CSIS BRIEFS

Mapping the U.S.-Canada Energy Relationship

Photo: Michael/Adobe Stock

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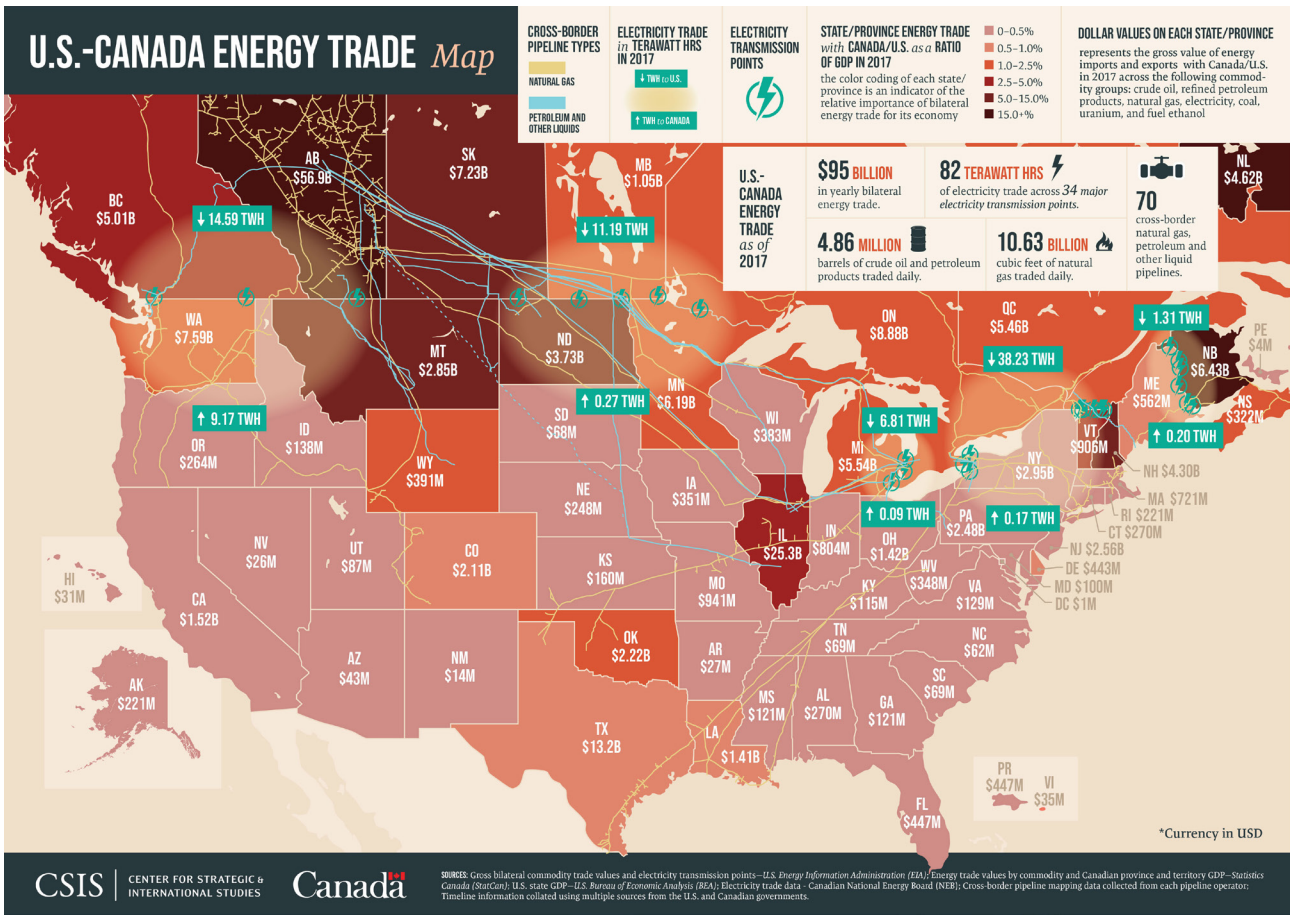
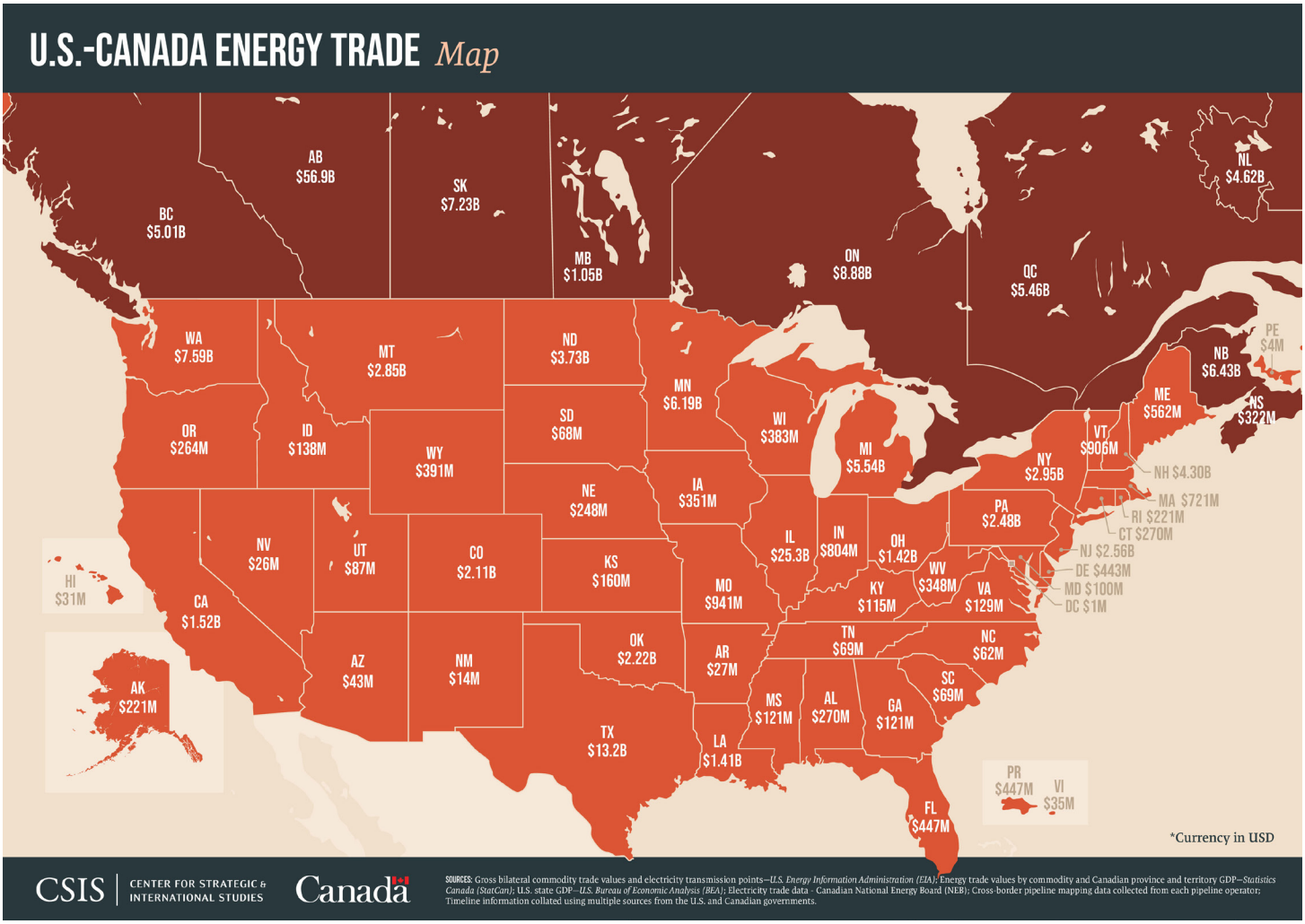
The United States and Canada are each other's largest energy trading partners as measured by the value of energy commodity trade, which in 2017 stood at U.S.$95 billion. The energy relationship between the two countries extends beyond just the trade of commodities, encompassing a variety of common, though not always identical, economic, security, and environmental priorities.

