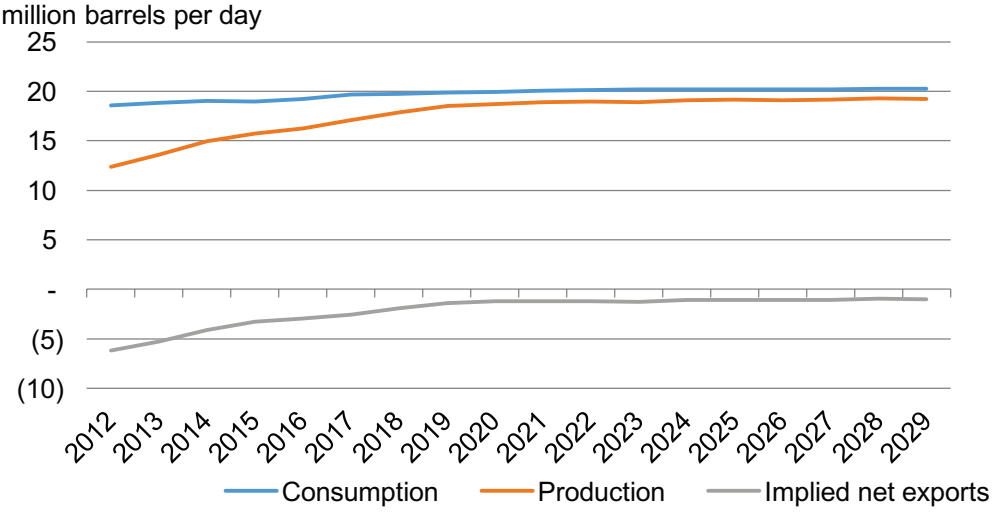
be understood to be in any way endorsed by these countries' energy agencies. By construction, the U.S. outlook in Trilateral Energy Outlook 2015 is identical to AEO2015. For official Canadian and Mexican outlooks, see EF2016 and Mexico's Energy Outlooks 2015-2029, respectively.

Results

Over the projection period, production growth in both crude oil and natural gas outstrips growth in consumption, reducing imports into the combined Trilateral region (Canada, Mexico, and the United States.)

Crude Oil

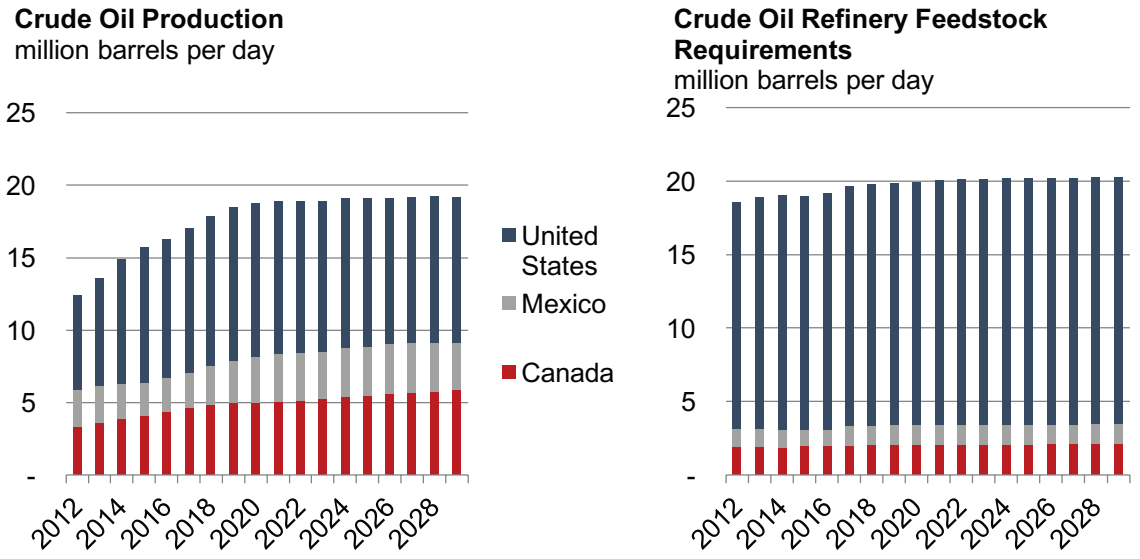
Crude Oil Overview: Combined outlook based on estimates provided independently by each country



Note: Implied net exports equals production minus consumption.

Disclaimer: Estimates provided by each country using a limited set of common assumptions and do not necessarily reflect the countries' own individual outlooks; combined results do not reflect an integrated tri-country model and may contain unresolved inconsistencies.

