Canadian energy storage roadmap: terms of reference

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Canadian Energy Storage Roadmap

Terms of Reference

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Document Change Log

Revision	Changes	Author	Approver	Release Date
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Contents

1. Summary

This project initiates, for the first time, a holistic approach to develop and maintain a multi-year (2016-2021) energy storage (ES) roadmap for Canada. It aims to understand market potential, roadblocks and actions required at the planning, procurement, rate treatment, interconnection, market, and regulations steps for adopting ES technologies in Canada by 2021. The project will result in fair and practical frameworks and mechanisms, published and updated annually, to support developing and integrating reliable and cost effective storage solutions at provincial and national levels. The impact includes, but is not limited to, increasing the engagement of the electricity and manufacturing sectors in new technology commercialization, both for local use and export opportunities.

2. Background

In Canada, the need to renew and modernize the electricity grid is estimated to require a $300B investment by Canadian utilities over the next two decades. These modernization challenges have created an increased awareness that fundamental changes in the way we build, own and operate our electricity systems are required. Several studies related to various aspects of ES technologies and their adoption in Canada have been developed over the past years [1-4]. Several of these studies show that ES technologies can have economic benefits, support energy security and climate change goals, as well as create a more integrated and optimized energy system. Some of these reports confirm that energy storage facilities can provide a wide range of reliability services for grid operation [5] including increasing the ability to integrate renewables, while others question the real economic and value of storage over other available options [6].

While the studies outlined above have enhanced the general knowledge of the industry as a whole, gaps still exist in specific jurisdictions where local market dynamics, supply mix and regulatory structures are unique. These gaps can only be filled through an in-depth analysis of how the benefits of ES can be realized based on the unique attributes of the provincial electricity market structures, the maturity level of relevant ES technologies and the capabilities and capacities that exist within the manufacturing and technology industries to meet market demand, both locally and in export markets.

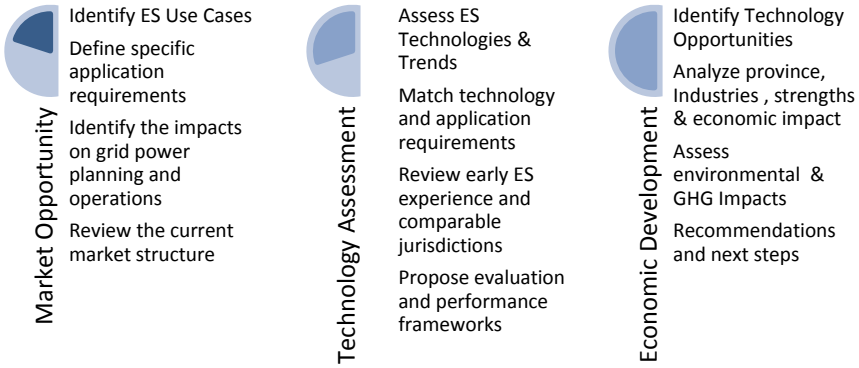
Several Canadian provinces have launched initiatives to evaluate the potential benefits of, and deployment strategies for, grid scale ES. Leaders in this area include Ontario and Alberta. Market developments in these jurisdictions are expected to be the first in a series of similar developments across the country as provinces and territories continue to face the challenges of grid modernization. However, the lack of coordination of the different stakeholders even within each province is hindering the sustainable deployment of effective ES solutions.

Based on the research completed and the information gathered to date, including that outlined above, the establishment of clear market rules, and the identification of financial frameworks for valuation of transmission and distribution benefits is of high priority in assessing the value that storage might provide on the network. Given that no single industrial or commercial player has

either the capability or mandate to inform the development of this policy, provincial and federal government agencies can play a key role to remove these barriers most efficiently.