In March 2018, the CSIS Energy and National Security Program undertook a project with the Embassy of Canada in the United States to create a physical map depicting the U.S.-Canada energy trade relationship. The following CSIS brief explains the various aspects of the energy trade relationship using this map , as well as highlights some of the important issues in the development of this partnership moving forward.

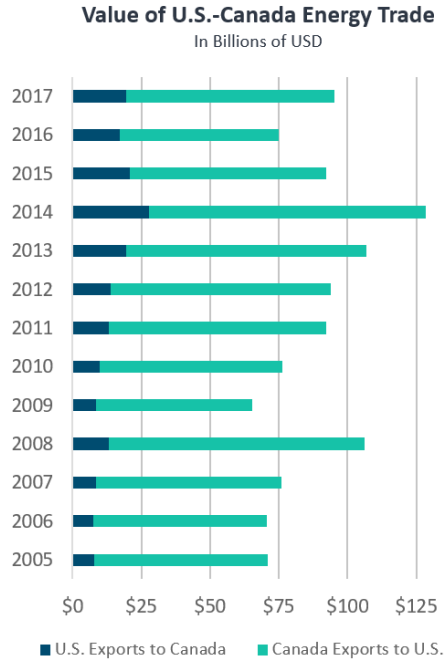


THE VALUE AND BREAKDOWN OF BILATERAL ENERGY TRADE

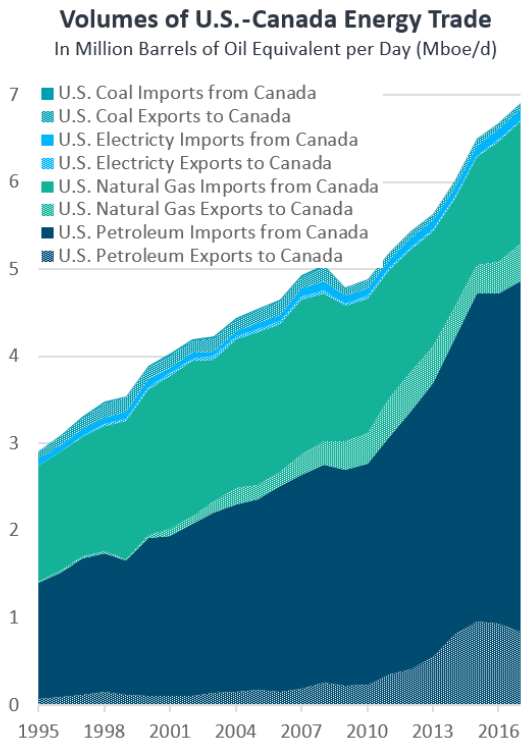


The first layer of the map presents the gross bilateral energy trade value for each U.S. state with Canada and each Canadian province with the United States. The value, measured in U.S. dollars and calculated on a customs basis, is the aggregated gross value of exports and imports of crude oil, refined petroleum products, natural gas, electricity, coal, uranium, and fuel ethanol in 2017. Of significant note on the Canadian side is the center of Canadian oil and gas production, Alberta, which recorded $56.9 billion worth of commodity imports and exports to and from the United States last year. In the United States, Illinois ($25.3 billion) and Texas ($13.2 billion) were the largest states in terms of energy commodity trade with Canada in 2017.

Even though the overall balance of trade between the two countries is relatively level (with the United States registering a goods and services trade surplus of $8.4 billion in 2017), Canada has a significant surplus in energy commodity trade with the United States, with $75.62 billion in energy commodity exports from Canada to the



Data Source: Statistics Canada.



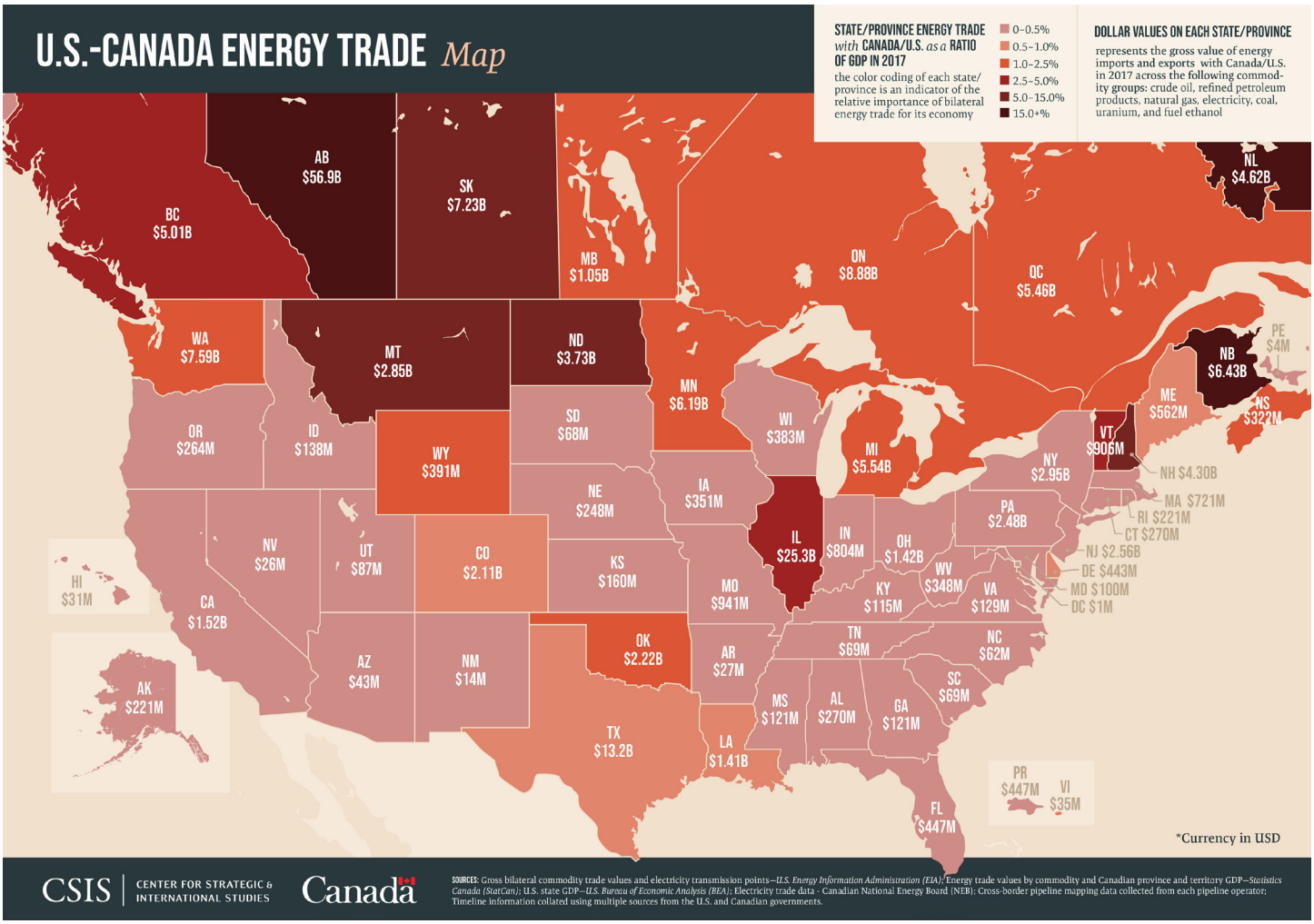
Data Source: U.S. Energy Information Administration (EIA).