Despite a 7% growth in total consumption of crude oil for refinery feedstock in Canada, Mexico, and the United States from 2013 to 2029, net imports into the Trilateral region are projected to decline by 97% because crude oil production increases by 42% over the same time period.



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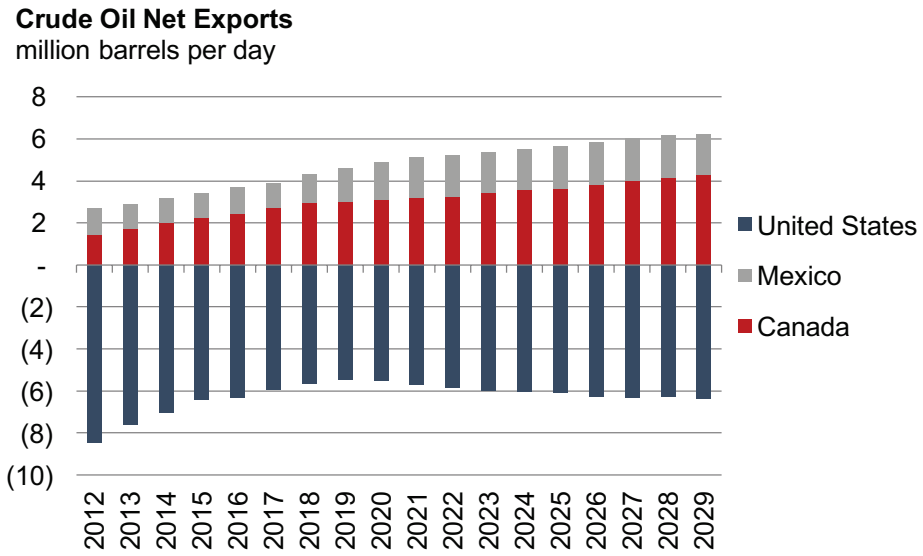
Canada: Crude oil production grows steadily in the Trilateral Energy Outlook, reaching 5.0 million barrels per day (b/d) in 2019 and 5.8 million b/d in 2029. This growth is driven by increases in Alberta's oil sands production, which at 4.2 million b/d in 2029, represents 71% of total Canadian production, increasing its share from 61% in 2013. Non-oil sands crude oil, including tight oil, remains fairly constant over the projection, ranging between 1.6 to 1.7 million b/d. Over the projection period, crude oil refinery feedstock requirements exhibit minor growth due to assumed efficiency improvements and the 50 thousand b/d addition of the Northwest Upgrader in Alberta in 2018.

Mexico: The recent Energy Reform allows the participation of third parties (private investment); removing barriers that previously restricted oil and gas production to Pemex, driving an increase in production for the projection period. Oil production is expected to increase from 2.5 million b/d in 2013 to 3.3 million b/d in 2029, with production peaking in 2026 at 3.4 million b/d.

While Mexico's refining sector is now open to private investment, the projections in this outlook, assume no atmospheric distillation capacity expansion. Instead, the output of light and intermediate distillates is expected to grow through the projection by the addition of capacity in delayed coking, increasing the share of heavy oil that is refined and the refinery utilization rate.

United States: Production from tight formations leads the growth in U.S. crude oil production across EIA projections, with total U.S. crude oil production peaking at 10.6 million b/d in 2020. In the AEO2015 Reference case, the existing U.S. competitive advantage in oil refining compared with the rest of the world continues over the projection period.



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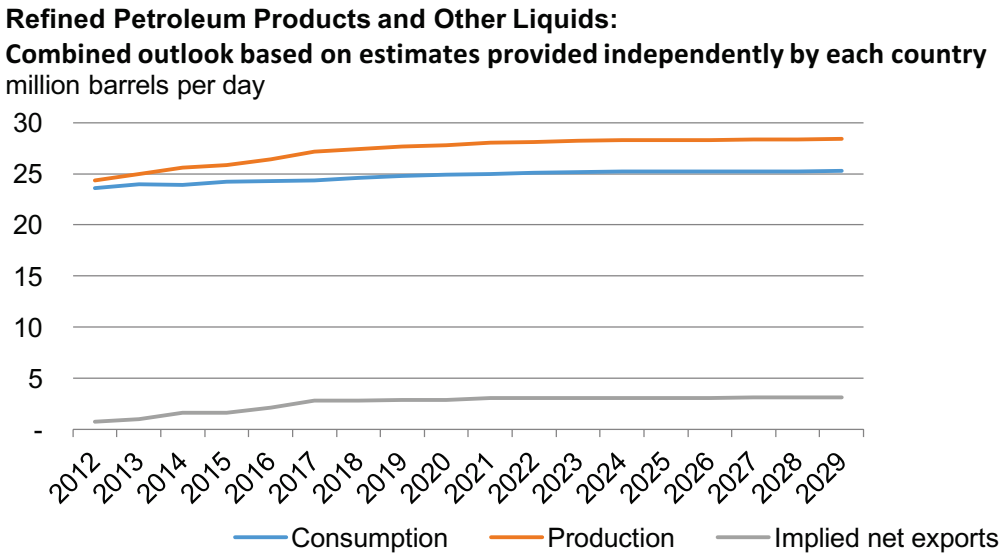
Canada: Given the modest growth in domestic feedstock requirements, net exports of crude oil from Canada increase from 1.7 million b/d in 2013 to 4.3 million b/d in 2029. In the Trilateral Energy Outlook, no assumptions were made on future crude oil export pipeline projects out of Canada. Insufficient crude oil pipeline capacity could lead to increased use of more expensive alternatives such as rail, which could lower production by decreasing netbacks to producers in western Canada.