3. Project Outline

The National Research Council Canada (NRC) and its partners are embarking on a 5-year project to develop a Canadian Energy Storage Roadmap. This work builds upon previous work in Canada and internationally to perform cost-benefit analysis of ES technologies under different electricity market structures. This platform integrates the specific conditions of the local market and the physical constraints of the local grid. Using a common framework, an ES roadmap will be undertaken for each province through each grid segment. In order to do this in a uniform method, and ensure a fact based approach to the detailed assessment of the various factors under consideration, the project team is focusing on three pillars of analysis:



Across all three pillars, engagement of key stakeholders such as regulators, power producers, and policy makers, along with storage technology vendors and system integrators, will be critical. However this project will continue to identify and engage key stakeholders within each province, assess particular stakeholder needs and opportunities, organize and document stakeholder input, and disseminate roadmap results. This proposal will also leverage recent Program of Energy Research and Development (PERD) projects (2A02.002, NRESOT-04 and NRESOT-05) focusing on real time load data collection and analysis, a CanmetENERGY project on the Canadian ancillary services market [3,5], and an NRC TEA (Techno Economic Analysis) platform including a Canadian ES valuation tool (ES-Select Canada) [7].

Results for each province will be completed independently, due to the varied nature of the markets, generation and supply mix, and providers/technologies used in each market. However the overall framework will be consistent and leverage learning across Canadian jurisdictions as well as from other early energy storage markets such as California and PJM. As outlined in the detailed project scope below, the project will be completed in phases, starting with overall framework development, applying this in Ontario and Alberta, and then moving to the other Canadian jurisdictions. These individual chapters will then be capped by an overall national picture of energy storage and its impact on the electricity grid.

The goal of this analysis will be to allow the market to compete in an open and fair manner, both for ES technologies as well as for existing assets and technologies. More specifically, it is expected that this analysis will result in:

- A clear understanding of the market need for the services that ES might provide in each jurisdiction, at generation, transmission, and distribution levels including the development of standardized use cases.
- An assessment of how much of the market storage might realistically compete in, including an analysis of the current and future state of the art of individual technologies, the value of each technology in an individual use case, and the identification of specific regulatory or market barriers that might prevent deployment.
- A uniform assessment of the environmental and economic impacts of the adoption of storage, including the possibility of increased engagement of the electricity and manufacturing sectors in new technology commercialization, both for local use and export opportunities.

3.1 Phase 1: Partnership and Framework Development

Task 1.1 - Partnership Development and Needs Assessment

In this task, partnerships with other organizations will be confirmed for ES roadmap activity within each province. Although this task is already well advanced, workshops will be held in the initial provinces for Phase 2 (Ontario and Alberta), in order to confirm the project plan and inputs/outputs with key stakeholders. In particular, required data and information to initiate future tasks will be secured, including a process for data confidentiality. Overall, it is expected that the most value can be gained from the Roadmap through a combination of:

- An intermediate summary of the results of stakeholder engagement.
- Roadmaps referencing the three pillars above, including additional data and references to support the analysis.
- A final version of the Roadmap for each identified province ready for public release, completed and agreed upon with validated data from multiple sources and references which can stand on its own as a master document.
- Annual workshops will be help to provide updates and obtain direct feedback from key stakeholders.

Task 1.2 - Grid Applications and Market Analysis Framework Development

ES technology is being actively promoted to solve various operational and security problems for power systems. However, distribution planners and operators are facing the challenge of understanding the value and impact of ES on the system. It is critical to understand the interaction between the distribution grid and ES technology with respect to its capacity, reliability, and power quality in specific use cases. Based on this understanding, distribution planners can more accurately predict the changes that ES will cause and make appropriate decisions to ensure power supply and reliability.

Integrating approaches applied in other jurisdictions, such as the working groups of the Energy Storage Integration Council (ESIC) of which the NRC is a member, this Roadmap will clearly assess the potential for storage on the grid system initially using data from Ontario and Alberta. Specifically, the project will:

- **Identify Energy Storage Use Cases –** This activity will categorize the use cases of storage on the distribution grid, and quantify the potential of the ES opportunity caused by congestion, variable generation, and capacity and regulation services requirements.
- **Define Specific Application Requirements –** This task will focus on the development of a framework to define common application requirements for each identified use case. This framework will assess the needs in each use case in areas not limited to: Performance (Ramp Rate, Efficiency, Availability, and Reliability, etc.), Environmental Impact, Codes and Standards Compliance, Physical Envelope and Siting.
- **Identify the Impacts on Grid Power Planning and Operations -** The Roadmap will develop guidelines based on technical analysis to support ES operating requirements in the areas of: Communication and Control Protocols, State of Charge and Capacity Requirements, Charge/Discharge Intervals, and other key parameters affecting grid integration.
- **Review the Current Market Potential –** This task will review both the current market regulations as well as approaches in other jurisdictions in order to identify any specific operational or economic barriers which may restrict the viability of storage. Where restrictions are found, several options for policy tools will be provided for consideration by Regulators.