United States in 2017, nearly four times the $19.64 billion worth of energy commodity exports from the United States to Canada.

While the cumulative volume of energy trade between the two countries has consistently risen year over year (with the exception of 2008–2009 when the financial crisis hit), the value of trade has reached higher levels in the past. The reason for this is that the values dramatically fluctuate due to the changes in prices of energy commodities, with the price of oil having the most significant impact on these values.

MEASURING RELIANCE AND INTENSITY OF ENERGY TRADE

The second layer of the map provides a color code ranking system, which depicts the gross bilateral energy trade value for each state and province as a ratio of its gross domestic product (GDP). This trade to GDP ratio provides an indication as to the relative importance of the bilateral energy trade relationship for the economy of each state and province. This ratio is calculated by dividing the dollar values on each state (i.e., the annual sum of energy imports and exports for each



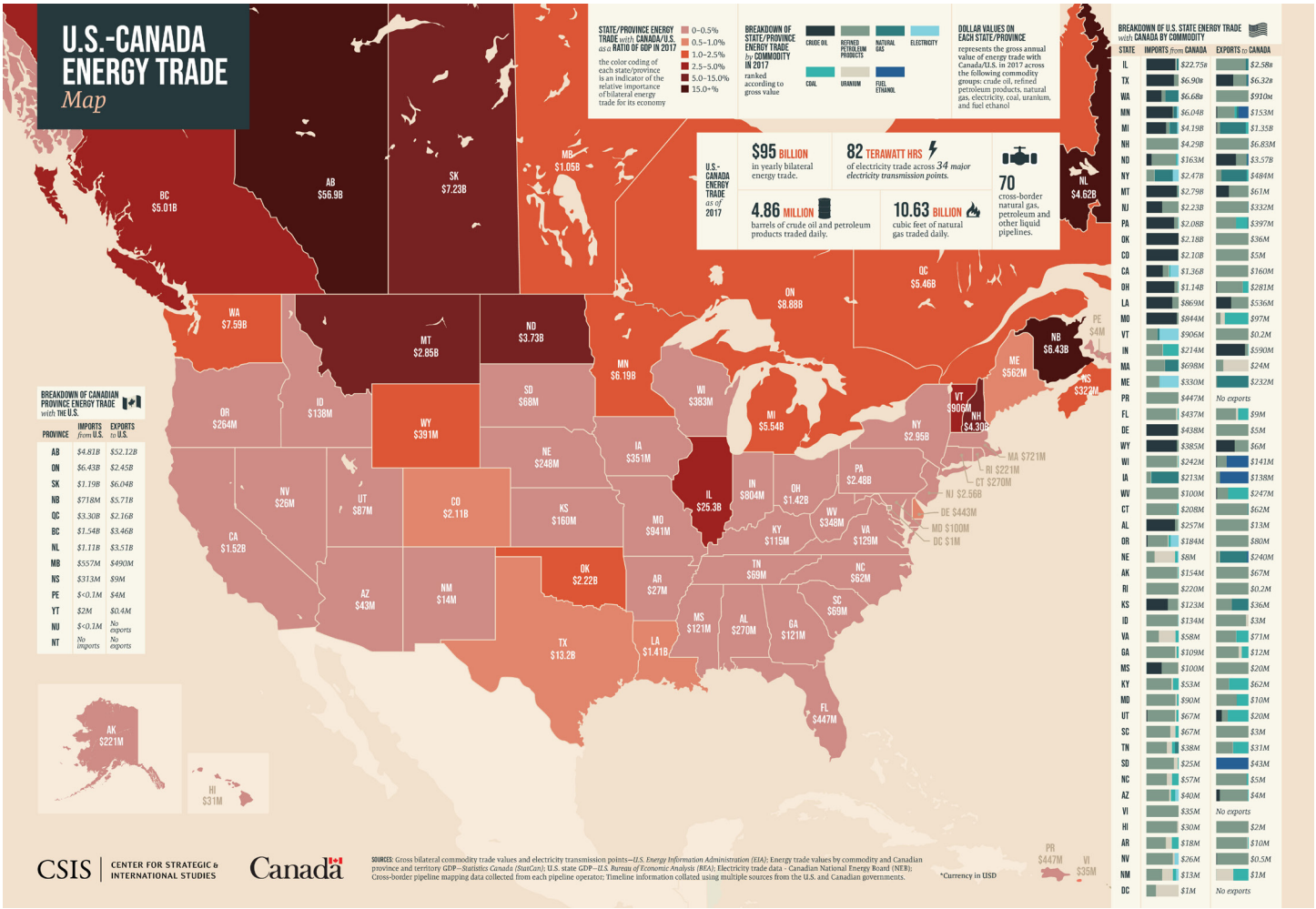
state/province within Canada/United States) by the gross domestic product of each state for the same period.

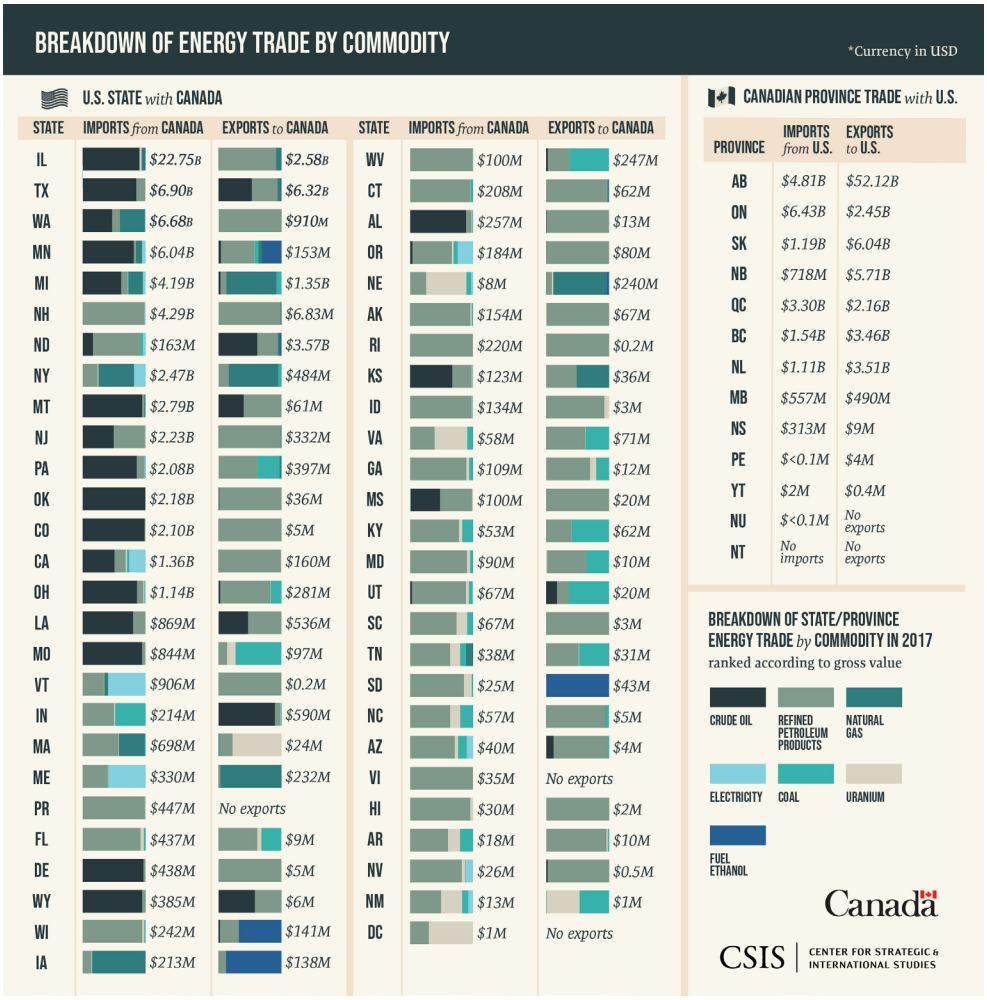
Working as a heat map, the use of this metric has helped to visualize the areas of energy intensive trade and the relative importance of cross-border energy trade for each state and province. By representing the combined weight of total energy trade in the economy of each state and province, this metric (in conjunction with the specific breakdown of imports and exports displayed in the next layer) helps us to understand the level of dependence of domestic energy exporters on the market across the border and the degree of reliance of state or province energy importers on U.S. or Canadian supply of energy.

