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EXECUTIVE SUMMARY

Canada, the United States and Mexico would benefit from a trilateral carbon exchange. As diverse as each country is, they are also very interdependent, except when it comes to their energy markets. A collaborative carbon exchange would improve all their energy systems, strengthening the combined response to energy and environmental security. Sustainability and security are the goals for all three governments, regardless of how different the path to that sustainability and security may be. This paper outlines the benefits and challenges of a North American carbon exchange and proposes policies and actions to create a sustainable and beneficial way forward.

The challenges of climate change are a common issue for all three North American governments. The effects of climate change impact all economies, from employment to quality of life and the provision of essential services. Rising costs and scarcity of domestic and international energy, compounded with effects of international events on the supply chain, are just some of the energy challenges facing the North American countries. The mutual benefits resulting from a trilateral carbon exchange can help mitigate these challenges and provide more reliable energy security.

North America has many hydrocarbon reserves and underused energy resources. Between the three nations, there is also a wealth of technology and information that together could create a more resilient and secure continental energy system, capable of facing the increasing impact of climate change and growing energy demand.

In order for this to happen, all three countries must commit to becoming more dependent on renewable resources and lower carbon non-renewable resources. All stakeholders must participate to ensure a successful result. This includes creating a North American carbon exchange task force, with government representatives from each country, to lay the foundation for the carbon exchange, setting up a trilateral trust fund to finance the task force's work and full transparency.

The task force's job would include setting tri-national baselines and caps per industry, creating a unified regulatory framework to ensure all industries in all jurisdictions have the same compliance and regulatory costs and setting up an independent trilateral regulatory panel.

The result would be sustainability strategies that work toward decarbonization while maintaining competitiveness, standardized regulations that reduce the cost of compliance and a move towards a low-carbon future and new markets, triggered by opportunities for new technology and services to meet the decarbonization goals.

With the right policies and actions, Canada, the United States and Mexico could create a successful North American carbon exchange that would provide a sustainable, secure, reliable continental energy system to benefit all involved.

ABSTRACT

Mexico, the United States and Canada are three of the world's most productive, diverse and interdependent economies in the world. In terms of energy systems, however, the three countries are incompletely interconnected and integrated in terms of infrastructure, reserves, operations and standards. This imposes costs, performance and security risks that affect GDP, labour and financial markets that could be mitigated through closer co-operative energy systems planning and interdependence.

Future energy challenges facing the three countries, individually and collectively, are formidable. These include rising costs and increasing relative scarcity of both domestic and imported energy supplies, as well as environmental externalities associated with energy production and consumption. The three nations collectively possess a wide range of hydrocarbon reserves, underused non-renewable and renewable energy resources and untapped production and utilization technologies necessary for meeting future energy needs and mitigating the increasing impacts of climate change.

Some co-operation is emerging between nations, such as the commitments from all three countries under the UN Climate Accord. Signed and announced in 2021, the commitments include 2030 targets on the path to net-zero emissions by 2050. While the adoption of global and sectoral carbon reduction goals by all three jurisdictions is positive, these commitments, supported by a tri-national carbon trading exchange, would incentivize the greater integration of North America's energy markets through increased use of the lower carbon energy resources and technologies available in each jurisdiction.

The result can be a more resilient energy sector, capable of meeting future demands for transportation, industry, heating and lighting loads that displace historically conventional energy supplies with renewable generation and alternatives that can support a future decarbonized region and world economy.

POLICY RECOMMENDATIONS

North America has one of the largest functionally integrated but not fully co-ordinated energy and commodity markets in the world. All three North American jurisdictions face common threats from climate change to sustaining their future energy security to ensure the economic and social well-being of their citizens.

Using climate change as the focus for common action in terms of carbon management offers important positive outcomes for all three nations. Through greater collaboration and co-operation, they can take advantage of their combined wealth of non-renewable and renewable energy resources, production and utilization technologies and know-how to mitigate these risks and transition to more sustainable and secure continental energy systems to meet their future energy needs.

Establishing a North American carbon exchange would provide standardized and verified carbon trading transactions that would incentivize greater integration of continental energy systems. The underlying value of the transactions would be supported by the three countries setting an agreed baseline for carbon emissions from the energy sector as well as a cap for energy sector emissions. By focusing on the common denominator of carbon emissions and accounting, we believe it is possible to arrive at a system that offers net economic benefits and better information to underpin policy and regulatory outcomes. Addressing the challenge of climate change will necessitate all three nations shifting their energy demand and supply to greater integration and dependence on their collective renewable resources and lower carbon non-renewable resources.

The success of a North American carbon exchange depends on all three jurisdictions committing to energy transition towards a low-carbon economy, seeking the commitment and participation from all stakeholders and full transparency to encourage opinion exchange and facilitate trust and common ground for all parties involved.

INTRODUCTION

North America represents a complex physical, financial and political landscape. Bordered by three oceans, situated primarily below the Arctic Circle and above the Tropic of Cancer, the land mass in North America occupies 9,500,000 square miles of territory and spans eight time zones. The three principal countries, Canada, the United States and Mexico, have significant economic interdependence and trade, guided by the United States-Mexico-Canada Agreement (USMCA). The three nations also possess key economic and natural resources including abundant supplies of both renewable and non-renewable energy.

While there is no comprehensive integration of energy systems in North America, there is a patchwork accumulation of economic and trade-driven infrastructure links including pipelines, electricity interconnections, virtual and physical storage, ports and rail access providing for significant regional transfers of energy between the three jurisdictions.

This array of physical infrastructure and trading relationships includes investment markets, cross-border pipelines and electrical transmission systems that link the three countries, enabling continuous flows of energy and capital throughout the region. These historical,

and in some regions increasing connection paths, however, are limited. They do not, for instance, co-ordinate common planning, oversight and expansion of the potential continental energy systems needed to support future growth and development in the context of increasing existential threats of climate change and global insecurity.

The underlying reasons are obvious. The political and cultural values and institutional frameworks of the three nations are different, from expectations about growth and investment to approaches that address environmental and climate impacts on energy systems. While these values and structures are sufficiently different between the nations to negate any attempt to unify or integrate objectives like the European Union, there are many examples of specific energy policy and regulatory co-operation and co-ordination accords between the three countries — water systems such as the Columbia River Treaty, concordance with the North American Electricity Reliability Corporation (NERC) electricity control standards and the energy chapter of the USMCA.

Energy supplies, infrastructure and delivery capability are fundamental to every nation's security and economic well-being. When economic dependency and geographic proximity are both obvious and important, we believe it is worthwhile to explore the potential to improve and integrate energy systems between the three nations to continue to support North America's security and well-being. While we do not suggest, or support, the imposition of a new standard energy market for any of the countries in North America or their states or provinces, we instead consider a common thread based on those markets. This common thread can enable and incentivize more cross-border trading, set an environmental standard consistent with a net-zero carbon future and expand both gross and net economic trading while improving regional energy security, taking advantage of all three nations' status and independent power.

