Energy Storage Systems

Statement of Qualifications

Energy Storage & Battery Systems
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Statement of Qualifications– Energy Storage Systems

Hatch is an award-winning consulting firm with a reputation for technical excellence, innovation, and overcoming complex engineering challenges. For over 60 years, Hatch has offered our public and private clients a complete range of services, from planning, feasibility studies, environmental assessments, conceptual to detailed design, procurement support, project and program management services, construction inspection and management, contract administration, as well as operations and maintenance support.

We recognize your need to operate at the leading edge of deploying energy storage in power grids and understand that this industry is changing rapidly. Your goal is our goal: to make the project concept a reality and optimize the value of your investment, not just for today, but for the complete project life cycle.

Operating throughout North America and around the globe, Hatch is a recognized leader in program, project and construction management, as well as in engineering and technical services. Hatch can draw upon 9,000 staff resources worldwide, this allows us to bring a unique depth of expertise to engagements, as our specialists are able to supplement their knowledge with the technical, market and environmental know-how of their colleagues, working in other facets of the energy and resources industry.

If you would like to clarify and further discuss any aspect of your project and how our technical services can enable your project, please call me at 1-514-992-9429 or my colleague, Dr. Jocelyn Zuliani at 1-289-326-9890.

Yours faithfully,

Michel Carreau, Ph.D.
Director of Hybrid Power, eGrid
Hatch Ltd.

Jocelyn Zuliani, Ph.D.
Energy Storage Lead
Hatch Ltd.

Table of Contents

Appendices

1. Introduction

Hatch is pleased to present this Statement of Qualifications (SOQ) in response to the increasing interest in the energy storage sector. Hatch is a qualified firm to provide engineering services for energy storage systems (ESS), including the latest in grid and microgrid-connected Battery Energy Storage Systems (BESS). This SOQ will include an overview of Hatch, and our experience in relevant projects.

Hatch's team is a pool of highly qualified personnel with experience in providing the following range of services:

- Conceptual studies to develop the use case and business case for an ESS, this would include sizing, ESS technology selection and chemistry selection for a BESS, and duty cycle assessment,
- Detailed design for interconnection of BESS to transmission or distribution systems, step up transformers, switchgear, protections and controls, and metering,
- Architectural, structural, mechanical and electrical designs for the BESS container/building,
- Site plan development including foundations and structural design, site modifications, drainage planning and utilities/services design
- Building permits, interconnection studies and permits, and electrical/fire code and standard compliance
- Development of specifications for a BESS and balance of plant, and assistance with procurement activities, including assessments and selection of technology providers and battery chemistries for specific applications
- Project and construction management

2. About Hatch

2.1 Why Hatch

For nearly 100 years, Hatch has been a world leader in renewable power; we have delivered professional engineering and technical services to renewable projects around the corner and around the globe.

As a multi-disciplinary firm, we have the bandwidth to support clients with multi-technology portfolios, including solar, wind, hydro, energy storage, microgrid, thermal, T&D, and nuclear. Developers, utilities, public and private companies, and financial institutions draw on our expertise.

2.2 Our Vision, Mission & Values

Our organization is passionately committed to the pursuit of a better world through positive change. We embrace your visions as our own and partner with you to develop better ideas that are smarter, more efficient, and innovative. Our global network of 9,000 professionals work on the world's toughest challenges. Our experience spans over 150 countries around the world in the metals, energy, infrastructure, digital, and investments market sectors.

We are employee-owned and independent—free to bring our best thinking to your business. Our exceptional, diverse teams combine vast engineering and business knowledge, working in partnership with our clients to develop market strategies, manage and optimize production, develop new game-changing technologies, and design and deliver complex capital projects.

We work closely with the communities in the 70 offices we operate from to ensure that our solutions optimize environmental protection, economic prosperity, social justice, and cultural vibrancy. We want their businesses, ecosystems, and communities to thrive, both now and into the future.

Our people are passionate about our corporate purpose and values. We believe in long-term relationships with our partners, and are committed to our clients' lasting success.

We are "entrepreneurs with a technical soul."

3. Core Areas of Expertise

Hatch has a proven track record of success integrating distributed generation systems, including energy, storage into the power grid or a microgrid system. Our experience in hybrid power developments, engineering and implementation of microgrids and mini-grids, along with energy management, uniquely positions Hatch to develop a robust and pragmatic technical framework for the assessment of battery energy storage systems. Hatch has worked on designing both grid connected and islanded power systems for decades and has first-hand knowledge of electrical stability issues and methods to address them.

Hatch has supported power developers through the development and implementation of renewables with lithium battery storage, advised Li-ion battery suppliers on grid integration, and recently provided due diligence of Li-ion battery manufacturing. You will see examples of each of these projects in Appendix B. In the following sections, we describe our capabilities in energy storage, power generation, and transmission and distribution.

3.1 Energy Storage

Hatch energy storage expertise began over 25 years ago with pumped hydroelectric storage. However, it has transformed since, as requirements for renewables have necessitated a greater range of energy storage characteristics. Hatch plays an active role in the development of energy storage standards through a seat on the Canadian Standards Association/International Electrotechnical Commission (CSA/IEC) committee for Electrical Energy Storage Systems, helping to set precedents for energy storage technology global standardization. Hatch's battery storage expertise has spanned all phases of

energy storage projects for communities, commercial and industrial systems including planning and development phase, as described below:

- Study, simulation and modeling of energy storage systems for frequency support and other grid ancillary services,
- Study of energy storage systems for spinning reserve for islanded microgrids and small island utilities,
- Study, design, detailed engineering, commissioning and performance monitoring of various types of energy storage systems in conjunction with renewable power assets,
- Assessment of inverter capacity to provide real and reactive power (respond to P & Q set points), close loop monitoring of grid frequency and voltage
- Financial modeling of energy storage system applications,
- Conceptual screening for energy storage technologies and project options,
- Optimal sizing and selection of energy storage equipment,
- Conceptual and detailed economic assessment of energy storage retrofits,
- Siting and Permitting support (Electrical Impact Assessment Submission),
- Design of control systems for energy storage integration including control strategies for optimal generation dispatch, renewable ramp rate control, and supplementary spinning reserve,
- Evaluation of the energy storage management system
- Availability of remote control and monitoring capability, remote start and stop of the energy storage system
- Review user interface, data storage, graphics, data compatibility and export, IT security, and SCADA.
- Due Diligence assessment for lenders on proposed or existing energy storage assets.
- Alignment of contractual elements to performance, O&M, and warranty goals
- Evaluate maintenance and operation conditions and costs over the lifetime of the energy storage; identifies spare part requirements
- Review of warranties, guarantees, exclusions and conditions
- Estimate the incremental cost needed to replace or augment components at the end of useful lifetime (when performance degrades below a threshold).