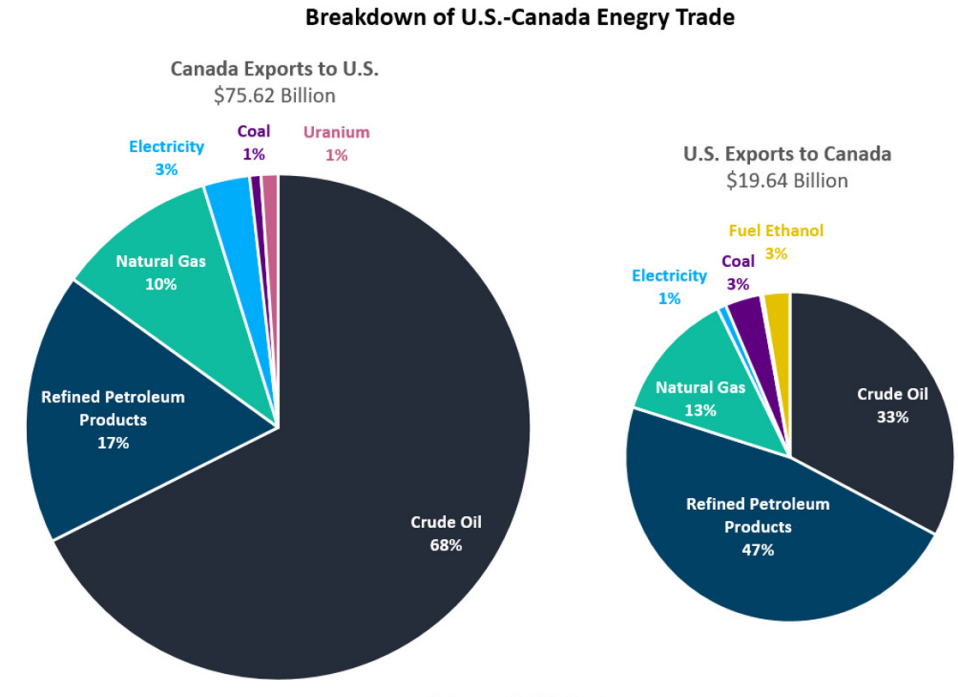
Because the denominator is GDP, large economies such as New York rank relatively low on the scale, even though the aggregate energy trade figure is one of the highest in the United States. Conversely, states and provinces with smaller economies, such as Montana in the United States and New Brunswick in Canada, rank highly on the scale. For example, even though Montana and New York register roughly the same gross energy trade value of $2.85 billion and $2.95 billion respectively, Montana's energy trade with Canada as a ratio of its GDP registers at 6.16 percent while New York's stands at just 0.2 percent. Exceptions to this on the U.S. side include Illinois, which ranks relatively high on the scale because its energy trade value with Canada is the largest and nearly double that of Texas, the next largest state in terms of trade. In Canada, Alberta is the third-largest economy, yet its energy trade value with the United States as a ratio of its GDP comes in at 24.4 percent, the second-highest ratio on the map just behind New Brunswick (25.37 percent). Geographic proximity also plays a crucial role in determining how important the energy trade relationship is for each state and province, with most U.S. states that have a high ranking on the scale being located close to the border.

THE BREAKDOWN OF ENERGY TRADE BY COMMODITY

The next layer of the map provides the breakdown of imports and exports of energy for each state/province, and for the United States the breakdown of the type of commodities traded. The states and provinces on these tables are ranked according to the corresponding dollar values found on each respective state and province.







Data Source: Statistics Canada.

Looking first at the breakdown of energy trade by each U.S. state on the right-hand side of the map, the first thing of note is that the bar charts are dominated by the colors black (crude oil) and light green (refined petroleum products). The states in the top third of the table primarily import large quantities of crude oil from Canada, with 68 percent of all U.S. energy imports from Canada in 2017 being made up of crude oil. This crude oil primarily goes to refineries in the Gulf Coast and the Midwest where it is processed into end use petroleum products. The U.S. export column is for the most part populated with light green (with a few notable exceptions), meaning that the United States predominately exports refined petroleum products due to its large refining industry. With 47 percent of the value of U.S. energy exports to its neighbor consisting of refined petroleum products, the balance of trade between the U.S. and Canadian refinery industries is more level. In fact, on a volumetric basis the United States exports more petroleum products to Canada than Canada does to the United States, but since Canadian exports tend to be finished transportation fuels while U.S. exports typically consist of pentanes and liquefied petroleum gases, the total value of Canadian exports registers at a greater level. It is for this reason that the balance of trade figure that we looked at in the first layer provides limited insight with regard to the complexity of the energy trade relationship between Canada and the United States. Sixty percent of the energy trade deficit with Canada originates from the importation of crude oil, and