Controlling carbon emissions requires a long-term systemic approach to land use, policy directives and investment market incentives. While this is widely acknowledged (e.g., COP 24, 25, 26), common definitions, standards and co-ordinated actions have been notoriously difficult to organize. Existing regional programs, such as California's Low Carbon Fuel Standard (LCFS) program, the Western Climate Initiative or the Regional Greenhouse Gas Initiative, have had regional and even some international co-operation and success but have not been emulated widely. These existing regional and state markets are incomplete, and rely prematurely on a premise of control that is prescriptive and normative. They simply cannot scale.

We believe that the stalemate facing the expansion of these laudable initiatives lies in the inherent conflict between policy-making regimes and regulatory institutions where standards and rules are implemented. This implies the need for a better common denominator as the framework for both working together across political and geographic boundaries and also, at the onset, some device or agreement where co-operation has some positive economic benefits that accrue to long-term adherence to standards.

All of the existing regulatory initiatives are constrained by an inability to impose standards or offer benefits beyond political or physical regional boundaries. Each initiative defines carbon compounds using proprietary language that is not fungible outside these defined trading or control areas. The missing link is a common denominator for carbon characteristics that allows time estimates of volume, transfer and control or retirement.

We assume that carbon markets will not be mandatory but believe that it will provide sufficient financial incentives that will ensure broad participation. These can emerge out of proposed platforms such as the USMCA, where there will be an opportunity to demonstrate the equivalency and value of carbon management and control technology.

While common commitment to a low-carbon economy is broader in scope, North America has realized past success in negotiating transboundary commitments to common environmental goals. In 1980, Canada and the United States signed a memorandum of intent concerning transboundary air pollution. It led to the 1991 Canada-United States Air Quality Agreement. The agreement included specific commitments by both countries to cut sulfur and nitrogen oxides emissions (Government of Canada n.d.(a)).

The success of a North American carbon exchange depends on the commitment of all three jurisdictions to these commonly accepted principles:

1. Energy transition towards a low-carbon economy is a priority

   Each jurisdiction would undertake consultation and consensus building to gain national and regional buy-in for such a policy.

2. Commitment and participation from stakeholders

   The commitment and participation from different stakeholders would be fundamental to make sure that the inputs, activities, outputs and outcomes result in successful implementation.

3. Transparency

   A commitment to full transparency would encourage opinion exchange and facilitate trust and common ground for all parties involved.

In sum, establishing a North American carbon exchange can provide standardized and verified carbon transactions and accounting. The result will initiate greater integration of continental energy systems. The underlying value of such transactions will influence every other economic sector in all three economies.

NORTH AMERICAN ENERGY INTEGRATION

Energy systems throughout North America operate in conjunction and co-operation with those in neighbouring nations but reflect each nation's unique cultural and economic strengths. For instance, demand for and use of cross-border energy transfers has led to widespread, but not complete, adoption of technical and regulatory standards (e.g., fuel characteristics, voltage and reserve characteristics). Emissions and environmental controls are left to the discretion of each national government; however, air and water systems are relatively porous and do not observe national or regional boundaries. Climate-driven changes have international repercussions and will not be fully addressed by individual nations alone.

Both Canada and Mexico share extensive physical borders with the United States, but the governance and rules that control commodity exchange differ in each case and, to some extent, also reflect variable U.S. state and Canadian province policy, rules and tariffs. The policy regimes reflect distinctly different expectations regarding energy exchange, and within each nation the jurisdiction, role, authority and responsibilities of regulation and oversight in energy matters vary widely. Nevertheless, the exchange of energy and other commodities plays a fundamental and critical role in the economies of the three nations, reflected by the monetary value of those transactions. It is fair to say that it would be difficult to provide needed domestic energy supplies without import and export access between countries; as well, the value of energy products is a key pillar in each of the three economies.

In terms of carbon waste, most cross-border attention and focus have been on emissions resulting from combustion of hydrocarbons, both liquid and gas. A recent publication from the American Petroleum Institute (API) illustrates this type of commentary based primarily on supply of raw materials and fuels and highlights the type of role such an industry tries to adopt in recognition of the issue(s) involved.

In its key takeaways from the study, the API concludes that integration of U.S. and Canadian petroleum markets strengthens the energy security of both countries (American Petroleum Institute 2021):

1. Increased imports of Canadian crude oil in tandem with booming domestic production have allowed U.S. refiners to significantly reduce crude oil imports from OPEC by 70 per cent from 2010 to 2019;

2. Increased imports from the U.S. have enabled a 68 per cent decline in Eastern Canada's imports from OPEC;

3. U.S.-Canada petroleum liquids trade doubled over the past decade, increasing from approximately 2.75 million barrels per day (b/d) in 2010 to 5.5 million b/d in 2019;

4. The trade relationship works both ways with each country relying on the other for approximately 15 per cent of total petroleum liquids supply.

In the U.S. Congress, research staff focused on growing the North American partnership and linked co-operation between Canada, Mexico and the U.S. to climate quality and stability, saying:

> To date, Congress has favored a growing North American energy partnership—but ensuring that this partnership continues to be as mutually beneficial as possible will likely remain a key oversight challenge for the next decades. Congress has been facing important policy questions in the U.S.-Canada and U.S.-Mexico energy contexts on several fronts, including the siting of major cross-border pipelines, increasing petroleum supplies from Canadian oil sands, exporting natural gas production from United States' shales, and meeting commitments to increase renewable energy supplies and reduce atmospheric emissions of greenhouse gases. Legislative proposals in the 115th Congress could directly influence these developments (Parfomak 2017).

A recent paper from Energy Strategies Review highlights the potential in terms of North American electricity integration, pointing out that:

> Expanding electricity trade between Canada and the U.S. could help both countries decarbonize their electricity systems more cost-effectively and enable both countries to leverage the most favorable low- and zero-carbon resources. For example, Canada has significant installed hydroelectric generation capacity and potential and is the third largest producer of hydropower in the world, while the U.S. has abundant solar resources. Similarly, electricity demand in most of Canada tends to be higher in the winter while load profiles in most of the U.S. peak in the summer. Hence, an expansion of electricity trade between Canada and the U.S. — enabled by cross-border transmission investments — could allow the North American electricity system to be decarbonized at a lower overall system cost. (Motalebia et al. 2022)In the second most recent installment of the U.S. Department of Energy (2017) *Quadrennial Energy Review*, there are a set of key findings with respect to electricity integration in North America, including benefits for both the U.S. and Mexico with its electricity utility industry reforms, that could have significant impacts on the future of cross-border integration:

- "The electricity reforms are focused on the overall goal of competitiveness, with the twin objectives of reducing electricity costs and developing more clean energy. A transition in Mexico from oil to natural gas in electricity generation could have significant impacts on the manufacturing sector, reducing electricity prices, boosting manufacturing output, and increasing overall gross domestic product for Mexico" (U.S. Department of Energy 2017).

- Mexico's increasing importation of U.S. natural gas could be an economic and environmental opportunity for both sides by offsetting expensive and high greenhouse gas–emitting diesel generation in Mexico and creating economic opportunities for U.S. exporters. The resulting reduction in electricity costs in Mexico could also boost overall North American competitiveness.

- California's ambitious clean energy policy provides an opportunity for energy exporters in Mexico, especially in the Baja California region, to supply clean energy, dispatchable power or essential reliability services.