Our specific capabilities in Due Diligence assessments are outlined in Appendix A. More specific project references in the field of energy storage are located in the Appendix B.

3.1.1 Independent Technical Advisor and Review

We support our clients in their efforts to make critical development or financial decisions for their projects in various roles, be it Owner's Engineer, Due Diligence Services for acquisitions, or Lender's Technical Advisor.

Whether buy-side or sell-side, we provide a complete set of technical services to developers, IPPs, lenders, and investors for greenfield development, M&A, or refinancing:

- Red flag reviews and residual risk identification.
- Review of overall site layout, equipment specifications and design.

- Resource assessment: hydrology, wind, solar, geothermal, feedstock.
- Energy yield estimation, uncertainty analysis, including P50, P70, P99-type probability forecasts.
- Curtailment analysis.
- Technology suitability evaluation.
- Technical review of project contracts including EPC, power purchase agreement (PPA), land use, interconnection, turbine/generator supply agreements, and balance-of-plant (BOP) contracts.
- Project development, budget, contractor performance, and construction schedule reviews.
- Evaluation of engineering, procurement, construction (EPC), and operations and maintenance (O&M) scopes and providers.
- Environmental compliance review.
- CAPEX, OPEX, sustaining CAPEX estimating and project financial modeling and reviews.
- Performance analysis and optimization, SCADA mining, underperformance troubleshooting.
- Site visits, certification inspections, punch list reviews, factory acceptance testing/inspections, end-of-warranty inspections.

3.2 Power Generation

Hatch has many decades of global power systems design and planning experience using state-of-the-art technologies and trained professionals. Our in-depth knowledge of the regulatory and commercial business environment, and our close working relationships with our clients, allows us to provide a complete range of services from conceptual planning to commissioning of generation facilities. A list of services includes the following:

- Prefeasibility and feasibility studies,
- Engineering, procurement and construction management (EPCM),
- Bidders' technical advisor,
- Owners' Engineer,
- Plant optimization and operational support.

Power developers, utilities, and system operators recognize that attention to detail differentiates Hatch. Our in-house professionals strive to present clients with the most technically and commercially viable solutions for maximum safety, quality, reliability, performance, operability and maintainability, and completion of projects on schedule and on budget.

For more than 60 years, Hatch has been a world leader in power generation, from our roots in hydropower to thermal power (coal, biomass, gas, waste), wind power, and solar power.

As a leader in the renewable power sector, with 25,000 MW of experience worldwide, Hatch provides a full range of wind and solar project development services in house. In addition, Hatch's in-house capabilities in the field of thermal energy make Hatch the favored company for our clients' full range of needs.

Hatch has a proven track record of success integrating power generation and energy storage. Our experience in hybrid power development, microgrids and energy management uniquely positions the team to offer a complete service offering for your unique needs.

3.3 Power Transmission and Distribution

Hatch has extensive experience in the justification, design, implementation and operation of modern transmission and distribution systems including lines, stations, SCADA systems, and protections and controls. Hatch uses state-of-the-art planning and design techniques in the provision of these engineering services, and has project experience with the most advanced software tools available.

Hatch's consulting, planning, engineering and project delivery services include:

- Strategic, business and regulatory consulting,
- Long-range transmission plans,
- Conceptual design and cost estimating,
- Generator connection studies,
- Interconnection studies,
- Detailed design and procurement,
- Construction management/oversight,
- Commissioning,
- Operational support services and operational performance.

4. Selected Projects

Utility Battery Feasibility Study, Yukon Energy Corp.

Yukon Energy Corporation, Yukon Territory, Canada

Yukon Energy is exploring the potential to install a grid connected battery to provide multiple services to the grid. Hatch supported Yukon Energy to assess the use cases, and their benefits to the grid, including diesel fuel savings. Additionally, Hatch supported sizing, siting and chemistry selection for the battery, prepared a capital and operating cost estimate, and prepared a preliminary layout for the project site.

Battery Energy Storage Subject Matter Expert

Saskatchewan Power Corporation, Canada

SaskPower is planning to install a 20 MW/20 MWh BESS to support grid reliability and power quality. The BESS will be used to reduce unscheduled flows on Manitoba Hydro intertie; provide blackstart services, improve power quality/reduce voltage and frequency excursion.

Hatch is providing the following scope:

- Use Case and Duty Cycle Assessment, and Battery Degradation Review
- Battery Energy Storage System Specification
- Power Plant Controller Specification
- EPC Bid Package
- Bid Review & Evaluation

2 MW/8 MWh Flow Battery Installation, Preliminary Engineering, Bid Package Development, and Engineering Cost Estimate

Lindsay Storage LP, Canada

Lindsay Storage LP retained Hatch to complete preliminary engineering a 2 MW/8 MWh Flow Battery Installation, which is part of the IESO Energy Storage Procurement Phase 2 Program. The scope of work involved preliminary design for the grid connection and balance of plant, support the Hydro One (HONI) Connection Impact Assessment (CIA), and support the EASR noise assessment. Additionally, Hatch provided support to review the flow battery technology and assess the suitability to meet the facilities contractual requirements with the IESO. Hatch also prepared the Bid Package for EPC quotes and prepared an engineering cost estimate for the project.

Feasibility study and implementation of two (2) 3 MW wind turbines with a 3 MW battery energy storage systems at the Raglan Mine

Tugliq Energy Co. & Glencore Raglan Mine, Canada

Hatch has been working with Tugliq Energy and the Glencore Raglan Mine since 2014 to support Glencore in their initiatives to reduce energy costs and diesel fuel dependence.

In Phase 1 of the project, Hatch support the implementation of a 3 MW wind turbine and energy storage systems (battery, flywheel, and hydrogen system)

with a microgrid controller. Completed the conception, engineering, commissioning, and operation monitoring.

As a part of the Raglan Mine project, Hatch was involved in screening and review of various energy storage technologies in order to meet the specific needs of the mine's microgrid. As well, the energy storage systems were sized in order to ensure reliable power supply, including sufficient capacity to provide power during diesel generator ramp up.