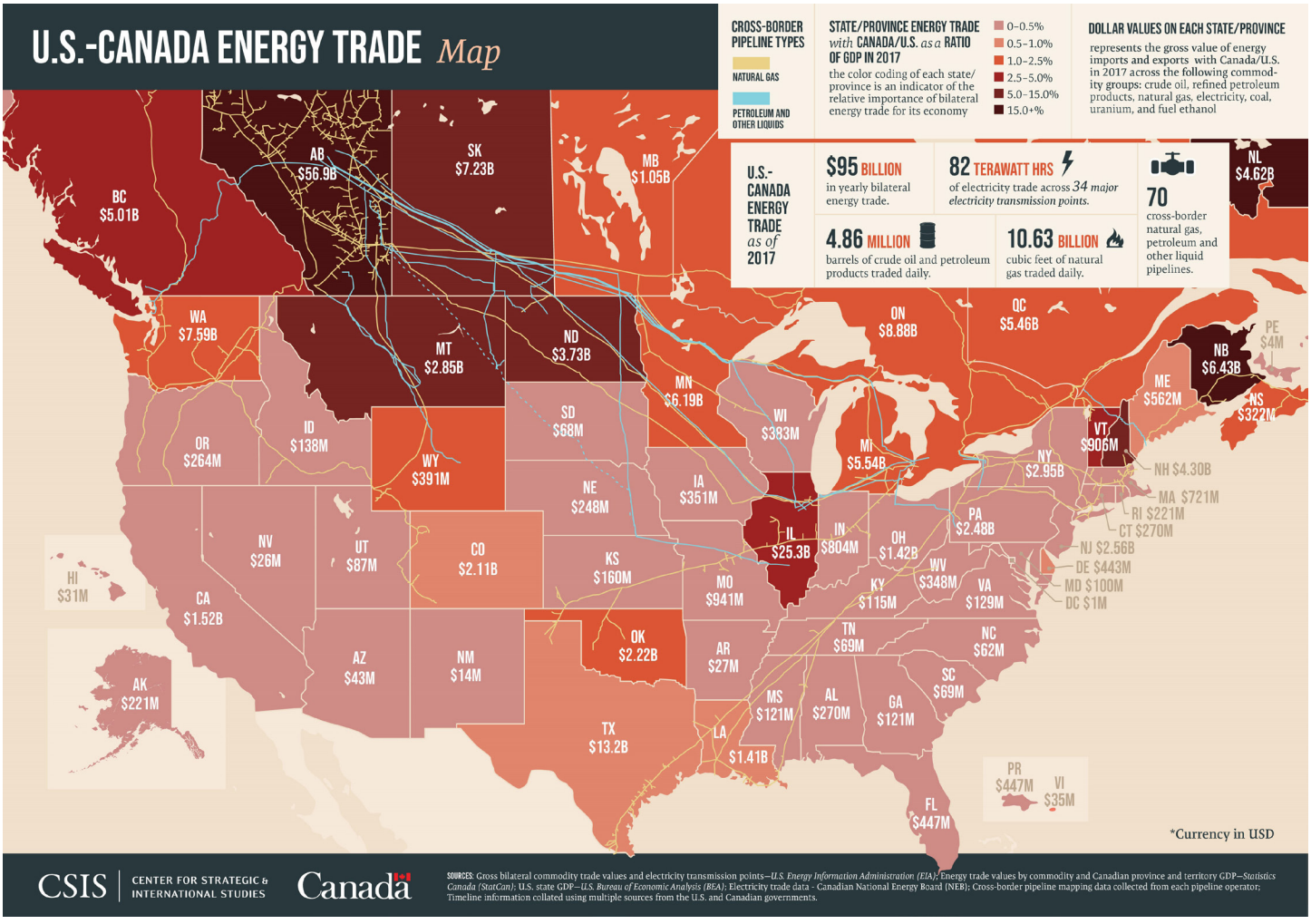
because of the sheer size of U.S. refining capacity, the United States has a value-added component to these imports by processing Canadian crude into finished products that are either consumed domestically or exported abroad (which in some cases includes to the Canadian market).

In terms of Canada's breakdown of imports and exports by each province, we can see that its exports primarily come from Alberta, Saskatchewan, and New Brunswick. These provinces record large energy trade surpluses, with Alberta and Saskatchewan accounting for the majority of Canadian crude oil exports and New Brunswick a significant quantity of Canadian refined petroleum product exports from Irving Oil's Saint John refinery, the largest of Canada's refineries. Manitoba, Ontario, and Quebec on the other hand record energy trade deficits with the United States.

While the vast majority of energy trade between the United States and Canada is made up of crude oil and refined petroleum products (constituting $80 billion of the $95 billion of energy commodity trade in 2017), the two countries do also trade significant quantities of natural gas, electricity, uranium, coal, and fuel ethanol. Of the over $10 billion of natural gas trade in 2017, the majority of this came in the form of exports from Western Canada to Washington State, Illinois, and New York, while the United States exported $2.5 billion of natural gas, primarily via Michigan. In terms of the $870 million of uranium that was traded in 2017, the majority of this was made up of exports from Canada, which predominately went to Illinois, but smaller quantities found their way to nearly every single U.S. state on the map. Finally, coal and fuel ethanol are two energy commodities in which the United States has a trade surplus with Canada. U.S. exports of coal primarily came from West Virginia, Pennsylvania, and Missouri and fuel ethanol chiefly from Iowa, North Dakota, Texas, and Wisconsin. Finally, electricity accounted for $2.4 billion worth of trade, the breakdown of which is further explored in the fifth layer of the map.

CROSS-BORDER PIPELINES

The map also displays major cross border pipelines, which we define as any pipeline that (1) carries petroleum liquids (including refined petroleum products) or natural gas; (2) crosses the U.S.-Canadian border; and (3) is classified as a single infrastructure asset by either the



pipeline owner or the relevant regulating agency (i.e., the National Energy Board in Canada or the Pipelines and Hazardous Materials Safety Administration in the United States). Once the relevant pipelines were identified, their positions were then traced and plotted using maps from three sources (listed by priority): (1) survey documents produced by the pipeline owners; (2) the U.S. Energy Information Administration's "Energy Infrastructure with Real-Time Storm Information"; and (3) the Canadian National Energy Board's "Interactive Pipeline Map." Finally, although not visually displayed on the map, we also collected information on the direction of commodity flows through each pipeline and their maximum capacity as measured in terms barrel of oil equivalent per day. These measurements are outlined in the table below.

By adding the positioning of the various pipelines to the map we can see the link this has to the energy trade to GDP ratio for each state and province. As previously mentioned, geographical proximity plays an important role in determining how reliant a state is on the energy trade relationship, with states that are more heavily reliant typically located close to the border. However, by adding the pipelines, we can also see that states that are well connected to the Canadian market by pipeline tend to be the ones that rank highly on this scale because they have the required infrastructure to import and export natural gas and petroleum economically.

While cross-border pipeline expansion efforts continue today, development has slowed considerably in recent years with pipelines becoming a politically contentious issue in both countries for both local environmental concerns and the broader issue of climate change. In the United States, opposition to the development of midstream infrastructure has become a rallying point for the environmental community to create pressure on the government to take further action on reducing emissions, through the federal presidential permit process, by which the State Department works to determine whether the pipeline is in the national interest. This has been most notably demonstrated with the proposed Keystone XL pipeline, which seeks to link Canadian oil sands and Bakken shale oil to Gulf Coast refineries (marked on the

Major U.S.-Canada Cross-Border Pipelines

Natural Gas Pipelines	Maximum Capacity (Boe/d)	Direction of Flow to
Transcanada Canadian Mainline	896,552	USA
Northwest Pipeline	655,172	USA
Foothills	517,242	USA
GTN	500,000	USA
Panhandle Eastern Pipeline	482,759	Canada
Northern Border Pipeline	413,793	USA
Great Lakes Gas Transmission	413,793	USA
BC Pipeline System	413,793	USA
Tennessee Gas Pipeline	379,310	Canada
Alliance Pipeline	275,862	USA
Vector Pipeline	224,138	Canada
Maritimes and Northeast Pipeline	143,103	USA
Trans-Quebec and Maritimes Pipeline	137,931	USA
Iroquois	86,207	USA
Empire Pipeline	86,207	USA
Viking Pipeline	86,207	USA
Portland Natural Gas Transmission System	36,207	USA
Vermont Gas	10,345	USA
Canadian-Montana Pipeline	1,724	USA
North Country	1,724	USA
NGTL	N/A	USA