Since energy in all forms is critical to support economic activity and underpin national security, all three governments recognized that addressing the threats that climate change pose to the sustainability of energy systems is a priority, albeit at different levels. The same paper comments:

> Both the U.S. and Canada have announced climate plans with ambitious emission reduction goals. The U.S. has set new targets, which include a 50–52% reduction from 2005 levels in economy-wide net greenhouse gas (GHG) pollution by 2030, and net-zero emission economy-wide by no later than 2050. This goal is to be accomplished by investing in infrastructure and innovation and fueling an economic recovery. In Canada, the plan titled "A Healthy Environment and a Healthy Economy" will increase the country's carbon tax by C$10/metric ton (mt) every year until 2030 starting in 2022. The Canadian plan includes C$15 billion in new investments in grid modernization,

green and inclusive community buildings, home energy efficiency upgrade grants, zero-emission vehicles program incentives, and more. Both plans place significant focus on both electrification and the decarbonizing of generation in the electric grid (Motalebia 2022).

These examples illustrate the range of tools policy-makers and regulatory institutions have devised to attempt to curtail and ultimately diminish the volume and impact of such gases. A related approach involves calculating the source and rate of emissions from various industries and initiating economic trading to enforce limits while offering incentives to firms with higher rates of success to auction off or trade excess carbon credits to less efficient firms. Often called compliance carbon markets, the technique creates virtual marketplaces where regulated entities can obtain, sell and surrender emissions permits (allowances) needed in order to meet predetermined regulatory targets.

There are examples of regional and national carbon taxes, charges and credits where governments calculate prices, equivalent values and trading equivalency for participants. These regulatory efforts exist with a high degree of variance in terms of their value or utility across industries or geography. In the aggregate, however, there is no standard for accounting for, banking or retiring these credits.

Given the breadth of the energy resources available and used throughout North America, the opportunity exists to establish a common trading arena for carbon credits. That arena could combine regulatory standards, estimates and reporting of emissions by industry, source or geographic location in a trading marketplace like the International Currency Exchange (ICE) or the New York Mercantile Exchange (NYMEX). Such an entity would serve as a timely and valuable step that could be taken by a pan-North American council focused on the energy system. In Box 1, we provide a conceptual approach for a North American carbon market.

The utility of a common accounting and credit value for emissions offers an opportunity to retain individual and unique national system characteristics, while opening a new economic marketplace that will support broader national, and even global, initiatives supporting a transition to lower impact energy systems.

In the following section, we discuss some of the unique political, cultural and physical attributes of the North American continent that present challenges and opportunities to implementation of a common information and economic carbon emissions exchange based on energy supplies and use patterns. We provide the rationale for tying the existing and emerging systems in transportation fuels, electricity and storage together based on equivalent values of use and control of externalities. While the North American energy system is not likely to ever emerge as a fully unified and seamless engineering model, energy demands, generation designs and control systems all operate with similar objectives and face similar challenges for controlling emissions in the face of meta regional and global impacts.

CHALLENGES AND OPPORTUNITIES TO NORTH AMERICAN ENERGY COLLABORATION AND CO-OPERATION

KEY DRIVERS FOR INCREASED CO-OPERATION

We frame our analysis of the opportunities for pan-North American co-operation potential in the context of two broad and interrelated characteristics of energy systems of common interest to all three jurisdictions.

Sustainability — Energy supply and infrastructure and the markets within which they operate represent significant investments by societies to secure their well-being and must be available, affordable and reliable over long timeframes. A constellation of forces that threaten the structure of markets frame the response and opportunities of each nation and continental energy and commodities exchange. The most overarching and problematic of these forces is the impact of climate change on using energy in terms of demand, resource availability and security. Since externalities from air and water pollution do not respect national boundaries, data about and collaboration directed at some of these issues can offer significant benefits to each nation.

Shifts in climate cycles and intensity can dramatically affect energy planning and delivery in both the near and long term. Recent extreme weather events in continental North America, including continuing severe droughts in the western United States and northern Mexico, summer heat domes in western Canada and the United States and increasingly severe weather events such as the 2021 winter storm in Texas, highlight the shifts in climate cycle intensity. The effect of climate change on natural resources could impact the three countries' availability to renewable and other natural resources. For example, the Intergovernmental Panel on Climate Change (IPCC) estimates a reduction of up to 22 per cent in precipitation in Mexico by 2100, limiting water availability in a country where 15 per cent of its electricity comes from hydro resources (IPCC 2014).

Climate change will become an existential threat to human survival by 2050 if it is not managed or minimized. The increasing risks of climate change from emissions on energy extraction and production is driven by both the demand for at-need energy and the continuous capacity necessary to meet that demand. If we are to limit the risks from a 1.5°C increase in global temperatures due to global warming, energy systems transition, according to IPCC, should include the widespread adoption of new and disruptive technologies and practices and enhanced climate-driven innovation to reduce demand for energy and to decarbonize energy extraction and production.

Security — A fundamental role for governments in any nation is to provide security for their citizens. This can include a range of threats, including threats to personal safety as a result of criminal activity and, increasingly, threats to personal health and safety from environmental changes or commercial activities that induce uncontrolled or unmitigated costs on society, associated with energy supplies and consumption. The relationship of energy to other commodities is acknowledged broadly in society ranging from reliable physical supplies to stable financial and economic benefits from their use. The ability to respond or plan in this area is influenced by decisions in the neighbouring nations and is a fundamental consideration when individual countries consider any collaborative or co-ordinated policies.

The vulnerability of and risk to energy infrastructure due to international military, cyber and economic conflicts pose a serious threat to energy security. The risk of global regional conflicts, particularly in the Middle East and Eastern Europe, present continuing threats to global oil and liquefied natural gas supply. The emerging reality of cyber-attacks by nation states and terrorist and criminal organizations is demonstrating the vulnerability of energy infrastructure to significant disruption. Economic conflicts between nations threaten global supply chains essential to manufacture that supply key components necessary for existing and emerging alternative energy technologies.

Greater interconnection and integration of Mexico's, the United States' and Canada's energy systems would create a more robust continental energy market that could alleviate these threats to North American energy security. Closer co-operation between North American countries has the potential to increase reliability of overall systems operations, improve the fuel access and price characteristics of delivered energy throughout the continent and improve the overall security of individual and integrated subsystems.

POLITICAL GOVERNANCE

While Canada, Mexico and the United States are all representative democracies, differences in political governance and political cycles are potential challenges that need to be considered in advancing collaborative and co-operative action. In all three countries, the long-term future and outlook of action on shared outcomes like climate change is often challenged by short- and medium-term political interests by political leaders for national, regional or local political gains.

The energy sector is based upon the development and availability of infrastructure with long life cycles; swings in short- to medium-term policy can have a lasting impact in the sector. Using Mexico as an example, a key risk faced when meeting a 2050 net-zero goal lies in the impact of changing political agendas. Although previous Mexican governments have advanced energy security as the guiding principle of the country's energy policy, the current government has changed it to self-sufficiency. This shift in focus has favoured energy investment by state-owned enterprises at the expense of private sector investment. This shift risks increasing the cost of doing business domestically, compounded by the inability of local companies to compete internationally with firms that are partly valued by their adherence to environmental, social and governance principles and source energy needs from renewables. In the energy sector, it will limit access to domestically produced technology and commodities that otherwise would not be limited by constraining the development of private sector activities. This, in turn, will result in energy production being increasingly dependent on government activity, eventually constraining growth opportunities and development.