In Phase 2 of the project, Hatch conducted feasibility engineering for a second 3 MW wind turbine and a 3 MW energy storage. The site now has 6 MW of wind power on a 16 MW load.

Hatch prepared detailed specifications of the energy storage, and supported procurement (RFP and Vendor Selection) and commissioning of the BESS. Hatch also upgraded its HμGrid microgrid controller to integrate the new wind turbine and larger energy storage system. The HμGrid controller is designed to provide fast response to reduce wind power variation and provide signals to the operator to change the diesel generator unit commitment.

Battery Energy Storage Procurement for 5 Remote Villages in Nunavik Quebec

Hydro Quebec, Canada

Hatch is working with Hydro Quebec to support the procurement of 5 battery energy storage systems for remote first nations communities in the Nunavik Region. Hatch is working with Hydro Quebec to develop the performance and technical specifications for the battery, and the request for quotations. Additionally, Hatch supported Hydro Quebec with an expression of interest, including identification of vendors, drafting the EOI and review of the vendor bids.
This project is part of a larger overall goal, in which Hydro Quebec will install energy storage + wind turbines to power these communities. Hydro Quebec is targeting diesel-off operation for these communities for prolonged periods.

Wind + Energy Storage Implementation for Kluane First Nation

Kluane Community Development Corporation, Canada

Hatch worked with the Kluane Community Development Corporation (KCDC) to develop a 300-kW wind power facility to provide renewable power to Kluane First Nation and reduce diesel fuel consumption. Additionally, an energy storage system will be installed at the ATCO diesel power plant to allow diesel off operation during periods of wind power generation that can meet the community load.

Hatch assessed the benefits of integrating different sized battery energy storage system, as well as prepared a detailed model to predict the duty cycle on the battery. Hatch also supported KCDC to review the dispatch protocol outlined by ATCO and assess ATCO's the proposed battery solution.

5. Key Staff

As grid-connected energy storage is an emerging need arising out of increasingly higher penetration levels of intermittent power generation, the team we propose for this project blends project engineering professionals with Hatch's in-house renewable power and technology development team, who has been spearheading Hatch's involvement and mastery of energy storage technologies. We believe that this team is likely a best fit for your project because it brings device-level energy storage expertise, controls technology expertise, T&D system engineering, interconnection expertise, renewable and thermal power expertise, as well as project engineering and management skills to the table. We bridge the gap between devices and commercially successful implementations of energy storage systems. This team has worked closely with the electrical system operators and countless major electrical utilities. Our global center of expertise for grid-connected battery storage, renewable power, and transmission & distribution is at our global headquarters in Toronto, Ontario and Montreal, Quebec.

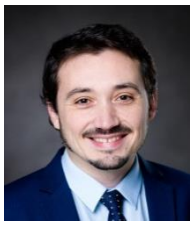
Name and Title		Fields of Experience	Years
	**Michel Carreau, PhD** Director –Hybrid Power	Michel is a specialist in energy with a PhD from the Massachusetts Institute of Technology and a Post-Doctorate from Boston University with more than 30 years of experience in energy. He has expertise in the development of energy project such as hybrid power, hydro-electricity, wind, solar, thermal power, biomass cogeneration, energy storage, micro-LNG supply chain, energy efficiency. Michel works directly with mining, ports and industrial companies to develop solutions to reduce their cost of energy and lower their carbon footprint.	30+
	**John Matthiesen, MBA** Director – Smart Grid	John brings a variety of team leadership experiences within the power sector ranging from OEMs, client focused service providers, engineering teams, consulting & advisory firms. He has significant experience with thermal energy (gas turbine power trains), renewable energy (onshore & offshore wind), distributed energy resources (energy storage, clean hydrogen, microgrids, and EV charging), and recently with Smart Grid and Asset Management Programs. John has led 20+ domestic & international multi-disciplined power equipment overhaul projects with teams up to 50 people on client sites. He has prepared and negotiated 40+ commercial agreements and master services agreements, provided performance management advisory services, contributed to due diligence and Independent Engineering activities on multiple multi-billion-dollar renewable energy assets, facilitated corporate strategy development & implementation plans, and led cost reduction & asset optimization projects	18+

Jocelyn Zuliani, PhD
Energy Storage Lead

Jocelyn is part of the eGrid Renewable Power group, working on integrating energy storage technologies with renewable power energy resources to reduce the need for fossil fuel energy sources. She is also working on the integration of energy storage systems at various facilities in order to improve power quality and reduce dependence on the power grid. During her time at Hatch, Jocelyn has worked on integration of energy storage systems for both commercial and industrial facilities.

Prior to starting at Hatch, Jocelyn completed her Ph.D. studying energy storage technology, focusing on supercapacitors. Jocelyn has published 7 peer-reviewed journal articles and has attended several conferences and workshops to present her work.

7+



Joel Guilbaud, PhD
Hybrid Power Lead

Joel has expertise in modeling and optimizing energy projects such as hybrid power, wind, solar, thermal power, energy storage, bio-gas and LNG alternatives. He has also gained considerable experience in cost optimization and decision-analysis from the various business ventures and research projects in which he was involved. Joel has over ten years of professional experience and worked with Fortune 500 clients and other market leaders.

In his latest project, Joel performed a techno-economic optimization of solar and wind power alternatives with respect to operational and capital costs as well as total-life-cycle costs and financing mechanisms. Joel has published several publications on hybrid renewable power systems and worked with the British Ministry of Energy and Climate Change on energy storage policy and regulations.

10+

Mark Mitchell – Battery Controls and Inverter Lead

Mark is a Microgrid & Power System Specialist with a diversified background in power system controls and energy storage systems. He has extensive experience working with renewable energy and energy storage projects from conceptual studies to procurement, commissioning, and operation.

Mark specializes in the constructability and “make it work” aspects of energy storage system integration; this comes from his extensive hands-on experience working with inverters, batteries, flywheels, compressed air, and hydrogen systems both on site and in the office through planning, design, and remote operations support. He has worked on several project that have led to commissioning and operation and is therefore well aware of the requirements that ultimately lead to successful project implementation.

7+

7. Conclusion

We hope this SOQ provides you with a good understanding of our capabilities in supporting your energy storage projects, and trust that you agree that our team is ideally matched to your requirements in this emerging industry space.