Mexico: As oil production increases, crude oil exports grow, reaching a maximum of 2.0 million b/d by 2027 and then falling slightly to 1.9 million b/d by the end of the projection period.

United States: As a result of increasing domestic crude oil production, net imports of crude oil fall from 7.6 million b/d in 2013 (48% of total domestic consumption) to 6.4 million b/d in 2029, after reaching a minimum level of 5.5 million b/d in 2019. Restrictions on crude oil exports from the United States remain in place throughout the projection.

Refined Petroleum Products and Other Liquids



Note: Implied net exports equals production minus consumption.
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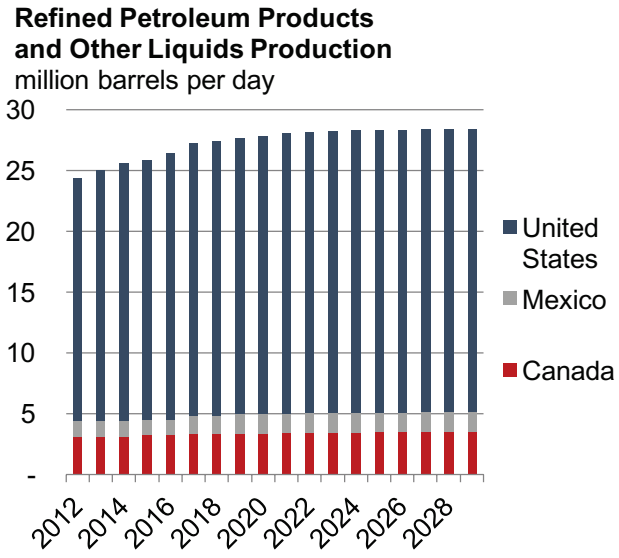
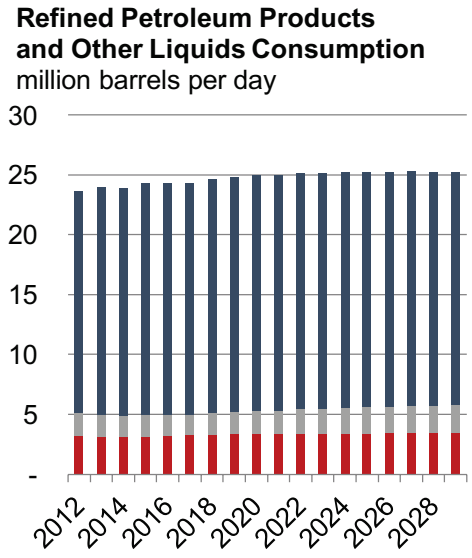
Production gains for refined petroleum products and other liquids in Canada, Mexico, and the United States, particularly early on in the projection period, support higher levels of net exports as consumption flattens.





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Canada: Canada's production of refined petroleum products and other liquids increases 15% over the projection period, reaching 3.5 million b/d in 2029. Most of this growth is attributable to increased production of propane and butane associated with rising natural gas production. Most of the ethane

