Executive Summary

CANADA'S THREE ENERGY CHALLENGES

- Add value to Canada's energy exports, extending our country's value chain and strengthening our innovation ecosystem.
- Contribute to reducing North America's carbon footprint, by becoming the lowest-cost producer of low-GHG electricity.
- Contribute to the increasing global energy demand, recognizing Canada's massive energy endowment.

CANADA'S INNOVATION STRATEGY

- Big national-scale projects
- Led by visionaries
- Implemented by private/public sector collaboration

NINE PROPOSED BIG PROJECTS

- For Implementation this half century
- Substantial increase in energy production
- Carbon content of energy input reduced from 86% to 61%

As presented at the 2011 World Energy Congress in Montreal, our planet faces two civilization-changing challenges in this century: access to energy by the 2 billion people who have limited or no access to energy, and climate change. With Canada's unique endowment of energy sources, both renewable and non-renewable, the nation has the capacity - some would say the responsibility - of contributing to the resolution of both of these challenges. To provide greater opportunity to its people and strengthen its long-term financial sustainability, Canada has an additional major challenge; that of capturing greater value from its natural resources by upgrading them to higher value products, thus capturing added wealth and jobs. This book presents a roadmap depicting how Canada can meet these three challenges through 'big projects'.

In our previous book, "Canada: Winning as a Sustainable Energy Superpower," sponsored by the Canadian Academy of Engineering, we described the significant impact that twelve previous national projects had in creating the Canada we now know. Wide-reaching projects of this nature have, in fact, constituted the key Canadian innovation strategy, releasing a torrent of new entrepreneurial activity and new technology. In each case, the resulting "innovation ecosystem" developed value chains and supply chains which brought these projects to fruition, and lifted Canada's national technological and business foundation to a new level of capability and performance. How were these big projects launched and how were they financed? They were launched by visionaries who overcame critical obstacles at crucial times. Eight of the endeavours were launched as crown corporations by various governments, but also actively involved the private sector in their implementation. Five of these have since been divested to the private sector. Four were launched as private sector initiatives, but with a significant portion of the risk shared by governments, through a variety of incentives, including equity. Nine of the twelve large-scale projects are now fully private-sector enterprises. All twelve were successful, and continue to generate incredible value.

The message here is clear: big, nation-building projects often take decades to reach commercial fruition and are not jobs for single companies and a single set of shareholders. They are national projects serving a long-term national interest. This is clearly the view of energy experts who gathered at the "Bitumen – Adding Value" conference (May 21-22, 2013), sponsored by the Canadian Academy of Engineering. In their Communiqué (discussed fully in Chapter 3), they stated that "Canada should launch national-scale energy projects as the foundation of its energy strategy and its pathway to sustainable wealth creation and jobs." A "Call for Action" was the theme of keynote presentations by the Honourable Frank McKenna (Deputy Chair, TD Bank Group), Senator Elaine McCoy, and Dr. Jim Stanford (Economist, Unifor).

What are the most compelling new energy projects that should now be carried out in Canada? In our previous book, "Canada: Winning as a Sustainable Energy Superpower," nine big energy projects were proposed for implementation between now and 2050 as a continuation of Canada's ongoing nation building.

In this follow-up book, "Canada: Becoming a Sustainable Energy Powerhouse," **Chapter 1** examines how these nine new big projects would impact both Canada's energy production and carbon footprint if they were implemented, as suggested, between now and 2050. As pointed out in this chapter, these new energy ventures would increase the amount of energy-related products that Canada could produce and export by 85%, and decrease the carbon content of its energy input from 86% to 61%. Clearly, Canada has the ability to be a sustainable energy powerhouse for the foreseeable future.

The next four chapters (Chapters 2 to 5) examine Canada's progress in adding value to its natural resources.

IMPACT OF DRAMATIC INCREASE IN RESOURCE EXTRACTION

- Canada again returning to reliance on extracting and exporting unprocessed resources
- Policies needed to increase value-add upstream and downstream, and to minimize damage to other export industries.

Chapter 2 describes the fundamental structural transformation of Canada's economy resulting from the dramatic expansion of petroleum extraction since the year 2000. Canada is once again primarily reliant on extracting resource wealth from the ground beneath our feet. We export that wealth to others who transform it, manipulate it, and add value to it – importing it back in the forms of advanced products and services. Because of this, policy-makers should aim to develop and implement policies which maximize the economic benefits (and minimize the environmental and social costs) of Canada's petroleum and other non-renewable resources. Examples of such policies would be measures to,)a) boost Canadian value-add content in inputs to petroleum and other resource sectors, (b) increase Canadian processing and manufacturing of our resource commodities after they are extracted, and (c) support and protect other value-added export industries (with no direct connection to resources) from being damaged by the macroeconomic side-effects of the resource boom.

ACTION ON VALUE-ADD

- Eight-statement strategy from energy leaders
- Bitumen upgrading a major current opportunity
- Sarnia-Lambton upgrader a logical next step

Chapter 3 provides additional value-added policy suggestions from participants at the May 2013 "Bitumen – Adding Value" conference organized by the Canadian Academy of Engineering. The consensus was captured in eight communiqué statements which outlined strategies and tactics to dramatically change Canada's value-added performance. Bitumen upgrading was clearly identified as a current, significant opportunity for adding value to Canada's massive bitumen resource, offering one of those few historic opportunities to reverse the country's trajectory of exporting its raw natural resources with little or no added value to the domestic economy.

Chapter 4 builds on the conclusions of Chapter 3, and provides a case study for a potential bitumen upgrading project in southwestern Ontario, providing access to markets in the central and eastern United States and Canada, and global markets via the St. Lawrence Seaway. This project, led by the Academy's Energy Pathways Task Force, is under review by several potential commercial partners, with the logical next step being a feasibility study on project design and product slate.