Petroleum Liquids Pipelines	Maximum Capacity (Boe/d)	Direction of Flow to
Keystone XL*	830,000	USA
Alberta Clipper	800,000	USA
Line 4	796,000	USA
Keystone	590,000	USA
Line 78	570,000	Canada
Line 5	540,000	Canada
Line 2b	442,000	USA
Line 3	390,000	USA
Enbridge Express	280,000	USA
Portland-Montreal Pipeline	280,000	Canada
Line 1	237,000	USA
LSR (Line 65)	186,000	USA
Puget Sound / Trans Mountain	180,000	USA
Southern Lights	180,000	Canada
Front range	150,000	USA
Line 26	145,000	Canada
Philips 66	126,000	USA
Cochin	95,000	Canada
Whiting-River Rogue	80,000	Canada
Kiantone	74,200	USA
Buffalo	74,000	USA
Vantage Pipeline	68,000	Canada
Mariner West	50,000	Canada
Plains Midstream Canada ULC	30,000	USA
Poplar System	30,000	USA

*Propsed pipeline

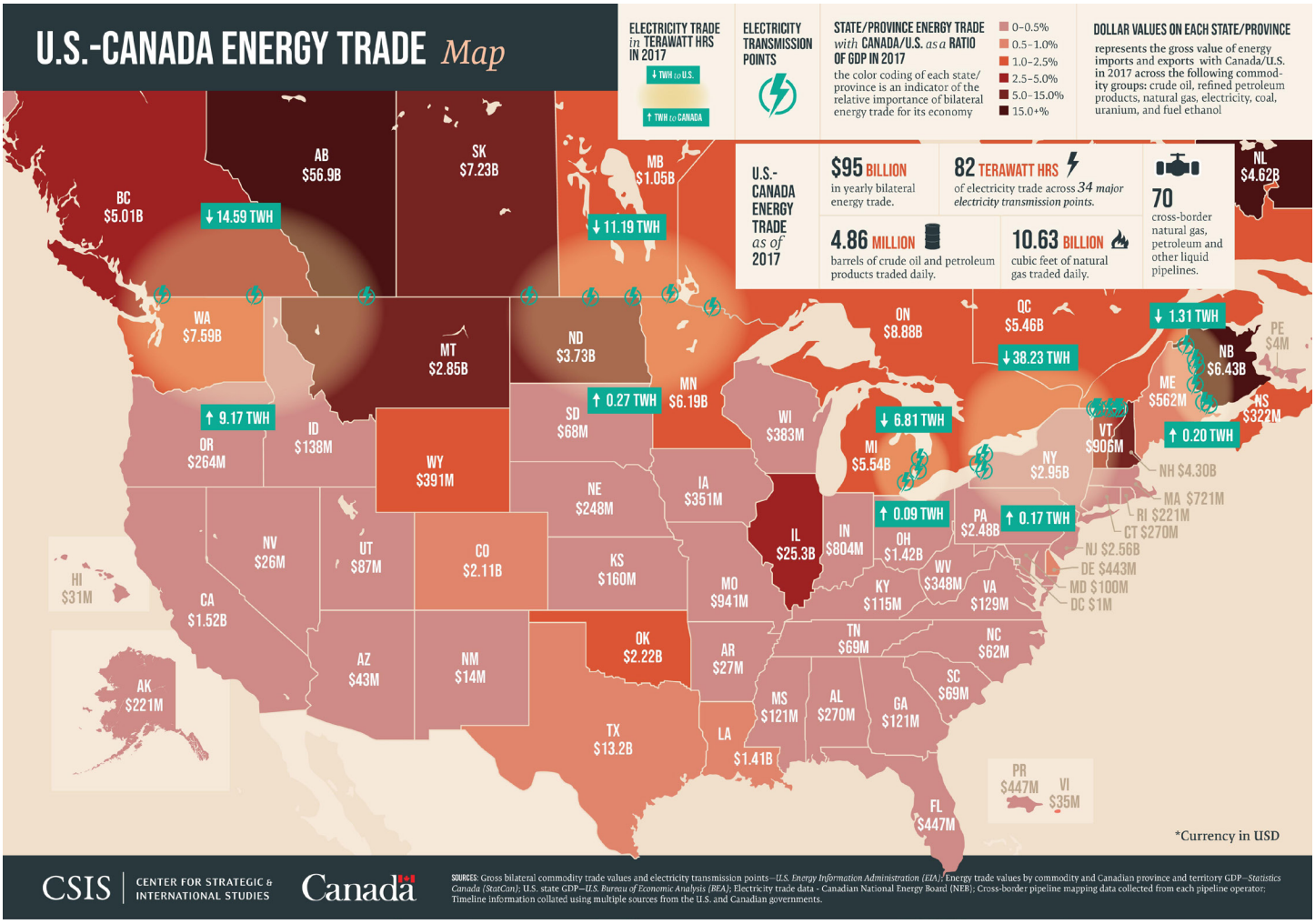
Data source: Individual pipeline operators.

map by the blue-dotted line). This cross-border pipeline was first proposed over 10 years ago but has been held up ever since. Pipeline construction and expansion delays such as those with Keystone XL and Line 3 have made it more difficult for Canadian oil sands producers to send oil to the Gulf Coast refineries that are configured to run on heavier grades of crude oil. Canadian heavy crude is important for those refiners, particularly now given the dramatic fall in Venezuelan exports that have traditionally been a major import source. These factors have led to a recent uptick in the amount of oil being transported from Alberta via railroad. It has also encouraged Canadian regulators and oil and gas stakeholders to seek expanded outlets to market through the east and west coasts of Canada rather than through the United States.

ELECTRICITY TRADE

The fifth layer of the map concentrates on electricity, an increasingly integrated component of the energy trade relationship. In 2017 electricity trade between Canada and the United States amounted to 82 terawatt hours, the equivalent of the total amount of electricity generated by a country such as Belgium. This layer of the map includes markers that pinpoint the location of the 34-major cross-border electricity transmission points (plotted using the North American Cooperation on Energy Information's North American Infrastructure Map), as well as five regional breakdown markers providing an indication as to where cross-border electricity trade is concentrated.

Starting in the West with the second most intensive area of cross-border electricity trade, British Columbia and Washington, and to a lesser extent Alberta, Oregon, and Montana, export electricity across the border. Both British Columbia and Washington, due to their rich hydropower resources, are the dominant players in this region for electricity trade, with Washington exporting 8.62 terawatt hours (TWh) in 2017 accounting for 87 percent of all U.S. electricity exports to Canada. These exports primarily went to British Columbia and to a lesser extent Alberta. British Columbia accounts for roughly 95 percent of the 14.59 TWh of Canadian electricity exports in this region, with approximately 75 percent of these sales ending up in California, 10 percent in Oregon, and the remaining 15 percent in Washington. The next electricity marker



connecting Saskatchewan, Manitoba, and Ontario with North Dakota and Minnesota primarily consists of Manitoba exporting electricity to both U.S. states. The electricity marker connecting Michigan with Ontario is predominately made up of Ontarian exports to Detroit. The fourth electricity marker makes up approximately half of all cross-border electricity trade in 2017, the majority of this came in the form of exports powered by hydro from Quebec to Vermont (11.95 TWh) and New York (10.39 TWh). Ontario also exported 8.22 TWh to New York, and 1.4 TWh of electricity exports from New Foundland and Labrador made its way onto the grids of New England and New York. The final marker is made up of cross-border electricity sales from New Brunswick to Maine.