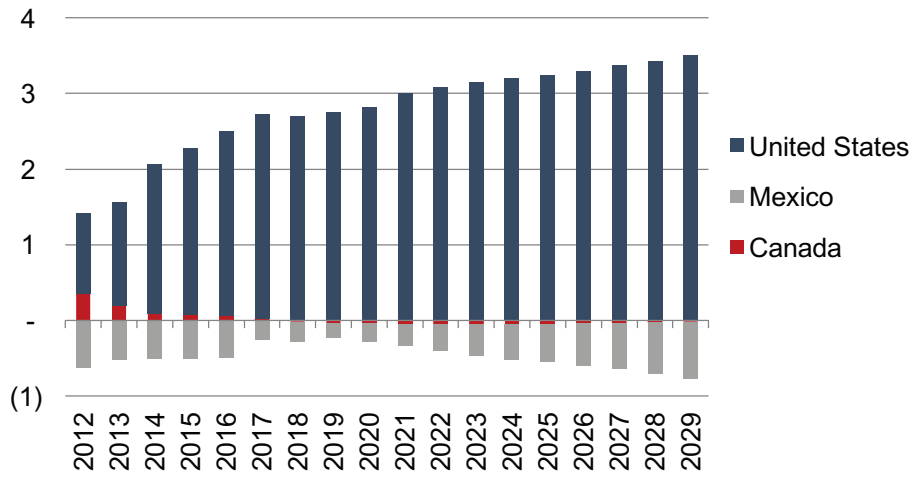
increases associated with the rising natural gas volumes are rejected into gas pipelines, although this ethane rejection could be reduced if the Canadian ethane-based petrochemical capacity further expands. Refined petroleum product growth is relatively flat due to the minimal increase in refinery capacity over the projection period. Consumption increases at an annual rate of 0.6% over the same period and reaches 3.4 million b/d as reductions in passenger use are outweighed by gains in the freight and industrial sectors.

Mexico: Refined petroleum products and other liquids production will increase as a result of refinery upgrades; deep conversion processes are currently being installed. The outlook assumes that delayed coking process additions at three refineries are complete by 2021.

During this upgrading work, refinery production is expected to reach its lowest level in 2015 with 1.2 million b/d output. After 2015, refinery output is expected to grow steadily, reaching a peak of 1.6 million b/d in 2019 and remaining at this level throughout the rest of the projection period. Refinery additions will improve the utilization rate, which has been lower than refineries with deep conversion units. The demand for fuel oil by the electric power company in Mexico is shrinking, and there are limited alternative markets. As delayed coking units come online, fuel oil production will be significantly reduced.

United States: Production of petroleum products at U.S. refineries depends largely on the cost of crude oil, domestic demand, and the competitive advantage of U.S. petroleum product exports in foreign markets. U.S. refinery production of gasoline blending components declines in the AEO2015 Reference case from 7.9 million b/d in 2013 to 7.3 million b/d in 2029, in response to a drop in U.S. crude oil production, higher crude oil prices, and lower demand. U.S. diesel fuel output increases to 5.1 million b/d in 2029. U.S. consumption of petroleum and other liquids, which totaled 19.0 million b/d in 2013, increases to 19.6 million b/d in 2020, and then declines to 19.4 million b/d in 2029. In the transportation sector, which continues to dominate demand for petroleum and other liquids, there is a shift from motor gasoline to distillate. Production of natural gas plant liquids (NGPL) including: ethane, propane, butane, isobutane, and natural gasoline, increases from 2013 to 2029. Most of this early growth in NGPL production is associated with the continued development of liquids-rich areas in the Marcellus, Utica, and Eagle Ford formations.

Refined Petroleum Products and Other Liquids Net Exports
million barrels per day



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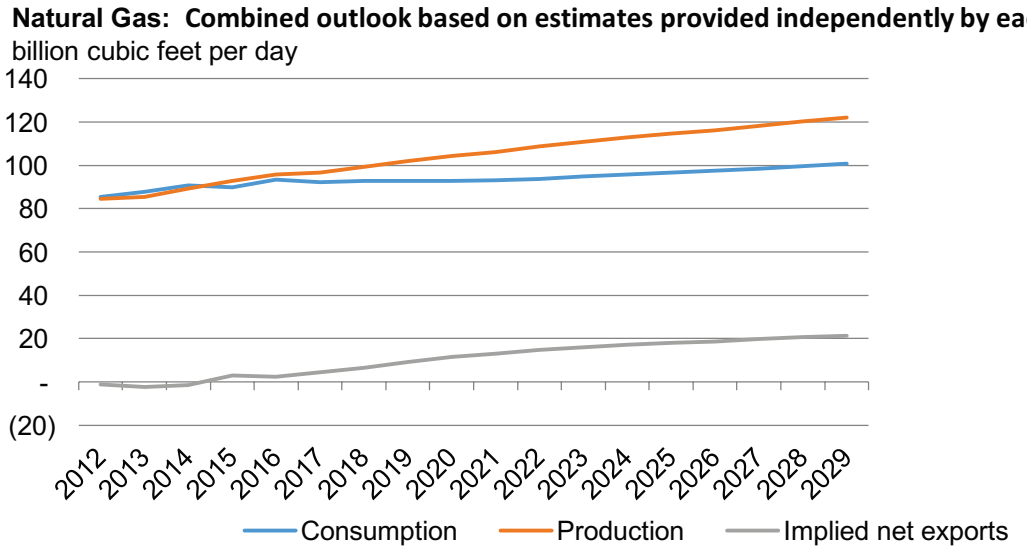
Canada: Exports of refined petroleum products and other liquids switch from a small net positive to a small net negative in 2018 as demand for liquids increases but refinery capacity remains relatively constant. Rising propane and butane exports will help exports balance out imports over the projection, with net exports reaching -0.02 million b/d by 2029.