Likewise, the separation of authorities at the sub-national level in Canada and the United States can create additional challenges to collaborative action. Using Canada as an example, the authority for climate and natural resources is divided between the national and provincial levels of government. Provinces have primary responsibility for energy development. Therefore, each province has developed its own energy market structure. This has resulted in 13 unique electricity markets in Canada that, other than for limited

reliability purposes, have discouraged the development of significant interprovincial infrastructure and trade. Curiously, however, when presented with economic opportunity, north – south infrastructure and trade between those provinces with surplus hydro-electric generation and the United States has blossomed.

INSTITUTIONAL ARCHITECTURE

Each of the nations in North America is culturally unique (and diverse) and, although different in policy orientation, has similar economic and public benefit goals. The energy markets and governing institutions are similarly unique and adapted to the political and policy objectives of each nation, but simultaneously are organized around common functional roles of regulation, operational service and safety standards and performance characteristics.

Table 1 highlights key similarities and differences in the structure of energy markets and governing institutional architecture of the three jurisdictions.

Table 1: Comparison of Key Characteristics of Energy Market Structure and Institutional Architecture

Characteristic	Canada	United States	Mexico
Competitive hydrocarbon market	Yes	Yes	Transitioning to control by state-owned enterprises
Competitive electricity market	Varies by provincial jurisdiction	Largely	Transitioning to control by state-owned enterprises
National energy regulator	Yes, but limited jurisdiction	Yes	Yes
State/province energy regulator	10 provincial & 3 territorial regulators	48 state regulators	Nil
Transmission control agencies	Only two independent control organizations in Alberta and Ontario	Seven regional control organizations	One national control organization
Pipeline safety and operating standards	Similar safety and operating rules and regulations in all three jurisdictions		
Transmission safety and operating standards	Safety and operating rules in all three jurisdictions generally adhere to NERC standards		

Following, we briefly review the individual characteristics of the energy markets and governing institutions in each country and discuss some of the challenges and opportunities to co-operation and collaboration.

Canada

Constitutionally, Canada is a federal state made up of the federal government and 10 provincial and three territorial governments, all with parliamentary governance. Energy governance and oversight is a shared responsibility of the federal and provincial governments.

Canada's federal government is responsible for international and interprovincial trade and commerce including energy infrastructure crossing international or interprovincial borders. Canada's provinces and territories own the natural resources within their jurisdictions and are responsible for development. Provinces and territories are responsible for electricity generation and distribution within their jurisdiction. Canada's federal and provincial governments share responsibility over the environment.

The Canadian federal regulators permit and regulate interprovincial and international pipelines and transmission lines, license exports of oil, natural gas and electricity and license and regulate all nuclear facilities in Canada including nuclear generation. The provincial and territorial governments license and regulate hydrocarbon resource development, processing and transmission within their jurisdictions through various institutional forms. They also license and regulate generation, transmission, distribution and sale of electricity.

Liquid hydrocarbon commodity prices are unregulated and reflect global and North American prices. The distribution and sale of oil and refined petroleum products is open and competitive. The distribution of natural gas is franchised and regulated by provincial regulators (including terms and conditions). The openness of wholesale and retail sales varies by province.

Canada has 13 distinct provincial and territorial electricity markets, often dominated by a Crown-owned generation and transmission utility. Wholesale and retail competition vary widely by jurisdiction. Most jurisdictions focus their electricity policy and market on meeting domestic demand. British Columbia, Manitoba and Quebec, with large hydro-electric production and surplus, also focus on exports. All Canadian jurisdictions participate in or recognize the North American Electric Reliability Corporation (NERC).

Mexico

Mexico is a federal republic made up of 32 federal entities: 31 states and the autonomous Mexico City. In Mexico, governance and oversight of energy is a federal responsibility.

In 2013, Mexico decided to modernize its energy sector, moving towards a market-based model, by implementing its landmark energy reform. The attractiveness of this reform was based upon the adoption of international best practice, resource availability and a sound and robust legal framework to provide certainty to investors. The energy reform set up a competitive market throughout the value chain, which together with innovative public policy and regulation created the conditions for Mexico to set the course in the transition path towards a low-carbon future.

The Department of Energy (SENER, by its Spanish acronym) continued to be the sector head with responsibilities across the whole value chain focusing strictly on policy-making. The new policies were developed through participatory exercises, with industry, civil society and government defining policies, programs and metrics to advance the development of a greener and more sustainable energy economy.

The federal regulators for hydrocarbons, the National Hydrocarbons Commission (CNH), and electricity, the Energy Regulatory Commission (CRE), were endowed with technical, financial and operational independence to allow them to reinforce the market model and promote competitiveness and operational reliability in each market. A new regulator, Agencia de Segurídad, Energia y Ambiente (ASEA), was also created to ensure environmental stewardship and operational safety in the hydrocarbon sector.

The state-owned productive enterprises, the Federal Electricity Commission (CFE) and Pemex, were given a single mandate over electricity and hydrocarbons, respectively: to create value for their stakeholders (i.e., the state). The system operators, El Centro Nacional de Control de Energía (CENACE) for electricity and El Centro Nacional de Control del Gas Natural (CENAGAS) for natural gas, were separated from the state productive enterprises. They were granted technical and budgetary independence and tasked with ensuring free access and sound operation of the electrical and natural gas network infrastructure. The only area where the government retained sole ownership and operation was nuclear energy.

In 2018, the change in government resulted in a significant shift in energy policy that, although not reversing the 2013 constitutional reform of the energy sector, has resulted in other legal and regulatory changes that have essentially brought the energy transition in Mexico to a halt.

United States

The United States is a federal constitutional republic which consists of 50 states, one federal district (Washington, DC), one incorporated territory (Palmyra Atoll) and a number of inhabited and uninhabited territories. The energy industry in the United States is functionally a public, quasi-public and private industrial service in every political jurisdiction (federal, state and municipal) and is overseen and regulated in some fashion at every political level.

In terms of energy, the scope of federal authority to regulate commerce and public health and safety has both a positive and a negative characteristic and prescription:

- It grants the federal government broad authority to affirmatively regulate activities that can have an effect on commerce between the states;
- Prohibits state governments from imposing an undue burden on the free flow of interstate commerce; and
- State actions that are inconsistent with affirmative federal action under the Commerce Clause or unduly interfere with the free flow of interstate commerce are pre-empted under the Supremacy Clause.