U.S.-Canada Cross Border Electricty Trade by State and Province

	MWh	MWh	MWh	Total TWh
Marker 1	**British Columbia**	**Alberta**		
Arizona	75,439			
California	10,610,049	7,038		
Idaho	35,100	140		
Montana	22,937	503,266		
Nevada	54,755			
New Mexico	9,188			
Oregon	1,652,860	1,951		
Texas	520			
Utah	10,090			
Washington	10,090,017	685,375		
Wyoming	928			
Nebraska		8,786		
Total				23.77
Marker 2	**Manitoba**	**Ontario**	**Saskatchewan**	
Minn/N.Dakota	10,112,007	1,043,440	303,304	
Total				11.46
Marker 3	**Ontario**			
Michigan	6,884,374			
Indiana	10,510			
Ohio	3,599			
Total				6.90
Marker 4	**Quebec**	**New Foundland and Labrador**	**Ontario**	
Maine	3,868,572			
New England ISO	1,436,976	428,645	686,945	
New York	10,491,344	970,524	8,265,432	
PA/NJ/MD			180,180	
Vermont	11,977,768		95,669	
Massachusetts			3,024	
Total				38.41
Marker 5	**New Brunswick**	**Nova Scotia**		
Maine	1,434,715	78,991		
Total				1.51
Total				82

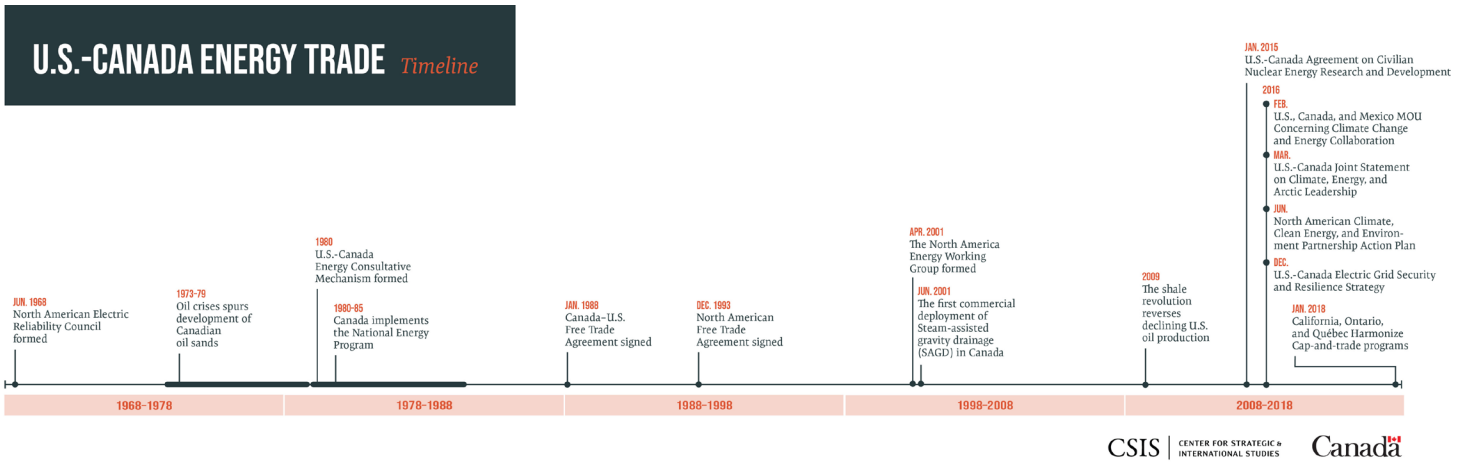
Data source: National Energy Board of Canada.

Increasingly integrated power grids and rising electricity trade have provided economic and energy security benefits for both the United States and Canada. While Canadian electricity sales to the United States made up just 2 percent of total U.S. retail sales in 2017, the transmission connections are an important component of electricity markets for northern states along the border. With the majority of electricity trade between the two countries coming from hydropower generation in Canada, U.S. states particularly in the Northeast have been able to take advantage of a cheap source of energy supply, while Canadian utilities have been able to find outlets for excess generation. This mutually beneficial, codependent relationship also exists in the Pacific Northwest with excess hydropower generation in Washington State finding markets across the border in British Columbia.

Efforts to further integrate the two grids is ongoing through various transmission projects, which seek to advance cross-border electric system reliability, reduce costs, and lower emissions. These efforts have been exhibited by the relatively recent development of the Montana-Alberta Tie Line, allowing for bidirectional flow of power from wind sources on both sides of the border, thus helping to address intermittency issues of renewables, and the proposed New England Clean Energy Connect, which would connect hydropower sources in Quebec with New England in a bid to lower costs for consumers and help states better meet their renewable portfolio standards.

CONCLUSION

This map provides a snapshot of the energy trade relationship between the United States and Canada, broken down by fuel and states/regions. As detailed as it is, the map still does not convey the full complexity or strategic importance of this relationship. For decades, as part of the quest for greater energy security, the United States and Canada, along with Mexico, have worked together to cultivate the kind of economic and security advantages that come with an integrated, close-proximity market for energy trade. Trade arrangements have been signed, cross-border infrastructure has been



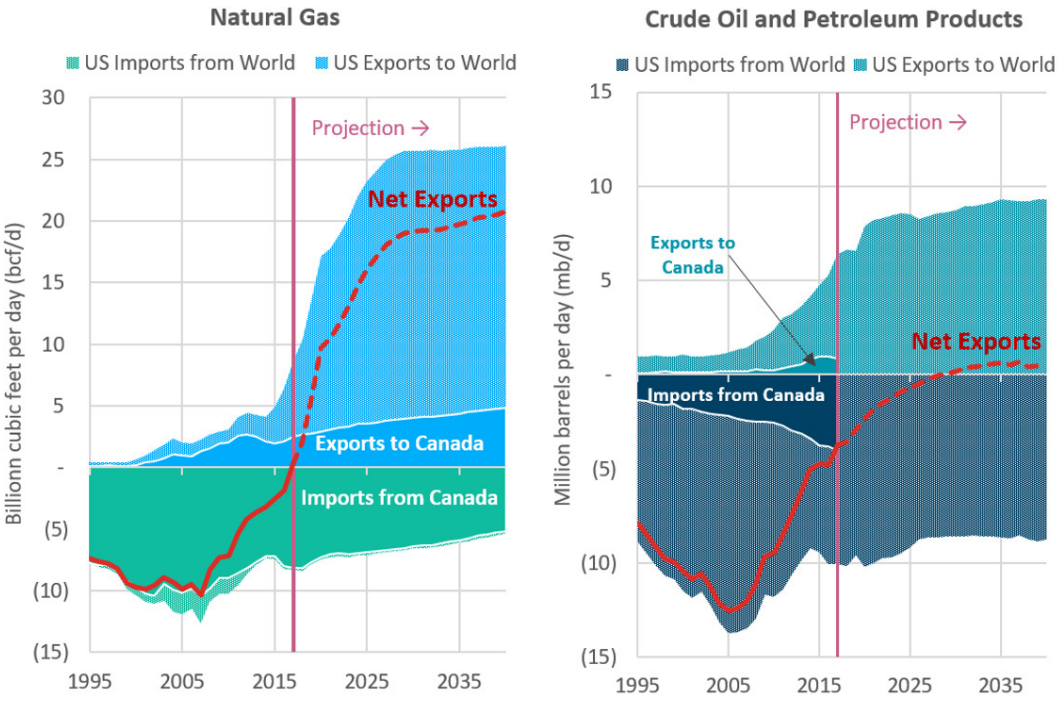
built, various consultative working groups, mechanisms, and dialogues were formed to raise energy policy and regulatory issues, and even efforts have been made to harmonize standards relating to electricity reliability and security, offshore drilling safety, and a host of other issues. In a bid to highlight some of these efforts, the final layer of the map includes a timeline of significant milestones in the energy trade relationship between the two countries.