Mexico: No major refining capacity additions are expected to come online over the projection period, and imports are projected to increase from 0.5 million b/d in 2013 to 0.7 million b/d in 2029 as a result of increasing domestic demand for gasoline and diesel. Nevertheless, it is important to note that refinery upgrades, increased natural gas production (which will increase liquid petroleum gas production), and the substitution of oil-fired electricity generation plants with combined cycle plants, will result in a reduction of refined product imports, which reach their lowest level in 2019.

United States: Production from tight formations leads the growth in U.S. crude oil production in the AEO2015 Reference case, with total U.S. crude oil production peaking at 10.6 million b/d in 2020. Due to the competitive advantage of U.S. refining capacity, gasoline and diesel exports grow through to 2029. As a result of declining consumption of liquid fuels and increasing production of domestic crude oil, net exports of petroleum products increase from 1.4 million b/d in 2013 (7% of total domestic consumption) to 3.5 million b/d in 2029 (18% of domestic consumption). Growth in gross exports of refined petroleum products, particularly of motor gasoline and diesel fuel drive the outcome.

Natural Gas



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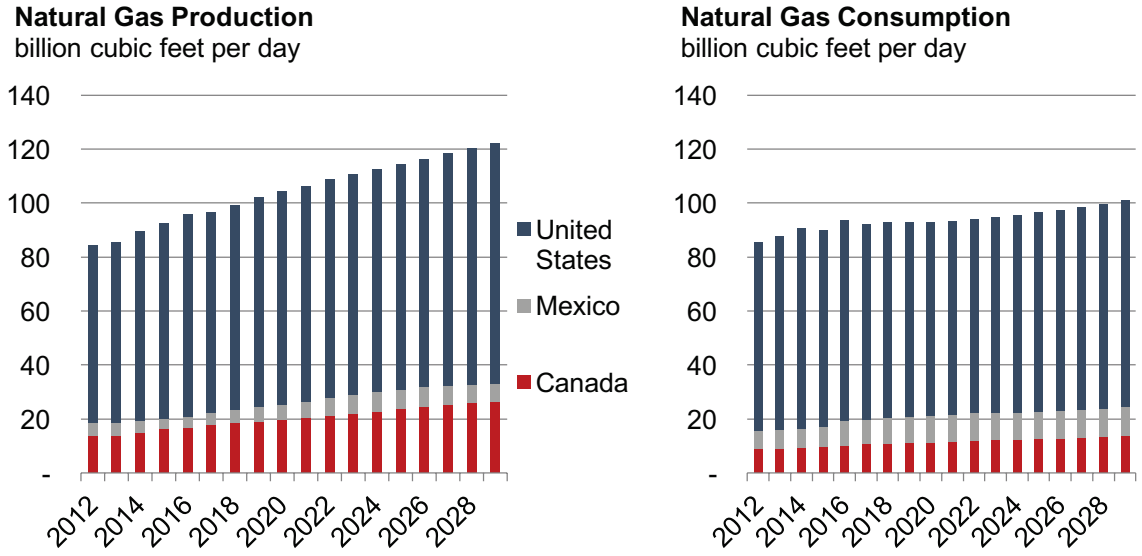
Driven by a 43% growth in total dry natural gas production in Canada, Mexico, and the United States from 2013 to 2029, the Trilateral region is projected to become a net exporter of natural gas by 2015.