The U.S. energy system includes a unique, interwoven set of agencies, policies and systems linking governments and private industry across federal, state and local government levels. The Federal Energy Regulatory Commission (FERC) is the federal agency that regulates the transmission and wholesale sale of electricity and natural gas and the transportation of oil by pipeline in interstate commerce. Other U.S. federal agencies with energy-related missions include: the Environmental Protection Agency; the Bureau of Ocean Energy Management, which oversees development of U.S. Outer Continental Shelf energy; the Mining and Minerals section of the Bureau of Land Management, in the Department of the Interior, which oversees energy development on federal lands; and the Department of Commerce, the Securities and Exchange Commission and the Federal Trade Commission, which oversee interstate commerce transactions. The Department of Energy (DOE) is the primary federal agency that manages the United States' nuclear infrastructure and administers the country's energy policy.

State governments have significant authority in their respective states. Individual states have their own constitutions and the right to make laws in specific areas where legislative power is not the prerogative of the federal government unless the power to do so is denied by the Constitution. Generally, fuel and energy resources are controlled by rules and regulations promulgated by individual states. As well, most states include a public utilities commission (PUC) for rate setting and energy policy and/or a state energy office. The PUCs are responsible for setting state and regional standards, rules, enforcement and permits for regulated utilities, regional transmission organizations and independent systems operators.

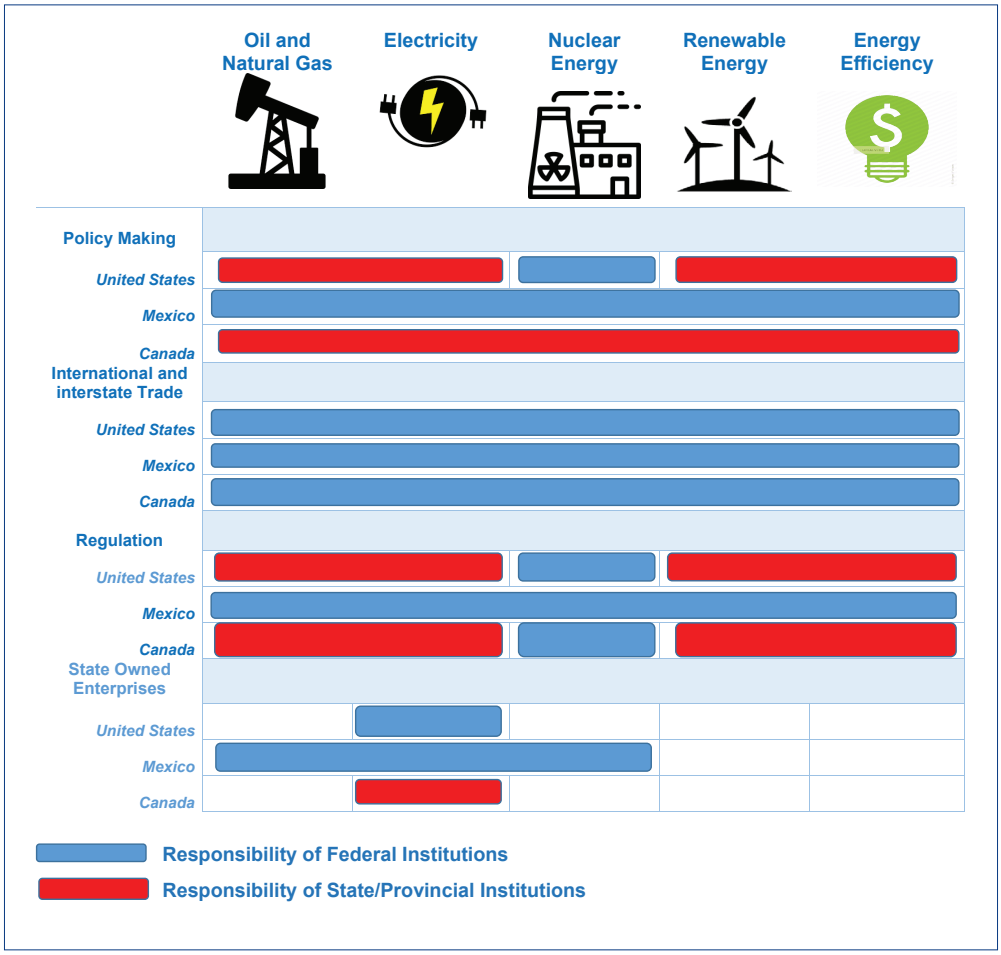
In addition, there are several large publicly owned systems, such as the Bonneville Power Administration, the Tennessee Valley Authority, the Strategic Petroleum Reserve and the Western Interstate Energy Board. These public agencies own, manage and regulate infrastructure, such as transmission lines or storage.

COMPARISON OF NORTH AMERICAN INSTITUTIONAL INFRASTRUCTURES

In Figure 2 below, we compare the institutional energy architectures of the three countries to visualize the institutional alignment challenges and opportunities in moving toward energy policy and regulatory integration to facilitate greater continental energy collaboration and co-operation. In general:

- In the United States and Mexico, federal agencies have much greater influence over national energy policies than in Canada;
- In the United States and Canada, states and provinces have significant control over regulation of energy production, use and delivery, requiring significantly greater effort in harmonizing regulatory standards in those countries; whereas in Mexico, energy regulation is an exclusive federal responsibility; and
- In Mexico, energy production and delivery are dominated by state-owned enterprises, whereas in Canada and the United States, state-owned enterprises are much less dominant.

Figure 2: Comparison of Institutional Energy Architectures of the United States, Mexico and Canada



Source: Generated by authors.

While there are some structural differences in institutional architecture that will need to be considered, policies and regulation for the international purchase and transfer of energy between nations are generally aligned:

- Markets for hydrocarbons are generally open and competitive;
- Markets for electricity are more formalized but allow for and, in some instances, encourage trade of electricity between countries; and
- Regulatory standards adopted by all three jurisdictions for energy infrastructure generally follow internationally accepted standards for construction and operation.

NORTH AMERICAN RESOURCE POTENTIAL

Mexico, the United States and Canada have a wealth of non-renewable and renewable energy resources, production and utilization technologies and know-how to transition to cleaner energy production to meet their future energy needs.

CANADA

Canada has significant renewable and non-renewable proven and potential resources. Canada's non-renewable resources include:

- Crude oil reserves of 178 billion barrels, second only to those of Saudi Arabia, and natural gas reserves of 58 trillion cubic feet as of 2006 (Government of Canada n.d.(b));
- Canada has about 6.125 trillion tonnes of coal reserves, one per cent of the world's coal reserves. Ninety-eight per cent of Canada's coal is produced in the western provinces (Natural Resources Canada n.d.(a); and
- With known uranium resources of 606,600 tonnes of U_3O_8 [1](514,400 tU),[2] Canada has about eight per cent of the world's unmined uranium resources, but accounts for some 13 per cent of the global primary uranium production (Natural Resources Canada n.d.(b)).

Canada has significant renewable resources including:

- Hydraulic energy, including both dammed storage and run-of-river used to generate electricity. Hydroelectricity makes up 59.3 per cent of Canada's electricity generation, which varies widely by province (Natural Resources Canada n.d.(c));
- Installed wind and solar energy capacity growth over the past 10 years has been rapid. Installed wind capacity in 2021 was 14,304 MW and installed solar capacity was 2,399 MW. Between 2009 and 2018, wind and solar energy accounted for 68 per cent of new generation capacity additions in Canada, making these resources the dominant form of new capacity installed in Canada (Canadian Renewable Fuels Association n.d.); and
- Synergies between wind, solar and energy storage technologies are starting to emerge across Canada. There is rapidly growing interest in the joint deployment of these technologies.

