

Strategic Plan for the Production & Operation of Canada's Electricity Generation to be from 100% Non-Emitting Energy Sources.

Executive Summary

The objective and purpose of this project is to generate a strategic plan for the production and operation of Canada's electricity generation to be from 100% non-emitting energy sources. This project is based on Canada's commitment outlined in the 2030 Agenda for Sustainable Development, which was proposed in the UN General Assembly in 2015. Canada plans to achieve 90% of its energy from renewable and non-emitting sources by 2030, and a completely net-zero electricity grid by 2035.

Canada's difficulty is that while having a wealth of renewable energy supplies and natural resources, it still struggles to electrify its economy and ensure energy security. This project's objective is to assess the balance between energy production and consumption in Canada and identify potential areas for improvement in terms of electrification requirements and energy sources to meet Canada's clean energy needs. In order to develop a comprehensive plan for achieving energy security in Canada, a variety of issues will be examined, including energy efficiency, reliability, cost-effectiveness, environmental impact, and sustainability.

For the analysis of this project, three viable clean energy sources were investigated, which are: nuclear, hydroelectric, and wind. For each of these energy sources, the background and its current state in Canada were explored, the major problems and concerns were addressed, and future steps and solutions were recommended to achieve the net-zero goal.

Nuclear:

Based on the Canadian Nuclear Association, it is estimated that 15% of Canada's electricity was produced using nuclear energy in 2021. Consequently, nuclear energy overtakes hydroelectric power as the second-largest source of low-carbon electricity. The 15% of nuclear energy comes from 19 nuclear reactors in operation. Canada has 19 nuclear reactors in operation, which are located at four different nuclear power plants: the Bruce Nuclear Generating Station (has eight reactors), the Darlington Nuclear Generating Station (has four reactors), the Pickering Nuclear Generating Station (has six reactors), and The Point Lepreau Nuclear Generating Station (has one reactor).

Development of nuclear energy across Canada is essential to achieve its net-zero goal due to the various advantages of nuclear power. Nuclear energy produces low carbon footprint energy, has modest operational costs, and is very ideal for Canada as it is one of the world's top producers of uranium, and also has substantial uranium reserves that can supply the country's and the world's needs for nuclear fuel. Nuclear energy also comes with its challenges, such as high upfront capital costs, disposing of radioactive waste, and the disasters of past nuclear plants. For the analysis of nuclear energy, the current state of nuclear energy in Canada is investigated, advantages and disadvantages are explored, and future projects and technologies are discussed. Finally, a set of goals and recommendations to reach zero emissions by 2035 were proposed, which are:

- Deploy the SMR Technology

- Build New Nuclear Reactors
- Invest in research to solve the radioactive waste problem
- Optimize the design of existing Nuclear power plants

Hydroelectric:

Hydroelectric is by far the largest non-emitting energy source used in Canada, accounting for 60% of Canada's overall energy generation, and over 90% of its renewable energy generation. It was shown that most provinces have a significant share of their energy coming from hydropower, as well as some provinces such as Alberta that severely lack in this field. Several case studies of past, present, and future hydropower projects were examined to analyze the issues and shortcomings of this energy source. Based on the findings, several recommendations were put forth to increase the growth of hydroelectric energy across Canada, and they are:

- Building New Large-Scale Hydropower Plants:
- Refurbishing Existing Hydropower Plants
- Building Hydropower Plants in Small Communities
- Building Transmission Infrastructure
- Building Pumped Storage Hydropower Plants
- Increasing Private Investments in Projects
- Increasing International Cooperation

Wind:

Wind energy is one of the fastest growing energy sources in Canada, with more wind-energy capacity installed over the last decade than any other form. Wind energy capacity is growing by 7.1% across Canada, which is ranked 8th globally for installed wind energy capacity, in 2022. Wind energy currently has the lowest-cost source of new electricity generation and is cheaper than gas-based power in 2020.

Over the past few decades, wind energy has seen significant technological improvements and has rapidly grown as an industry around the world due to its high energy output and use of applications. Today, it is a crucial component of the world's supply of a renewable energy mix, due to its clean, sustainable source of energy that produces no greenhouse gas emissions or air pollution during operation. Wind energy is a very lucrative source of energy in areas with strong and consistent wind resources, which makes Canada and its geography ideally suited to capitalize on large amounts of wind energy.

For the analysis of wind energy, various case studies and issues were investigated. The major concerns of wind power and its reliability were explored, as well as current and future projects. Finally, a set of goals and recommendations to reach zero emissions by 2035 were proposed, which are:

- Deploy wind power to remote areas of Canada
- New Projects – Utilizing Offshore Wind Farms in Canada & its Success in Denmark
- Technological Advancements for Wind Operations
- Recommendations to improve reliability of wind energy