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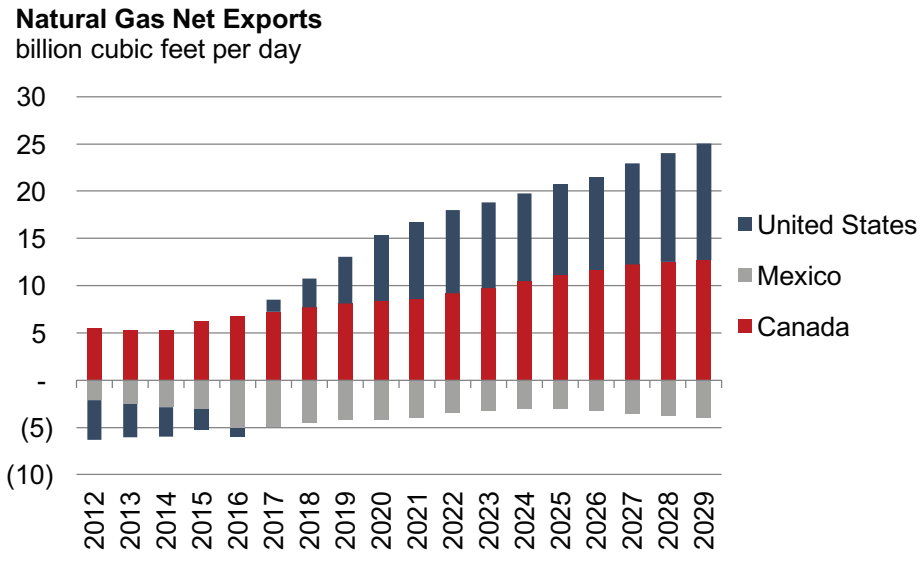
Canada: Natural gas production is projected to increase from 14.0 billion cubic feet per day (Bcf/d) in 2013 to nearly 26.7 Bcf/d by 2029. This high level of production is driven by the relatively high natural gas price in the AEO2015 Reference Case. With the lower U.S. benchmark Henry Hub prices projected in the AEO2015 High Resource Case ($3.66 per million British thermal units (MMBtu) by 2029), Canadian

production increases to just over 18 Bcf/d, which is significantly lower than the 26.7 Bcf/d projected when using the EF2016 Reference Case Henry Hub price ($5.71/MMBtu in 2029). Canadian natural gas consumption increases from 9.2 Bcf/ in 2013 to nearly 14 Bcf/d in 2029.

Mexico: Now open for private investment, natural gas extraction is likely to grow, increasing production over the projection. Production peaks in 2024 at 7.2 Bcf/d. Shale gas production was not considered in these projections. The highest share of the production is projected to come from shallow waters, followed by onshore fields, while production coming from deep water fields is expected to begin in 2016.

Natural gas consumption sees highest growth rate among all fossil fuels, due mainly to electricity generation relying heavily on natural gas combined cycle capacity. Currently, many power plants and refineries are switching from fuel oil to natural gas; the biggest increase in demand is expected at the completion of these projects between 2015 and 2016, resulting in a 26% increase in demand year-over-year. Additional pipeline capacity will also come online in 2016, facilitating the movement of increased gas imports and the delivery of gas to industries that were formerly supply-constrained. After 2016, demand reaches its peak in 2029.

United States: U.S. dry natural gas production increases from 66.9 Bcf/d in 2013 to 89.0 Bcf/d in 2029, with a 56% increase in Lower 48 shale gas production (including associated natural gas from tight oil formations), which grows from 31.0 Bcf/d in 2013 to 48.5 Bcf/d in 2029. Natural gas consumption increases from 71.7 Bcf/d in 2013 to 76.4 Bcf/d in 2029. The largest growth is in the industrial sector, where demand for natural gas grows from 20.3 Bcf/d in 2013 to 22.9 Bcf/d in 2029, benefiting from the increase in shale gas production that has resulted in slower growth of natural gas prices. Natural gas consumption in the electric power sector also increases, in part because of the retirement of 40.1 GW of coal- fired capacity by 2025.



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Canada: Net available exports of natural gas increase considerably due to the relatively high natural gas production levels projected in the Trilateral Energy Outlook. When LNG exports are subtracted from net available exports, the result, 10.2 Bcf/d by 2029, is significantly higher than the 4.1 Bcf/d of net imports into the US from Canada projected in the AEO2015 and in EF2016. This represents one of the key findings of the Trilateral Energy Outlook, and researchers at the NEB and the EIA will continue to collaborate to explore these differences. In the NEB's EF2016, which features a lower Reference Case price for Henry Hub, net exports are 3.7 Bcf/d by 2029.