Going forward, the energy landscape is shifting in both the United States and Canada. The lower 48 U.S. states, particularly Texas, are undergoing an oil production boom that is reshaping the nation's oil supply and demand balance, which has impacted current and projected trade with Canada across the oil and natural gas landscape. Rather than consider U.S. and Canadian oil and gas production for U.S. consumption, the resources that the continent produces together will increasingly meet the needs of both countries and growing export markets.

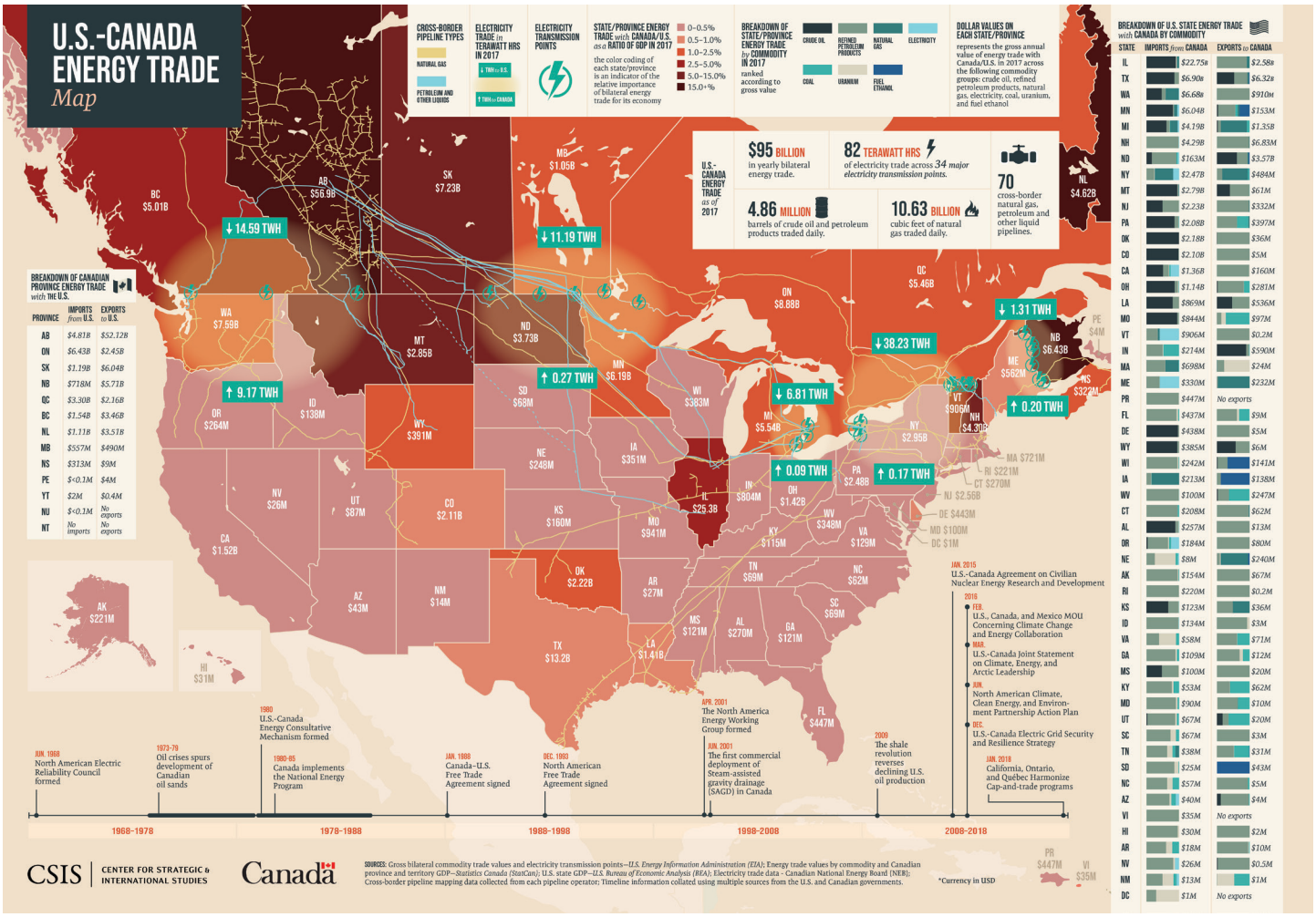
Energy supply changes are only half of the story. Total primary energy demand on the continent is less than it was a decade ago, and a combination of policies, regulations, and cost declines for various power generation, transportation, and energy end-use technologies are changing the way energy is consumed throughout North America. While the continent is deeply integrated for the energy systems of today, it will no doubt continue to change as regional power markets and infrastructure evolve to incorporate new technologies, capabilities, and preferences, like electric vehicles, smarter appliances for homes and grids, and a cleaner, more flexible mix of central and decentralized power generation, storage, and demand response options.

Thanks to historical as well as ongoing efforts to optimize the continent's energy resources across

U.S. Natural Gas and Petroleum Trade



Data source: U.S. Energy Information Administration (EIA).



borders, North America is now one of the most energy-advantaged continents on the planet, with attributes that extend beyond just the domestic resource base but include aspects that relate to cooperative political, legal, and economic frameworks that incentivize transborder private-sector development of energy resources and expansive cross-border trade. To continue this long and successful track record on energy market integration, both countries should seek to modernize the North American Free Trade Agreement (NAFTA) and other energy consultative mechanisms to prepare for the future; conduct regionalized infrastructure discussions to consult with local stakeholders on long-term energy plans and overcome contentious permitting issues; and jointly assess and address vulnerabilities to continental energy security.

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ENDNOTES

1 All energy trade values presented in this paper were collected from Statistics Canada and calculated by Statistics Canada or the U.S. Census Bureau. These values are calculated on a customs (census) basis. Customs-based trade data aims to capture the movement of goods across the border, both outgoing (exports) and incoming (imports). For customs-basis Canadian import data, the U.S. state within which the good was extracted, produced, or last processed determines the trading partner. For customs-basis U.S. import data, the Canadian province or territory within which the good was extracted, produced, or last processed determines the trading partner. For example, crude oil produced in Texas and exported to Canada, which passes through other states, registers as exports from Texas (but if that crude oil from Texas were to be refined in another state before being exported to Canada, then those refined product exports would register with the state where the crude was refined). Canadian import data are collected via electronic transmission of Canada Border Service Agency (CBSA) B3 forms. U.S. import data are collected via electronic transmission of U.S. Census Bureau data compiled from U.S. Customs and Border Protection documents. Since 1990, Canada and the United States have exchanged import data; the import data of one partner country are used to derive the export data of the other. Canada's exports to the United States are compiled using U.S. import statistics. U.S. exports to Canada are compiled using Canadian import statistics. The following link provides more information on the sources and methodology used to calculate these values: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=2201.