Through the experiences Hatch has acquired over many decades, clients can have a sense of comfort knowing an extensive and comprehensive team of professionals will manage their projects and their needs with the highest level of integrity possible. Hatch adds value by assessing existing and potential projects and reporting the truth, through which stakeholders can then identify and capitalize on viable opportunities in each dynamic sector. Hatch deploys the services and resources needed to provide a safe and cost effective project, from initial assessment and concept right through to implementation and operational support. Please do not hesitate to contact the team with any further inquiries.

Appendix A:
Energy Storage Due Diligence Capabilities

Energy Storage Due Diligence

eGRID – Wind, solar, hybrid power, energy storage, microgrids & Smartgrids

Tugliq Energy – Flywheel, Electrolyser, Fuel and Battery install at Raglan Mine. Nunavik, Northern Quebec, Canada

Identifying the optimal energy storage technology and configuration for your project that will perform appropriately for the desired lifetime at the estimated cost is not a simple matter.

The range of practical applications for energy storage is diversified and each type has its own specific requirements and performance.

We can help you understand the financial and technical risks when evaluating energy storage as well as review the technical assumptions going into the financial models underpinning your investment.

Drawing on a wealth of experience, we can quickly and thoroughly conduct technical due diligence on energy storage projects. Our technical experts work with all all forms of energy storage, covering hydropower (pumped storage), mechanical (CAES - terrestrial and aquatic, flywheels, gravitational), thermal (molten salt), electrochemical (Li-Ion, flow batteries, supercapacitors).

A detailed due diligence study typical entails the following activities and can apply to grid-connected, off-grid, or behind-the-meter storage applications:

Characterization of use case

- UPS type utilization, fast response spinning reserves and ancillary service to ensure grid resiliency
- Power quality, frequency control to ensure grid stability
- Time-shifting/energy banking of generation for later use

Technology viability review including

- Historical performance and safety track record in different climate conditions to validate the maturity of the technology
- Maintenance and service requirements, including supplier performance risk related to service and warranties

Sizing, performance, lifetime, project details

- Review system sizing and multivariate optimization of project goals, e.g. revenue maximization, performance requirements, capital performance, and O&M cost minimization
- Evaluation of expected, useful service life and degradation assumptions

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Energy Storage Due Diligence

eGRID – Wind, solar, hybrid power, energy storage, microgrids & Smartgrids

Robust High-Precision Measurement Hardware–Built upon the proven National Instruments (NI) PXI/RIO platform, 24-bit analog to digital conversion and 50 kHz simultaneous input sampling; equipment used during FAT and SAT

- Evaluation of round trip efficiency and energy lost from auxiliary loads (such as air conditioning, supplement heating, etc.)
- Charge and discharge rates, influence of temperature and other variables on performance
- Duty cycle limitations
- Lifetime evaluation based on intended utilisation
- Fire suppression and noise
- Balance of plant: Project site, permit review, interconnection agreements

Management System and Control Capabilities

- Capacity for the inverter to provide real and reactive power (respond to P & Q set points), close loop monitoring of grid frequency and voltage
- Evaluation of the energy storage management system
- Availability of remote control and monitoring capability, remote start and stop of the energy storage system
- Review user interface, data storage, graphics, data compatibility and export, IT security, and SCADA

Purchase Contract, O&M, warranties

- Alignment of contractual elements to performance, O&M, and warranty goals
- Evaluate maintenance and operation conditions and costs over the lifetime of the energy storage; identifies spare part requirements
- Review of warranties, guarantees, exclusions and conditions
- Estimate the incremental cost needed to replace or augment components at the end of useful lifetime (when performance degrades below a threshold).

Factory and Site Accept Testing (FAT and SAT)

- Measure charging/discharging ramp rates and curves, roundtrip efficiency, energy storage power limits and capacity
- Measure duty cycles limits (and ability to disperse heat buildup)
- Monitoring stability of string management systems

Appendix B:
Representative Experience List

Energy Storage

Representative Experience

Years / Project	Client / Scope of Work
2020 – Ongoing **Detailed Engineering and Procurement Support for 2 MW/1 MWh BESS** Canada H-364270	**De Beers Canada** Hatch is currently supporting De Beers with the specification and procurement of a 2 MW/1 MWh BESS to support solar PV integration at the Gahcho Kué Mine in the Northwest Territories. De Beers is currently integrating a 2.4 MW solar PV installation at the mine and plans to use the BESS to provide improve renewable penetration and grid stability Hatch completed the following services as part of the project: • Use case assessment and Battery Sizing • Battery Specifications • Controls Requirements and Specification • Procurement support for the BESS and controls • Detailed Electrical and Civil design for the Balance of Plant • Design Review for BESS supplier • FAT testing support • Construction Supervision and Commissioning Support
2020 **Utility Battery Feasibility Study and Procurement Support** Yukon, Canada H-362094	**Yukon Energy Corporation** Hatch is working with Yukon Energy to assess the potential benefits a utility scale battery can provide to their grid. As part of this study, the primary, secondary and tertiary use cases for the battery were identified. Based on the use cases, the preferred sizing and battery chemistry were proposed. Additionally, three potential sites were assessed to determine the benefits and challenges associated with each option. Hatch is now supporting Yukon Energy with the preparation of battery specifications for the procurement of the 20 MW/40 MWh battery and terms for reference for the basic engineering for the balance of plant.