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1 U3O8 — uranium oxide.
2 tU – tonnes uranium.

MEXICO

Mexico has significant renewable and non-renewable proven and potential resources. Mexico's non-renewable resources include:

- Crude oil reserves of 17.1 billion barrels and natural gas reserves of 30.7 trillion cubic feet;
- Mexico has about 1.33 trillion tonnes of coal reserves or 0.1 per cent of the world's coal reserves. All Mexico's coal production comes from the state of Coahuila (Government of Mexico n.d.); and
- Although Mexico has some uranium resources in the northern part of the country, Chihuahua, Nuevo Leon and Sonora, there is no production.

Mexico has significant renewable resources including:

- Biofuels for power generation represented 0.2 per cent of Mexico's electricity generation in 2020, and it has an installed capacity of 378 MW (0.5 per cent of the total) (SENER n.d.);
- Geothermal electricity represented 1.5 per cent of Mexico's power generation in 2020, it has an installed capacity of 951 MW (1.1 per cent of the total) (SENER n.d.); and
- Hydroelectricity represented 11.4 per cent of Mexico's electricity generation in 2020, which varies by the presence of the El Niño-Southern Oscillation phenomenon. In El Niño years, rain increases while in La Niña years rain decreases. Mexico has 101 hydro power generation facilities for an installed capacity of 12,612 MW (15.2 per cent of the total);[3]
- Solar power represented 4.3 per cent of Mexico's electricity generation in 2020, and it has an installed capacity of 5,149 MW (6.2 per cent of the total) (IMTA 2017; SENER n.d.);
- Wind power represented 6.3 per cent of Mexico's electricity generation in 2020, and it has an installed capacity of 6,504 MW (7.8 per cent of the total) (SENER n.d.).

United States

The United States has abundant, albeit inconsistently distributed, hydrocarbon-based and renewable resources within its continental borders:

- Proved reserves of U.S. crude oil and lease condensate of 38.2 billion barrels at the end of 2020 (EIA 2022);
- As of December 31, 2020, U.S. total natural gas proved reserves — estimated as wet gas, which includes hydrocarbon gas liquids (HGLs) — totalled about 473.3 trillion cubic feet (Tcf) (EIA 2022);

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[3] The El Niño/La Niña Southern Oscillation (ENSO) has a major influence on climate patterns in various parts of the world. This naturally occurring phenomenon involves fluctuating ocean temperatures in the central and eastern equatorial Pacific, coupled with changes in the atmosphere. For more information, see World Meteorological Organization, "El Niño/Southern Oscillation," WMO-No.1145, https://library.wmo.int/doc_num.php?explnum_id=7888.

- At the end of 2019, reserves were estimated to range from 14,000 tU_3O_8 at up to $30/t to 176,700 tU_3O_8 at up to $100/t (EIA n.d.(a));
- U.S. recoverable coal reserves are at about 252 billion short tonnes, of which about 58 per cent is underground mineable coal (EIA. n.d.(b)); and
- The U.S. renewable resource potential is vast and tends to be regional in scope and density for power generation or in terms of offsets for heat and electricity currently provided by hydrocarbon-based fuels. Table 2 below is generally representative of estimates from the National Renewable Energy Library (NREL) in 2014.

Table 2: Total Estimated U.S. Technical Potential Generation and Capacity by Technology

Technology	Generation Potential (TWh)[a]	Capacity Potential (GW)[a]
Urban utility-scale PV	2,200	1,200
Rural utility-scale PV	280,600	153,000
Rooftop PV	800	664
Concentrating solar power	116,100	38,000
Onshore wind power	32,700	11,000
Offshore wind power	17,000	4,200
Biopower[b]	500	62
Hydrothermal power systems	300	38
Enhanced geothermal systems	31,300	4,000
Hydropower	300	60

[a] Non-excluded land was assumed to be available to support development of more than one technology.
[b] All biomass feedstock resources considered were assumed to be available for biopower use; competing uses, such as biofuels production, were not considered.

Source: National Renewable Energy Laboratory.

A NORTH AMERICAN NET-ZERO COMPACT

THE CHALLENGE AND OPPORTUNITY

While all three national and the state/provincial governments in North America face similar, albeit not identical, energy challenges over the coming decades, these challenges are generally comparable in the sense that they are intrinsically woven into every other facet of society, from food production and water supplies to transportation and mobility, to economic markets and ultimately personal and collective wealth.

Since energy is essential to power every form of economic activity, and consequently employment throughout each country, breakdowns in energy systems resulting in loss of energy supply — even for short periods of time — can result in significant disruption to economic activity and physical losses that may span years rather than days in recovery.

Defining this risk in a large context brings us back to the broader context of security and the steps that can be taken to reduce the risk of breakdowns or failures in national energy security. Consequently, the risks of dysfunctional, non-integrated or uncompetitive energy systems affect each nation at the core of its responsibilities and aspirations.

North America presents a unique opportunity to expand, and benefit from, improved energy system operations, standards and trading exchange. Existing infrastructure age and design are similar between Canada, the U.S. and Mexico, albeit at different levels of sophistication or control. The incentives and investment pathways are remarkably similar. The impact of increased demand, substitution of lower emissions supplies and replacement and upgrade of existing infrastructure makes collaboration on more resilient systems very attractive for future investment. This attraction increases when proximity and access are considered.

Although we refer to this broadly as energy systems resilience, the role of energy is so broad that it is more reasonable to cite the role of energy in terms of risk avoidance for every sector of the economy throughout North America. This risk avoidance strategy then becomes intrinsically mixed with geopolitical concerns and domestic, cultural and economic competition from expanding urban areas to rural and agricultural reserves. The decisions and co-operation we recommend here will be central to reaching objectives that will mitigate negative climate changes, loss of habitat productivity and general economic welfare. The objectives of the three nations have converged and will continue to in ways that will reveal common, rather than dissimilar, risks, while suggesting more benefits from co-operation over time.

A NORTH AMERICAN CARBON EXCHANGE: THE PATH TO A SOLUTION

To meet the challenges facing the provision of a secure, reliable and sustainable North American energy future and to take advantage of the opportunities offered by our collective energy resource potential while moving towards net-zero greenhouse emissions by 2050, we are proposing that the three nations commit to a North American net-zero compact by creating a common carbon exchange. A North American net-zero compact will incentivize cross-jurisdiction development of low carbon energy resources. The economic opportunities offered by these investments and the benefits of enhanced pathways for these jurisdictions to meet their emissions reduction targets will also incentivize them to look at changes to any institutional barriers.

In Box 1, we describe a conceptual model for a North American carbon exchange.

BOX 1: A CONCEPTUAL NORTH AMERICAN CARBON MARKET

Carbon Markets

Carbon markets is a general term for an exchange where commitments to account for, regulate, trade and manage carbon emissions take place. Carbon markets reflect a general compliance with rules or standards that identify the impact of various industries or activities, and allow dynamic trading, banking and exchange over time. Such markets, whether mandated or voluntary, mimic commodities exchanges such as ICE (International Carbon Exchange) or NYMEX (New York Mercantile Exchange).