Task 1.3 - Energy Storage Technology Assessment Framework Development

As with any new technology, it is expected that the state of the art in ES will continue to evolve over the course of early development and deployment. Several well-known sources of ES technology review exist, such as the US Department of Energy (US DOE) Energy Storage Handbook, the IEA (International Energy Agency) Energy Storage Roadmap, as well as assessment frameworks completed by the NRC and its partners.

The Roadmap will build upon these resources to provide a technical overview of the potential for various ES technologies to meet the pre-defined applications, and integrate this with validated data from existing demonstration projects across Canada and internationally. This will include information on:

- **Assess Energy Storage Technologies & Trends –** This task will provide information on technology performance, codes and standards (including upcoming amendments and new standards in development), and an overview of technology providers and relevant experience.
- **Match Technology and Application Requirements –** Utilizing technology and application matrices, this task will evaluate the suitability of specific ES technologies to meet the use cases developed in the project.

- **Review Early Energy Storage Experience –** Ontario and Alberta are recognized as early leaders in the development and deployment of ES technologies, and an analysis of current system performance will be provided. This performance can be compared against data from other markets to ensure that lessons learned in those jurisdictions can be leveraged.
- **Propose Evaluation and Performance Frameworks -** A summary of evaluation frameworks developed in this project will be provided in order to inform future procurements and inform technology developers of performance requirements. This will be compared against other technology roadmaps and requirements that have been developed or are currently under development.

3.2 Phase 2: Draft Technical Roadmaps for Ontario and Alberta

Although the electricity market dynamics within each province may have differences, they share numerous common elements. The establishment of a framework and ES roadmap methodology in Ontario and Alberta during the first 2 years of the project will streamline the deployment of a national ES roadmap in future phases. The outputs of each task will produce a chapter of the roadmap following the framework above including:

- Grid requirements by segment.
- Generic distribution feeder models.
- Cost/benefit of ES storage for each use case.

Task 2.1 - Develop Technical Roadmap for Ontario

In 2013 Ontario represented about 24.5% of Canada's electricity generation. The majority of electricity generation is nuclear at 93.1 TWh (61.8%) followed by hydro at 36.7 (24.4%) TWh with the remainder being thermal steam (4.7%), combustion turbine (5.3%) and wind (2.2%). Solar is only 0.24 TWh, but combined with wind, both are expected to grow and represent a significant part of Ontario's generating capacity. Ontario's wholesale electricity market is de-regulated for consumers consuming greater than 250,000 kWh/yr, but regulated for consumers consuming less than that. The market clearing price of electricity is set at the equilibrium of supply and demand on a price versus quantity graph. The Ontario market is comprised of generation, transmission, distribution, and finally, behind-the-meter. The latter is out of scope for this proposal. Generic use cases will be developed using a methodology developed by Pacific Northwest National Laboratory (PNNL) for the distribution grid [8].

In Ontario, Independent Electricity System Operator (IESO) has already embarked on evaluating the grid requirements for generation and transmission. Discussions with the IESO, Ontario Ministry of the Environment (MOE), and other key stakeholders will continue to ensure that the outcomes of these studies will serve the regulators and industry. The roadmap will be completed in Ontario following the framework and stakeholder engagement methodology developed in Phase 1.

Task 2.2 – Develop Technical Roadmap for Alberta

Alberta generated 63.6 TWh in 2013 or 10.4% of Canada's electricity. Although both Alberta Electric System Operator (AESO) and IESO are de-regulated electricity markets, the make-up of Alberta's grid is very different from that of Ontario's. Alberta's generating capacity is the most GHG intensive of all provinces and territories where 44.87 TWh (67.1%) is thermal steam, 13.7 TWh (20.5%) is combustion turbine, and 2.3 TWh (3.5%) is wind. AESO owns no transmission or market assets; these are provided in regulated portions by many generating market participants. Current ancillary services include operating reserves, transmission must-run, load shed services, and black start services. In this project, we will be looking at the same segments of generation, transmission and distribution as for Ontario. Based on previous work, it is expected that an analysis of the market will show significant potential for ES in Alberta using the same methodology as for Ontario.