Years / Project	Client / Scope of Work
2020-Ongoing **Basic Engineering and Energy Storage System Sizing – Wind + Storage Microgrid** Yukon, Canada H-364372	**Kluane Community Development LP** Hatch is working with the Kluane Community Development LP (KCDLP) to complete the basic engineering for the wind + storage microgrid that will be integrated with the existing diesel generators. Hatch developed a hybrid model to simulate the microgrid operation. This model is used to estimate annual wind energy sales, and select the preferred energy storage system sizing. Hatch is also supporting KCDLP with the preparation of specifications for the wind turbine, performance requirements for the battery, and basic engineering for the electrical interconnection and site works. This information will be used to prepare an engineering cost estimate for the project. Hatch is working directly with the Kluane First Nation development corporation to support this project development.
2020 – 2021 **Emerging Energy Storage Assessment** Canada H-363248	**De Beers Canada** Hatch is working with De Beers to support their initiatives to achieve net zero operations for their mining sites. Currently De Beers is focusing on achieving 100% renewable penetration at the new Chidliak Mine. Hatch was retained to complete an assessment of emerging energy storage technologies. This included reviewing the technologies, engaging in discussions with vendors, and assessing their suitability for the proposed usage. Both electrical and thermal energy storage technologies are assessed. The technologies are ranked against a baseline using an weighted evaluation matrix to select the leading options for the mine.
2019-Ongoing **Inuvik High Point Wind – Owner's Engineer** Northwest Territories, Canada H-360609	**NT Energy** Hatch was the Owner's Engineer for the Inuvik High Point Wind Farm. This project integrates a 3.5 MW Wind turbine and a 3.5 MW battery energy storage system with existing diesel generation that currently generates electricity for Inuvik. As part of this project, NT Energy plans to operate diesel off overnight, with 100% of the power supplied by the wind turbine and the battery. Hatch has supported NT Energy to prepare battery specifications for the 3.5 MW system, respond to bidders questions and to evaluate the bids. Hatch also supported technical contract negotiations with the preferred bidder. In the next phases, Hatch will support NT Energy with the design review for the battery system, FAT testing and commissioning.

Years / Project	Client / Scope of Work
2019-Ongoing **Battery Energy Storage System Procurement for 5 Remote Villages in Nunavik** Quebec, Canada H-360935	**Hydro Quebec** Hatch is working with Hydro Quebec to support the procurement of 5 battery energy storage systems for remote first nations communities in the Nunavik Region. Hatch is working with Hydro Quebec to develop the performance and technical specifications for the battery, and the request for quotations. This project is part of a larger overall goal, in which Hydro Quebec will install energy storage + wind turbines to power these communities. Hydro Quebec is targeting diesel-off operation for these communities for prolonged periods. Hatch continues to support Hydro Quebec in the design review and validation of the battery selected for 1 village.
2020 **Due Diligence Review for Two Grid Connected Battery Energy Storage Projects** USA H-364011	**Confidential** Hatch was engaged by this client to perform a technical due diligence review of several power plants in the southwestern United States prior to a potential purchase of a stake in these assets; two of the assets were grid connected energy storage facilities. This project involved a technical and financial review of a 100 MW/400 MWh and a 10 MW/ 40 MWh battery installation. The scope included the evaluation of the seller's technical designs, operating and maintenance procedures and financial information. Risks and associated mitigating measures were presented to the client that were inputted into the client's financial case for purchase of the assets.
2020 **Independent Engineering Review for Two Battery Energy Storage Projects Behind the Meter at Commercial & Industrial Facilities** Ontario, Canada H-364011	**Confidential** Hatch was retained to perform an independent engineering assessment for two operational energy storage facilities in Ontario, connected behind-the-meter at a commercial facility and an industrial facility. As part of Hatch's assessment, the team completed review of off taker agreements with host sites, a technical review of the projects, review of the certification requirements, review of the battery warranty and capacity retention, review of maintenance plans and agreements with battery vendors, review of the planned battery usage and forecasted degradation, technical review of the project pro forma, including revenue, operating & maintenance costs, and provided recommendations on the major maintenance reserve account.
2020 **Independent Engineering Review for Two Battery Energy Storage Projects Connected to the Ontario Grid** Ontario, Canada H-363489	**Confidential** Hatch was retained to perform an independent engineering assessment for two operational energy storage facilities in Ontario, connected to the local distribution grid. As part of Hatch's assessment, the team completed a technical review of the projects, review of the certification requirements, review of the battery warranty and capacity retention, review of the historic battery usage and forecasted degradation, technical review of the project pro forma, including revenue, operating & maintenance costs, and major maintenance reserve account.

Years / Project	Client / Scope of Work
2020 **Independent Engineering Review for Microgrid including geothermal heating/cooling system, battery energy storage system, and solar carports, for a Secondary School in Ontario** Ontario, Canada H-363490	**Confidential** Hatch provided Independent engineering review for a microgrid energy project development located a secondary School in London, Ontario. The Project consists of multiple technologies, including solar PV, ground-source heat pumps, and battery energy storage. The project proponent engaged Hatch to carry out the role of Independent Engineer to provide a review of the project design and construction for the purposes of closing project financing with third party lenders. The scope of the Hatch review included: • High-level technical review of microgrid components, including PV arrays, Battery Energy Storage System (BESS), geo-exchange system, including related building-side heating/cooling equipment; • Review of heating/cooling performance models; • Site visits to review installation work and site conditions; • Review of project capital and operating cost estimates; • Review of the financial model and underlying technical assumption; and • Review of contracts, O&M, warranties, and other relevant agreements.
2020-2021 **Methodologies to Optimize the Value and Amount of Energy Storage: Economic and Technical Evaluation** Canada H-362112	**CEATI International Inc., Strategic Options for Integrating Emerging Technologies and Distributed Energy Interest Group** Hatch is working with CEATI to support the development of a high level user friendly tool to evaluate the value of energy storage in various regulated and deregulated markets. As part of this study, Hatch's team reviewed the existing and emerging opportunities for energy storage in both ISO and non-ISO markets. This information will be gathered to develop a high level methodology to estimate the potential value for energy storage in the market. Different scenarios and value stacking opportunities will be assessed. Additionally, sensitivity analysis on the impact of energy storage system sizing will be completed.
2020-2020 **Energy Storage as a Transmission Asset** Canada H-362017	**CEATI International Inc., Power System Planning and Operations Interest Group** Hatch is working with CEATI to complete a study assessing the opportunities and technical requirements for energy storage systems for transmission grid applications. As part of this assessment, Hatch's team is reviewing the technical capabilities of commercially available storage technology as well as emerging technologies. Additionally, Hatch's team reviewed the various transmission scale use cases. The technical capabilities of the commercial storage technologies were compared to the use case requirements. Opportunities for the storage technologies to improve were identified, to better meet the needs of the transmission grid.