Such markets are a key proxy tool for countries or regions to use in managing current and future greenhouse gas targets, typically based on intercountry agreements or even state and national policies, such as the Paris Agreement and International Code Council (ICC) standards. The ultimate goal of controlling carbon emissions is to create rules that reflect good science and engineering; these can be combined with policies that change emission levels while not destabilizing the national or regional economy. This demands cost estimations that reflect the impact of controlling excess emissions based on activities or product design on regional and national climate regimes. The end product will be a range of relative values, or carbon prices, that have similar relative impacts throughout an entire region.

The Benefit of Carbon Markets versus Carbon Taxes

An alternative is direct controls by taxation, which targets excess carbon emissions, and is a more typical historical approach governments use to intervene in various sectors of the economy where the market price for goods or activities does not internalize externalities or emissions. Taxes on greenhouse gases come in two broad forms: an emissions tax, which is based on the quantity an entity produces and a tax on goods or services that are generally greenhouse gas-intensive, such as a carbon tax on gasoline.

For example, in Alberta, the government has set a predetermined price that resource extractors or processors must pay for each unit of greenhouse gas that is created net of operational controls. The addition of the tax is reflected in the price of production and paid by consumers in each part of the supply chain. If successful, producers will find methods of reducing overall emissions in their industry and gain the appropriate competitive advantage, passing on reduced costs to the consumer, and reduce collective emissions in the process.

In contrast, emissions trading is a market-based approach to controlling pollution by providing economic incentives for reducing the emissions of pollutants. Focused primarily on identifiable point source emitters, these programs are generally regional in nature and encourage gradual reductions in emissions through substitution and replacement of technology and operations in specified industries. In the simplest version, a government sets a level of maximum emission in the area (cap) and issues permits for operations based on that level. Companies that exceed the cap must purchase credits from others who operate underneath the limits, ultimately allowing the total in a region to decline under average conditions.

A Continental Approach

Without trying to specify either direct policies or derivative regulations, identifying and tracking carbon emissions across the continent can offer the opportunity to develop various market or exchange instruments that reflect national and regional objectives. Over time, these values acquire the capability of equivalency (Kassem et al. 2021) or even simple comparative characteristics in terms of both energy capability and economic value.

We believe that creating the incentive for a pan-national carbon credit exchange benefits each of the three nations in North America. Collaborating on the definition of target carbon emissions, then agreeing on a common metric of that set of values, will provide the base for a future series of policies, programs and incentives that are comparable across national boundaries.

The first step will be to create interest in the data necessary to begin assessment, mapping and description of the emissions that are most dominant in carbon management over the next decade. Each nation has agencies that possess the skills and capacity for accomplishing this. Using the vehicle of a co-operative treaty, the nature and breadth of the research and data collection task can be defined and serve as the vehicle for both domestic and international carbon exchanges, banks and trading houses. Prices and relative values can change or move freely across national borders, like futures or even commodity contracts, and will reflect the equivalency of their core characteristics. This value can be embedded in product streams or measured as an end product of production.

Following, we propose a pathway for the three jurisdictions to explore, develop and implement a North American carbon exchange.

ESTABLISHING A NORTH AMERICAN CARBON EXCHANGE

ASSUMPTIONS

Three assumptions are key for the North American carbon exchange to achieve success:

1. Energy transition towards a low-carbon economy is a priority

   For a carbon exchange to be successful, there needs to be nationwide acceptance and support for a low-carbon economy in all three jurisdictions. Each jurisdiction would undertake consultation and consensus building to gain national and regional buy-in for such a policy.

2. Commitment and participation from stakeholders

   The commitment and participation from different stakeholders would be fundamental to make sure that the inputs, activities, outputs and outcomes result in successful implementation. Each jurisdiction would establish an open platform for discussion and participation.

3. Shift from fossil fuels to electrification

A commitment to implement a long-term policy shifting an extractive resource/fossil fuel-based economy to an electrify-all economy model is essential to have political and social support from the different stakeholders, from the legacy industries to ensure that no one is left behind and from the overall economy to support a just transition.

JURISDICTIONAL COMMITMENTS

The key commitments or inputs by the three jurisdictions to initiate development of a North America net-zero compact are critical and should include:

1. Institutional

   The governments of Canada, Mexico and the United States would establish a tri-national North American carbon exchange task force to undertake negotiations on the authority for, the scope of, the mandate for, the principles, objectives and purposes of, and legal and organizational framework for the carbon exchange. Each nation would designate a

special envoy to represent and lead the creation of the task force. The task force would be comprised of government officials from the departments of energy, environment, finance and trade, and supported by an industry advisory council to incorporate the private sector's viewpoint.

2. Financial

   The governments of Canada, Mexico and the United States would have to appropriate the required financial resources to set up a trilateral trust fund to carry out the joint work of the task force.

3. Transparency

   A commitment to full disclosure of all the relevant information is essential to provide the necessary information to all stakeholders to facilitate decision-making. Full transparency would encourage opinion exchange and facilitate trust and common ground for all parties involved. There would be a need to create an open web-based platform to disclose all actions and information relating to the North America net-zero compact.

TASK FORCE ACTIVITIES

The task force would negotiate and present to the three national governments a draft international agreement which would establish the authority for, the scope of, the mandate for, the principles, objectives and purposes of, and legal and organizational framework of the carbon exchange.

In addition to the organizational foundations, three sets of supplementary functional prerequisites would have to be uniform across the three jurisdictions to launch a North America carbon exchange:

1. Set tri-national baselines and caps by sector

   The governments would have to work with different stakeholders from industry and the public to understand the situation across industries in the region; quantify the potential contribution and shares from each sector domestically and regionally towards a total carbon budget for North America; and set a progressive medium- to long-term cap domestically and regionally to provide the incentives for the different stakeholders to take part in the carbon exchange. A carbon budget would be allocated according to the national contribution to the region which will generate the scarcity and the corresponding price signals for the carbon exchange to operate.

2. Set a unified regulatory framework for a trilateral carbon exchange

   The governments would adopt a unified regulatory framework to ensure that all industries in all three jurisdictions face the same compliance and regulatory costs regardless of the location of the headquarters.

3. Install a trilateral regulatory panel to harmonize standards and enact border adjustments for carbon content

   The governments would have to set up the corporate governance of the carbon exchange. It should be an independent board composed of an equal number of

representatives from each jurisdiction. The appointees should be experts in at least one of the following subjects: energy, environment, finance, regulation or trade. Decisions will be made by consensus.

OUTPUTS

Three key procedural elements can be expected from a future North America carbon exchange:

1. Sectoral sustainability strategies

   The development of sectoral sustainability strategies will focus on investment and drive performance in decarbonization pathways while maintaining the competitiveness of the sectors and regions.

2. Streamlined regulation and a strong environmental, social and governance (ESG) framework

   The unified regulation for the North America net-zero compact will reduce the cost of compliance for industry and will ensure that the region would operate consistently towards a low-carbon future.