3.3 Phase 3: Draft Technical Roadmaps for the Rest of Canada

This task will build on Phases 1 and 2, in order to analyse the potential of ES in each province and territory. Scenarios, market situation, drivers and use cases will be developed for these jurisdictions. In order to do this most efficiently, we will identify the markets by their critical differentiators, and complete the analysis on an exception basis. The following jurisdictions have initially been identified as key chapters in the national roadmap:

- ***Maritime Provinces:*** The maritime provinces have some of the higher energy prices in the country, and many have high amounts of renewables.
- ***Saskatchewan:*** This province is now pushing towards increasing intermittent renewable generation to reduce the relative weight of coal power generation.
- ***Quebec and British Columbia:*** The market conditions in these two provinces are quite different from Ontario and Alberta, given the vertically integrated utilities in both jurisdictions and that hydroelectricity is a significant contributor to the overall energy mix in both provinces. Energy storage will be required due to commitments to increasing intermittent renewable electricity in the generation mix.
- ***Territories:*** We will need to consider at least one territory in this study. The development of microgrids within these territories has been a subject of several PERD projects. ES could assist in the deployment of microgrids, especially as they integrate intermittent renewables to reduce diesel use.

3.4 Phase 4: Impact Assessment and National Perspective

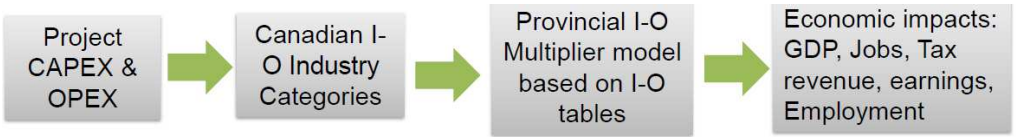
Task 4.1 – Assess the Environmental and Economic Impact Potential of Storage

From a technology perspective, there are companies and stakeholders spread across multiple storage technologies and segments of the ES value chain. Supporting industry in the development and deployment of these technologies is core to the mission of the NRC's Energy Storage for Grid Security and Modernization Program, and likewise meets the economic development and innovation mandates within each jurisdiction. In order to achieve these objectives, the Roadmap will:

- **Identify Technology Opportunities -** For ES technologies, cost, durability and performance have been barriers for their wide adoption for grid applications. The

Roadmap will identify technology opportunities in existing and prospective market segments, as well as opportunities for new products, services and enabling technologies.

- **Analyze Canadian Industries Strengths –** ES technology developers range from battery manufacturers, inverter and controls suppliers, system integrators, EPC (Engineering, Procurement and Construction) to project developers and operators. The Roadmap will develop an economic impact model outlining the potential benefits of adopting storage within the provinces. This project will build upon background work the NRC has completed in other projects to detail the supply chain across Canada, and identify the market participants outlined above as well as other key market players and enablers who can be engaged to support and further enhance the development of the sector.
- **Assess Environmental & GHG Impacts -** The environmental impact will be limited to the GHG (Green House Gas) emissions. First, a baseline of the current power generation, transport and distribution of electrical power in each province will be established. The life cycle assessment will be carried out using a Life Cycle Analysis (LCA) approach within the Cradle-to-Grave framework. For each case, a comparative GHG impact will be quantified which includes three components: (i) ES Cradle-to-Grave, (ii) ES Use and (iii) ES End of Life (recycling or landfill).
- **Economic Impact Calculation -** As outlined below, the economic impact calculation will be performed in a 4-step approach. Depending on market capture, current and future impact will be estimated.