Years / Project	Client / Scope of Work
2019 **100% Renewable Energy for Chidliak Mine (Wind - Solar – Storage-Diesel Hybrid Microgrid)** Northwest Territories, Canada H-359596	**De Beers – Childiak Mine** De Beers is in the final design stages of the new Chidliak Mine in the Northwest Territories. As part of sustainability initiatives, De Beers has targeted 60-100% of the energy consumed by the mine should be generated from renewable resources. Hatch was retained to conduct a wide-ranging study investigating various opportunities to achieve these high renewable penetration. As part of the study, Hatch assessed the energy storage options required for the proposed microgrid. Due to the high renewable penetration targets, long duration energy storage is required. Hatch conducted a technology review and preliminary vendor assessment of both Lithium Ion Batteries and Flow Batteries. This included assessing the technology's fit for the desired application, its readiness for deployment in the Arctic, and developing a preliminary cost estimate for deployment of the technology, including balance of plant indirect costs.
Phase 2: 2017 – 2019 **Detailed Engineering and Implementation of a 3 MW Wind Turbine and 3 MW Lithium Ion Battery for the Raglan Mine Microgrid** Quebec, Canada H-355542	**Tugliq Energy Co. & Glencore Raglan Mine** Glencore's Raglan nickel mine in northern Québec has added wind power and energy storage to reduce the high cost of diesel-based power generation. The project has 6 MW of wind power with 3 MW of battery to offset diesel costs with fast response battery and control systems to maximize the integration of wind power. Tugliq Energy Co. is the IPP (independent power producer) for the wind–storage system. Over a portfolio of projects for both Glencore and Tugliq, Hatch provided the following: • Feasibility engineering for the new 3 MW wind turbine and 3 MW energy storage • Detailed Specification of the energy storage, Procurement (RFP and Vendor Selection) and commissioning of the storage systems • Design the operation and control strategy, programing and delivery of microgrid controller to provide fast response to reduce wind power variation and provide signals to the operator to change the diesel generator unit commitment.
2018-2019 **Development of an Integrated Resource Plan and Supporting Cost of Service and Tariff Study for Montserrat's Power and Water Sectors** Montserrat H-358368	**Caribbean Development Bank and Montserrat Utilities Limited** The objectives of the study are wide ranging to prepare a detailed assessment of the country's electric power and water sectors, both of which are served by MUL. As well, the study includes a review of operating costs by customer blocks (domestic, commercial, industrial), and the analysis of proposed tariff structures to distribute the costs equitably between customer classes. For the electricity sector, analysis focuses on the use of on-island resources, such as wind and solar, along with energy storage, in order to support the integration of the intermittent renewables with the grid.

Years / Project	Client / Scope of Work
2017-2019 **Hybrid Power System Design (Wind – Storage-Diesel)** Yukon, Canada H-356247	**Kluane Community Development Corporation** Hatch is working with the Kluane Community Development Corporation to develop a business plan for the integration of wind and energy storage into the remote diesel powered grid. The business plan addressed wind turbine selection, system performance simulations with and without energy storage, project costs and financing, industry/market analysis, operations, financial modelling, risks and mitigation, and an implementation plan. Hatch is working directly with the Kluane First Nation development corporation to support this project development.
2018-2019 **Flow Battery Energy Storage Interconnection Feasibility** Ontario, Canada H-357720	**Lindsay Storage LP** Technical Support and Balance of Plant Preliminary Engineering for a Flow Battery Energy Storage project. This project involves design of the electrical interconnection for the facility and balance of plant layout and site design. As part of this project, Hatch is providing technical reviews of the potential flow battery suppliers.
2018-2019 **Utility Battery Study, St. Vincent Electricity Services Ltd.** Saint Vincent H-357499	**Rocky Mountain Institute – Carbon War Room – Clinton Climate Initiative** The goal of this study was to determine the optimal connection points for utility scale batteries on the Saint Vincent grid. This included power flow and dispatch modelling, as well as economic analysis to determine the optimal size and location for the BESSs. BESS locations were investigated for the current grid operation, as well as various planning cases for proposed renewable integration or additional thermal generation on the grid in the next 3 years. After the study has been completed, the first BESS for installation will be selected.
2018-2019 **Utility Battery Study, St. Lucia Electricity Services Ltd.** Saint Lucia H-356974	**Rocky Mountain Institute – Carbon War Room – Clinton Climate Initiative** The goal of this study was to determine the optimal connection points for utility scale batteries on the Saint Lucia grid. This included power flow and dispatch modelling, as well as economic analysis to determine the optimal size and location for the BESSs. BESS locations were investigated for the current grid operation, as well as various planning cases for proposed renewable integration on the grid in the next 5 years.

Years / Project	Client / Scope of Work
2017-2018 **Solar and Battery Energy Storage Assessment for Northern Ontario Mine** Canada H-356249	**GoldCorp** Technical and cost assessment of solar power farm combined with energy storage for a mine with a limited grid connection. The solar (1-3 MW) + battery energy storage system (1-3 MW) is planned to alleviate a near term energy gap and to displace a portion of the diesel power generation. Evaluation of reliability performance with respect to unplanned outages, environmental, health and safety performance as well as operating costs (by reducing diesel consumption and peak electricity cost related to the Ontario Global Adjustment Cost). Detailed project review to ensure that the business case is sound, and that the project plan can be implemented without major obstacles.
2017 - Ongoing **Nassau Container Port Solar + Storage Minigrid & Energy Assessment** Nassau, Bahamas H-352289	**Arawak Port Development** The initial assessment identified the potential of improved power supply and reliability through the installation of a solar + storage minigrid. The minigrid system will combine solar + energy storage to have increased resiliency to utility power outages. The project will reduce the carbon footprint of the port in an ecologically sensitive area of the Caribbean. Hatch continues to support the Arawak Port Development with engineering and feasibility studies for the proposed minigrid.
2017-2018 **Cannington Renewable Power + Energy Storage Feasibility Study & Project Cost Estimate** Australia H-353406, H-355680	**South 32** Detailed wind power, solar power, and energy storage project cost estimate at scoping level for low to high wind power penetration (8, 12, 20 MW) to Cannington Mine. Characterization of different levels of solar PV and energy storage integration on the grid in order to maximize renewable penetration and minimize power costs. Detailed system simulations of diesel and natural gas dispatch along with solar PV and energy storage. Sizing of energy storage system to optimize spinning reserve and load shifting capabilities.
2017-2018 **Driland Microgrid Renewables + Energy Storage Engineering Study** Canada H-355529	**Enercon Canada Inc. & Wind Power Canada Inc.** Evaluate the technical and economic feasibility of developing a grid connected microgrid system with energy storage and wind and solar generation. This study investigates the effects of the grid tied microgrid on the transmission network, operating by the Alberta Electric System Operator (AESO). As well, the battery chemistry and sizing will be determined in order to ensure that the 100% renewable microgrid supplies reliable and resilient power. The system is designed to operate in either grid tied or “islanded” mode. If the project is both economically and technically feasible, Hatch plans to work with the AESO to develop a demonstration project.