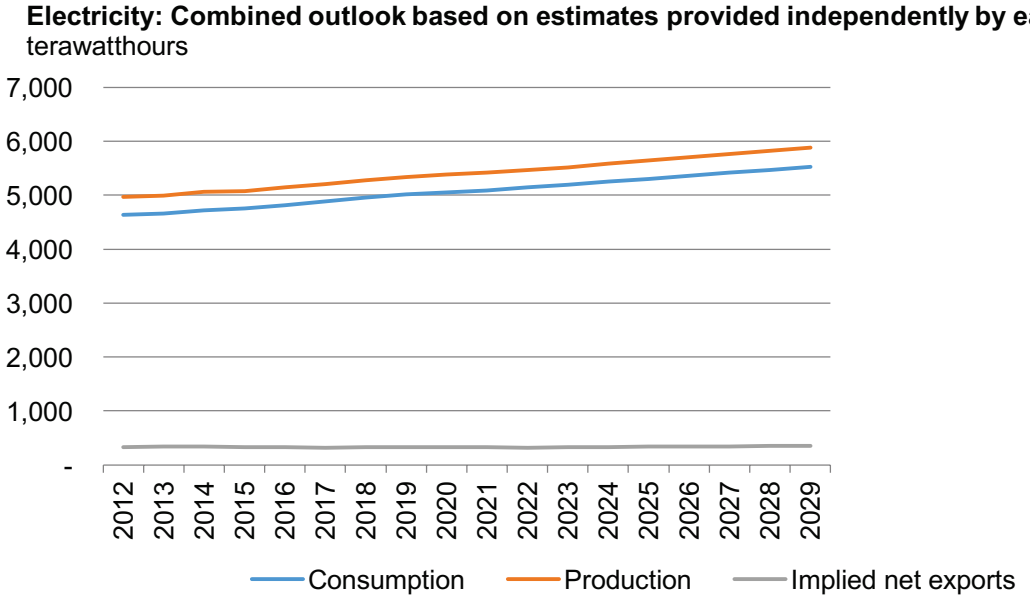
Mexico: While production increases, natural gas demand is expected to grow at a faster rate, driven by increased demand for natural gas in the electricity sector. As a result, natural gas imports will grow, particularly in the first years of the projection period. This projection assumes that CFE will increase natural gas pipeline import capacity from the United States in order to supply combined-cycle power plants.

The increased pipeline capacity will also help provide natural gas to the industrial sector and Pemex, allowing Pemex to switch from fuel oil to natural gas in some of their refinery processes, and to install cogeneration (electricity-steam) plants in the future.

After reaching its peak in 2016, Mexico's projected imports will decrease as a result of increasing domestic production, but will remain higher compared with current import levels. Liquefied natural gas (LNG) imports are included in the first years of the projection after which they are expected to stop entirely.

United States: Net exports of natural gas from the United States total 12.3 Bcf/d by 2029. The growth in U.S. net natural gas exports from 2017 to 2029 is driven by increasing gross LNG exports, which reach 8.5 Bcf/d by 2029. The United States remains a net pipeline importer of natural gas from Canada through the projection period, but at lower levels than in recent history. Net pipeline exports of natural gas to Mexico increase from 1.8 Bcf/d in 2013 to 4.5 Bcf/d in 2029.

Electricity



Note: Implied net exports equals production minus consumption. For electricity, transmission losses are also included in implied net exports.
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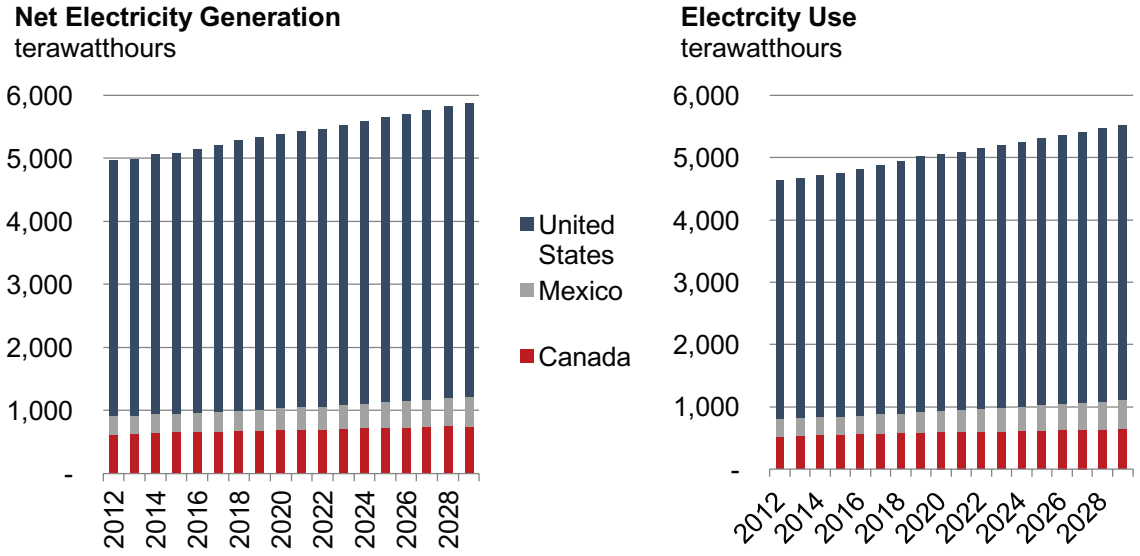
Electricity consumption grows by 19% in Canada, Mexico, and the United States from 2013 to 2029. Differences between production and consumption are largely a result of transmission losses.