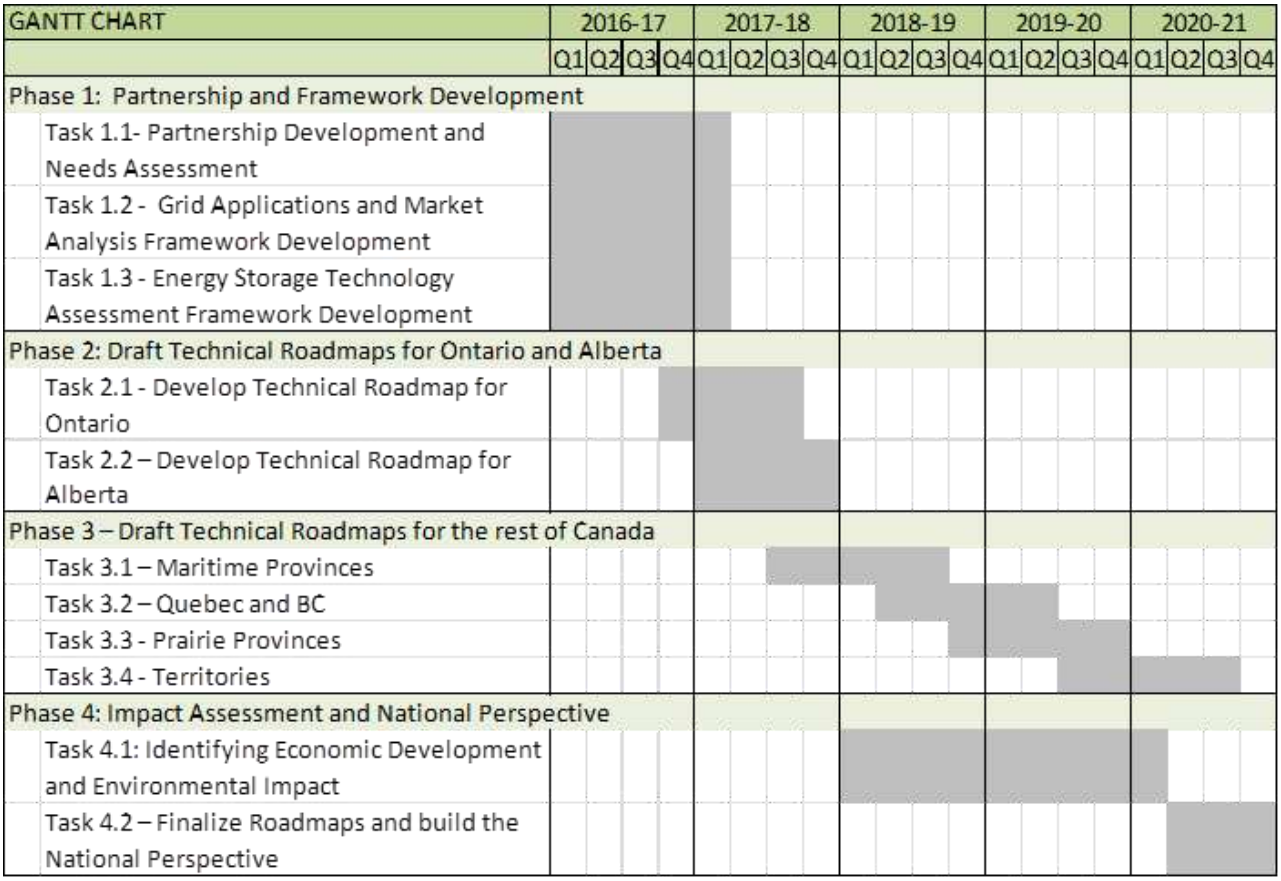


Economic impact calculation will be performed for each year of project life time. The impacts of each year are added to estimate the total economic impact of the project life cycle within each jurisdiction.

Task 4.2 – Finalize Roadmaps and Build the National Perspective

Based on the analysis completed in the tasks above, final recommendations for consideration in procurement and policy environments will be summarised, as well as next steps for the development of ES. Opportunities for synergy between the works completed in different Canadian jurisdictions and abroad will be summarized and integrated into next steps.

4. Timeline and Schedule



5. Governance and Stakeholder Engagement

External stakeholder input is critical to the success of the Canadian Energy Storage Roadmap Initiative. To facilitate communication and coordination, forums will be established to provide information to, and collect feedback from, three distinct groups:

1) **Advisory Board Members** – representatives from NRC, provincial systems operators, regulatory bodies, association(s) and other government departments.
2) **Contribution Partners** - key industry participants in each province available to provide expert insight, data and feedback.
3) **Other Interested Parties** - stakeholders interested in the progress and outcomes of the initiative.

Advisory Board Members and Contribution Partners will be formally invited to participate in the development of the project, with access to webinars, workshops and a private on-line collaboration space. Other Interested Parties will also be kept informed regarding the progress and outcomes through public webpages, NRC's quarterly newsletter and other forums such as conference presentations, reports and other informal communication methods.

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