3. New markets

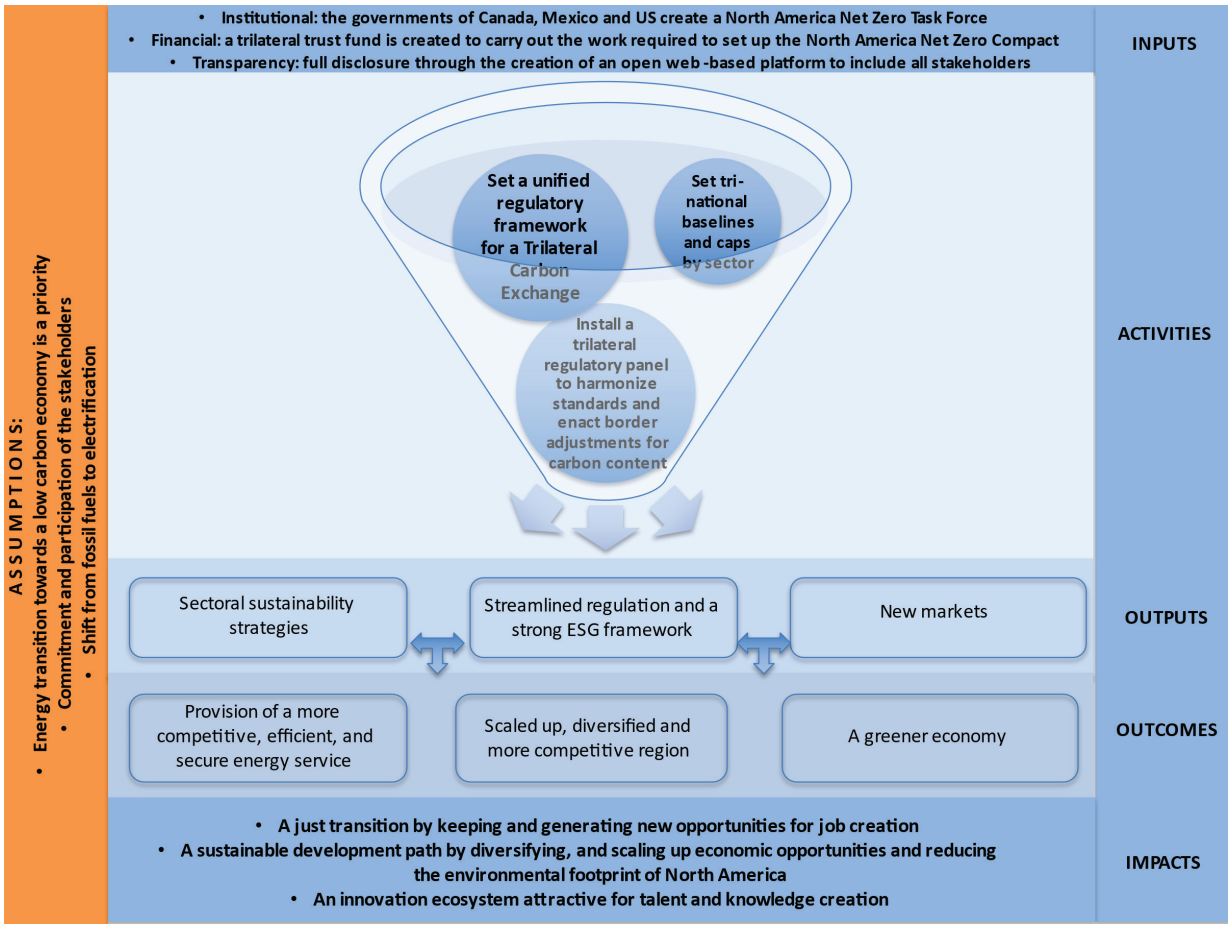
   The emergence of new markets to comply with the new regulation and sustainability strategies of the region will stimulate new business and economic opportunities to supply new technologies and services to meet the demand for decarbonization.

POTENTIAL OUTCOMES AND IMPACTS

We expect a North America carbon exchange to encourage a transition to a lower carbon, more competitive, more efficient and more secure North American energy future. Integration of the region would support businesses to scale up productive capabilities, specialize and diversify production trains, and, with a focus on clean technologies and a green economy, there is room for a more competitive region. In that sense, it can generate new opportunities for investment and job creation to incorporate workers from legacy industries and add new talent in a just transition fashion, create a sustainable development energy pathway for North America, create a reduced environmental footprint and potentially create an innovation ecosystem attractive for talent and knowledge creation.

Figure 3 provides a graphical presentation of the proposed pathway.

Figure 3: A Pathway to Establish a North American Net-Zero Compact



Source: Generated by authors.

CONCLUSION

North America and its three independent nations host a mix of cultural diversity, energy resources and open trading relationships that represent one of the most powerful and resilient economic zones in the world. The abundance of resources and opportunities for trade, however, do not include fully integrated energy markets. This report has endeavoured to outline a series of collaborative actions and policies that can improve the energy system that supports all three nations and can strengthen the collective response to energy and environmental security in decades to come.

In terms of energy systems, all three nations have internal and cross-border interconnections of crude oil, refined petroleum products and natural gas pipelines and high voltage electricity transmission. These interconnections allow for transfers of energy and provide limited supply and reliability of regional electrical grids. Other access paths allow the selective trading of hydrocarbons, currently dominated by processing capacity in areas primarily in the U.S.

We believe that the most salient emerging threats to continental security are reflected in current trends of international conflict and energy exchange and the existential threat emerging from climate changes. Meeting the challenge of climate change will require all

three countries to undertake significant shifts in the demand for and supply of energy services. Climate impacts induce losses across every economy in terms of employment, quality of life and overall security for providing essential services to each society. The forces leading to and exacerbating climate instability are complex and interrelated, becoming virtually insoluble when using a technique that breaks them into smaller issues to be solved individually.

We believe that using climate impacts as the focus for common action in terms of carbon management can have important positive outcomes for all three nations. Our metric for advocating a carbon exchange is based on the key tests of economic, strategic and operational advantage. By identifying a common thread of carbon-based impacts, a more cohesive system of identifying, accounting and assigning values to these impacts can emerge. Such a system can increase reliability of overall systems operations, improve access to the widest range of fuels and incent more robust and competitive prices for delivered energy throughout the continent. The outcome will improve the overall security of individuals, regional energy distribution and economic and financial activity.

A North American carbon exchange would provide standardized and verified carbon trading transactions. The underlying value of the transactions would be supported by the three countries setting an agreed baseline for carbon emissions from the energy sector as well as a cap for energy sector emissions. A carbon exchange would also allow countries to use the metric of embedded carbon content to inform and tailor national policies and regulatory practices to maximize economic investment in energy systems, while minimizing the costs of externalities.

Addressing the challenge of climate change will require all three nations to shift their energy demand and supply to greater dependence on renewable resources and lower carbon non-renewable resources. The benefit will be improved flows of data and corresponding incentives for investment, enhanced internal energy flows and regulation and a buffer of a more fully integrated energy system continent-wide.

By focusing initially on this issue, a path to co-operation and collaboration that is mutually beneficial for the entire continent is not only possible, but attractive and sustainable.

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