ENERGY IN NEWFOUNDLAND AND LABRADOR

- Case study of an energy-driven innovation ecosystem having a transformative effect on the provincial economy

Chapter 5 describes the dramatic emergence of the Newfoundland offshore petroleum industry, illustrating the impact of a provincial megaproject not only on its host province, but the country as a whole. The result is the creation of a new economic sector serving local, national and international markets, increased business confidence, a highly entrepreneurial environment, new industrial investment, and significantly enhanced government revenues. This is a clear 21st-century example of the emergence of a high value-added innovation ecosystem arising from "big projects," resulting in the transformation of both the economy

and the social structure of the host region. This shows that Canada's nation-building "big project innovation strategy" is as relevant today as it was at the birth of Confederation!

The next five chapters (Chapters 6 to 10) drill deeper into Canada's energy opportunities, such as the establishment of a national electricity grid which would enable Canada to be the premier low-cost provider of low-carbon electricity to North America, and the establishment district energy systems for more optimal delivery of municipal thermal energy requirements.

CANADA'S HUGE ELECTRIC POWER POTENTIAL

- New interconnected grid with regional hubs would make Canada a low-cost supplier of low-carbon electricity to the continent, resulting in a major decrease in North America's greenhouse gas emissions

Chapter 6 presents an opportunity for Canada to achieve a ten- to twenty-fold increase in clean electricity trade with the United States over the next 30 to 50 years, compared to current levels of about $2 billion per year. This would deliver on goals of enhanced energy security and substantial reduction of greenhouse gases (GHGs) on a continental scale. New interconnections and transmission links acting as "regional hubs" between provinces and neighbouring states would be required to meet these goals. Canada's low-carbon electricity advantage, fully integrated with energy trade and climate change policies of Canada and the US, represents a major "big project" opportunity. A dramatic shift in thinking and support for a national energy strategy will be required that has, at its fulcrum, large-scale cross border inter-regional trade in electricity.

REALIZATION OF CANADA'S HYDROELECTRIC POTENTIAL

- Muskrat Falls is already underway
- Mackenzie River is ready for detailed engineering evaluation

Chapter 7 describes another ground-breaking "big project" currently underway in the Province of Newfoundland and Labrador; the Muskrat Falls hydroelectric power development. It incorporates a major, low-carbon, hydroelectric development on Labrador's Churchill River coupled to overhead and undersea high voltage AC and DC transmission lines. It will deliver power from Labrador, under the Strait of Belle Isle, through Newfoundland, then under the Gulf of St. Lawrence River to Nova Scotia. At the time of commissioning, this will be one of the most complex transmission systems in the world, and will open new avenues for integrating low-carbon hydroelectric power to continental power grids.

Chapter 8 presents the conclusions of one of the first complete studies dedicated to harnessing the Northwest Territories' Mackenzie River potential for hydroelectric development. This project is enormous by any standard, similar in scale to Quebec's James Bay Hydroelectric Complex. Describing flows of up to 9,000 cubic meters per second, steep shorelines avoiding wide-area submersion, and large lakes acting as flow regulation reservoirs, this chapter depicts a practical implementation scenario for harnessing the Mackenzie River's potential, with an overall capacity slightly greater than 13,000 MW. The chapter describes key features of the project, including an upstream water control structure and six downstream powerhouses. The Mackenzie River hydroelectric complex would help the provinces of Alberta and Saskatchewan transition from high-carbon footprint thermal generating stations to low-carbon hydroelectric power stations as the thermal generating stations of these two provinces approach the end of their useful life spans.

PATHWAY FOR NUCLEAR ENERGY

- Large nuclear sites generating both electricity and steam offer the unique opportunity of supplying low-carbon electricity to the grid, and steam for producing a broad range of value-added, energy-intensive products

Chapter 9 proposes the concept of large nuclear generating sites producing both bulk electricity and process steam, for use by adjacent industrial parks consisting of high-affinity, energy-intensive plant operations. A key feature of this concept is that of the "energy cascade" in which the inputs and outputs of different industrial activities would be both complementary and mutually supportive. Ontario's Bruce Energy Centre is an example of this concept. Canada's fully established fission energy system (CANDU) would be the backbone of this

development, with the required resources of expertise, fuel and other materials fully available within Canada.

DISTRICT ENERGY POTENTIAL

- Thermal grids in cities can dramatically reduce dependence on electricity grids and conventional energy delivery systems
- Emerging Canadian know-how in partnership with existing international technology providers present a significant business opportunity

Chapter 10 explores the potential – and presents the pathway forward – for a dramatic decrease in energy dependence from electricity grids and conventional energy delivery systems for home and business space heating and cooling, through the establishment of District Energy (DE) thermal grids in Canada's major cities. Thermal energy use represents roughly one third of all energy consumed in the country. Nearly all of this energy is now provided by high-grade energy sources (e.g., electricity, natural gas, oil, etc.), which are inherently inefficient for maintaining building temperatures between 20 and 23 degrees Celsius. This chapter provides a description of District Energy Systems and how communities inside Canada, and in the international arena, have successfully deployed district energy solutions to meet their energy needs while increasing flexibility in the choice of energy resource, decreasing operating costs, and lowering carbon footprint. It also points the way to significant new opportunities for Canadian know-how and business in developing this area in Canada and abroad.

The Canadian Academy of Engineering is committed to pursuing and promoting its ongoing work on sustainable energy development, an initiative launched in 2005. The actions described in this book will contribute to Canada's three urgent nation-building energy objectives: contributing to global energy demand, reducing North America's carbon footprint, and adding value to our raw resources.

As an ongoing task, the Energy Pathways Task Force will monitor Canada's progress in capturing the energy opportunities presented in this book.