Years / Project	Client / Scope of Work
2018 **Electrical Hauling Truck Assessment for Underground Mines** Canada H-356624	**Goldcorp** Hatch was retained to evaluate the technical feasibility and business case for underground electrical hauling trucks for 5 of Goldcorp's mines in Northern Ontario and Quebec. The study involved validating OEM models, review of the required energy for ore hauling based on mine grading, review of battery performance, degradation and lifetime, and analysis of the CAPEX and OPEX of the electrical hauling truck (EHT). The EHT performance, CAPEX and OPEX were compared to a diesel hauling truck of similar payload to determine the potential savings associated with EHTs. In addition to reduction in diesel usage, the shift the EHTs will result in reduced ventilation requirements and costs for underground mines.
2018 **Compressed Air Energy Storage Market Assessment** Canada H-352228	**Tugliq Energie Co.** Market analysis of available compressed air energy storage (CAES) technology to be deployed in a novel application as part of a remote microgrid in Arctic Canada. This study included identifying potential vendors of CAES systems and assessing the applicability of their CAES systems for the desired microgrid application.
2017-2018 **Alternate Power Generation Pre-Feasibility Study** Northwest Territories, Canada H-355272	**De Beers Canada Inc** Alternative power prefeasibility study to evaluate the integrating of wind and solar generation to a mining diesel power plant, along with opportunities to use energy storage, waste heat recovery and carbon capture. Includes resource assessment, sizing options, cost estimates and project economics.
2017-2018 **Norman Wells Wind + Storage Integration Study** Northwest Territories, Canada H-355879	**Government of the Northwest Territories** A feasibility study assessing the optimal sizing and configuration of wind power generation and energy storage technology for the Norman Wells community. This project will investigate both low and high wind power penetration into the existing power system, based on diesel generators. The study includes a review of the available storage technologies and the benefits they can bring to the microgrid to ensure stability and reliability. The study also reviews storage integration into the existing power system, cost estimates, sensitivity analyses and financial evaluations for the community.

Years / Project	Client / Scope of Work
2017 **Commercial BESS Integration** Canada H-355287	**Confidential Client** Provision of integration engineering services to connect a battery energy storage system (BESS) (1-3 MW) to the electrical network of a commercial facility for peak shaving and load shifting applications. Includes the verification of the existing electrical network at the facility, design of the electrical interconnection point, and identification of any upgrades required to safely and effectively integrate the BESS.
2017 **GEMCO Solar PV Network + Energy Storage Study** Australia H-352903	**South 32** Detailed High Solar PV integration Study at GEMCO Mine, up to 14 MW with the addition of a 4 MW/1.8 MWh battery energy storage system. The study included hybrid power operation and control strategy to manage the battery and solar system with the existing grid, solar assessment and detailed electrical analysis of the network. The battery system was studied to understand its contribution to spinning reserve and the potential for load shifting to reduce solar curtailment.
2017 **Peru Off-Grid Solar + Storage Project** Peru H-354710	**Ergon Peru S.A.C.** Independent Engineer, Environmental and Social consultant on the Peru Off-Grid project for rural microgrid installations. Part of the work involved the assessment of battery chemistry, vendors and choice of battery management systems including charging, discharging, equalization and replacement strategies to extend usable capacity over the duration of the project.
2017 **Isolated Communities, Renewable Power Generation Feasibility Study** Alberta, Canada H-353767	**ATCO Electric Ltd.** Feasibility study assessing the optimal sizing and configuration of renewable generation and energy storage technology at three (3) diesel powered remote communities in northern Alberta. The study included solar and wind resource assessments, diesel to propane conversion, optimization of high penetration hybrid configuration, energy storage selection and controls evaluation, cost estimates, sensitivity analyses and financial evaluations for each community.
2017 **Alternative Power Feasibility Study** Democratic Republic of Congo H-351379	**Kinsevere Primary Copper** Feasibility study for alternative power options, including solar, wind, and storage for a remote mine in the Democratic Republic of Congo. Part of a broader study on the expansion of the mine, this study looked at a range of options to expand the mine's power supply and mitigate the production loss and downtime associated with a weak and unreliable grid power connection.

Years / Project	Client / Scope of Work
2016 –2017 **Grid Connection Study for Battery Energy Storage System** Canada H-351197	**NextEra Energy Canada Development and Acquisition Inc & Alberta Electric System Operator (AESO)** The study investigates a proposed grid-tied battery energy storage system on the Alberta Electric System Operator (AESO) transmission system. The scope of work involves the preparation of Project Data Update Package for Stage 1 and 2, Connection Study, Facility Study, Cost Estimate for Upgrade facilities, and Connection Study proposal. These studies are to be carried out according to the AESO scope and guidelines as well as the applicable system reliability standards and requirement.
2016 **Conceptual and Prefeasibility Study for Hybrid Power System** USA H-305423	**Confidential Client** Provided bid support for a 20 MW PV + 110 MWh storage system, intended to provide load shifting services to a municipal electrical utility. Services included cost estimates, sizing requirements, solar production estimates, battery storage estimates, and preliminary electrical system architecture and design.
2016 **Conceptual Study** Bahamas H-344299	**Interamerican Development Bank** Preliminary Sizing and conceptual study costing for Energy storage used for the time-shifting of solar photovoltaic energy from the weekend to weekday times to reduce client energy demand for an industrial site in the Caribbean. This study involved a review of the available battery chemistries and suppliers to identify the optimal system to meet the use case requirements. As well, with the goal of reducing solar curtailment, the battery system was sized based on technical and economic constraints.
2016 **Borden Mine Power Supply Alternative Study** Canada H-351877	**Goldcorp** A holistic approach was taken to review and identify potential alternative applicable for the site. The following alternative were analyzed: diesel, natural gas, propane generators, thermal heat recuperation, solar PV, Solar Thermal, biomass cogeneration, hybrid power combining wind, solar, energy storage and generators. Each alternative was reviewed and described with sufficient details to provide a CAPEX and OPEX estimate. The levelized cost of energy was estimated for each option.