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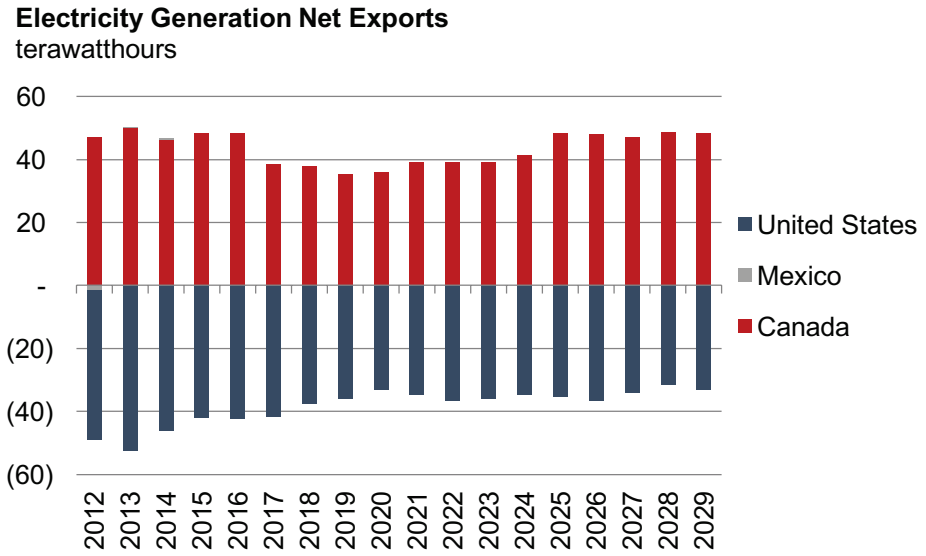
Canada: Electricity generation in Canada increases to 752 terawatthours (TWh) by 2029, a 20% increase from 2013 levels. Hydroelectricity remains the main source of electricity generation in Canada over the projection. Between 2013 and 2029 the share of natural gas-fired generation rises from 10% to 20%, while coal's market share declines from 10% to 5%. The share of non-hydro renewable generation doubles over the projection period, from 4% in 2013 to 8% in 2029. Canadian electricity use increases an average of one per cent per year from 2013 to 2029.

Mexico: Electricity consumption is projected to increase from 278 TWh in 2013 to 472 TWh in 2029 as economic activity of the country increases. New installed capacity must comply with legal mandates, such as the 65% limit on fossil fuel-associated generation by 2024. The mandate's target is to increase the capacity of renewable, zero-emission energy generation. Mexico projects that wind generation will grow nearly seven-fold compared to 2013 levels, and geothermal generation nearly three-fold.

United States: Total electricity use in the AEO2015 Reference case, including both purchases from electric power producers and on-site generation, grows by an average of 0.9% each year from 3,836 TWh in 2013 to 4,415 TWh in 2029. The relatively slow rate of growth in demand, combined with rising natural gas prices, environmental regulations, and continuing growth in renewable generation, affects the shares of fuels used for electricity generation. In the AEO2015 Reference case, natural gas-fired generation remains below 2012 levels until after 2025, while generation from existing coal- fired plants and new renewable plants increases. In the longer term, natural gas fuels, on average, generate more than 85% of the new generation needed from 2025 to 2029, and growth in generation from renewable energy supplies most of the remainder.



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Canada: The majority of Canada's electricity exports are sourced from provinces with large hydroelectricity capacities, and generation from these regions can fluctuate depending on water levels in any given year. In the next few years electricity flows from Canada to the United States are projected

to decline partly due to scheduled nuclear refurbishments in Ontario. Between 2016 and 2031 Ontario is expected to refurbish 10 nuclear units, which will put downward pressure on net exports. After 2020, several large hydro facilities in British Columbia, Quebec, and Manitoba are expected to come online, which leads to increasing net exports of electricity.

Mexico In this model, there is no projection about electricity exports/imports.

United States: The United States remains a net importer of electricity over the projection period, with most imports originating in Canada.

Major Findings

Across North America production exceeds consumption for all primary fuels except for crude oil.

Price trends are an important determinant of production and exports.

There is a large difference in how the NEB and EIA view Canadian natural gas productivity at specified price levels.

Overall, the outlooks are fairly consistent aside from a few specific issues like, gas production in Canada.

Appendix

- Data tables from templates for each country
- List of terms