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2015-2016 **Red Rock Pumped Storage Project** USA	**Red Rock Power Corp.** Hatch prepared the qualitative assessment of the potential benefits of the pumped storage project such as levelization of electricity price, provision of operating reserve, ancillary services (black-start, regulation, reactive support and voltage control), and capacity reserve, reduction of export during off-peak periods and import during peak periods, mitigation of transmission congestion, reduction of water spilling and system GHG emissions and improvement of system stability. In addition, Hatch performed an assessment of key issues regarding the project, including an initial assessment of geotechnical matters, an environmental assessment and obtaining of permits, approvals or other authorizations.
2014-2015 **Raglan Flywheel Energy Storage System** Canada H-346870	**Tugliq Energy Co.** Design and supply of a skid mounted flywheel energy storage system. Included selection and coordination of vendors, electrical and controls integration of DC flywheel and grid-tied inverter, design, dynamic analysis and fabrication of skid, factory integration testing and site commissioning.
2013 –2016 **Development of a Utility Grade Controller for Remote Microgrids with High Penetration Renewable Generation** Canada	**Natural Resources Canada** Grant funded development of a microgrid control system for hybrid power to manage diesel and renewable generators, energy storage and loads for the most economical operation of the grid while maintaining power quality (frequency and voltage) within required limits. In collaboration with University of Toronto, University of Waterloo, Hydro One and Kasabonika Lake First Nation.
2013-2015 **Hybrid Generation Options for Microgrid Project, Feasibility Study** Gabon H-336241	**Ministry of Oil, Energy and Hydraulic Resources of Gabon** Feasibility study of a solar/wind/diesel hybrid plant with 400 kWh of energy storage (flow battery, Li-ion battery) to power an isolated microgrid. Hybrid generation to reduce fuel consumption by 50% compared to diesel only.

Years / Project	Client / Scope of Work
2013 – 2015 **Application of Composite Flywheels and Development of Control Platform for Integration of Renewable Energy in Remote Communities** USA H-345153	**Alaska Energy Authority** This grant-funded project involved the following activities: • Collection and analysis of village power system data • Dynamic and economic model of system demonstrating benefits of energy storage • Development of a fast response microgrid control system • Design and build of a grid tied flywheel energy storage system • System testing at UAF's Power Systems Integration Lab
Phase 1: 2012 – 2015 **Feasibility study and implementation of a 3 MW wind turbine with 3 energy storage systems at Raglan Mine** Canada H-346545	**Tugliq Energy Co. & Glencore Raglan Mine** Implementation of a 3 MW wind turbine and energy storage systems (battery, flywheel, and hydrogen system) with a microgrid controller. Completed the conception, engineering, commissioning, and operation monitoring of the project. As a part of the Raglan Mine project, Hatch was involved in screening and review of various energy storage technologies in order to meet the specific needs of the mine's microgrid. As well, the energy storage systems were sized in order to ensure reliable power supply, including sufficient capacity to provide power during diesel generator ramp up. The Hatch team also designed a rapid microgrid controller in order to accommodate instantaneous fluctuations in power supply and demand. The project is currently in its second phase, with additional wind power and energy storage being integrated into the microgrid.
2013 – 2014 **Dynamic System Modeling SmartCAES Project** USA H-346366	**Ronald J. O'Mara** Development of a model for a 135 MW Dresser Rand Compressed Air Energy Storage System for the Gaelectric DS3 (Delivering a Secure Sustainable Electricity System) purposes in Ireland. The model was used to simulated and optimize the system's response to grid regulations and conditions.
2013 **Wind-Hydrogen-Storage Pilot Feasibility Study** Nunavik, QC, Canada	**Glencore Raglan Mine** Scoping, prefeasibility and feasibility of a 3.0 MW wind turbine at Raglan mine in combination with 600 kW of energy storages (fly-wheel, battery and hydrogen system) and micro-grid controller. The studies involved micrositing, estimate the energy production of the entire wind-hydrogen-storage system considering the energy losses from each technology and the combined operation with the diesel generators. The fuel reduction has been estimated as well as the number of reduction operation hours for the gensets. Detailed cost, logistic and financial model has been developed for this project.

Years / Project	Client / Scope of Work
2013 **Wind-Diesel Project for Kangiqsualujjuaq (Hydro Quebec)** Canada H-338349	**Enercon Canada Inc.** Detailed integration study of wind generation (800 kW) and flywheel storage with existing Diesel plant (1975 kW) to demonstrate performance and plan its implementation executing the following tasks: • technical description of the plant layout and all required components and modifications to the existing plant • estimate of the wind power production • description of the plant operation • estimate of the expected fuel consumption • description of the electrical protection system • description of the electrical controls system • demonstrate the dynamic electrical stability using a MATLAB system model • planning of the project implementation in terms of budget and schedule.
2012 **Power Options Screening Study** Canada H-342650	**Glencore Raglan Mine** Power generation technology screening for expansion of mining operations. Included a review of energy storage technologies and their potential applications at site.
2012 **Due Diligence** Canada H-343864	**TAQA** Due diligence of energy storage company – manufacturer of Li-ion energy storage systems.
2012 **Precious Metals Recovery Project - Power Supply Options Study** USA H-340940	**Barrick Gold** Design of a solar photovoltaic based islanded power supply integrated with a Li-ion battery and diesel generation to provide 80% average contribution of renewables.
2011-2012 **System Integrator Role for Electrovaya BESS** Canada H-339853	**Electrovaya** Integration of Utility Scale Lithium Ion Battery (300 k W/1.2 MWh) at two sites, one on the Hydro One Transmission Grid and on the Toronto Hydro Electric System Distribution System. This project involved the design of the interconnection and projections, as well as studies to determine the effect of the energy storage system on the grid (Transmission and Distribution, respectively).

Years / Project	Client / Scope of Work
2009 - 2011 **Wind Power Aggregation – Fatal Flaw Study** Canada	**Confidential Client** The intent of the project was to contract with several thousand MWs of wind power projects spread over several western States and Provinces and through geographic diversity be able to deliver a high capacity factor, green product to the Nevada and California markets. In order to assess the ability to increase the "firmness" of the product, analysis of energy storage was included. This involved providing an overview of firming technologies available, including battery, pumped storage, compressed air energy storage, conventional gas turbines, etc.; the development of a firming analysis model; the assessment of the amount of firming capacity required; estimation of the fixed and variable costs of each firming technology; and determination of the annual costs to provide the required firming.
2010 **Optimal Performance Tool for Remote Grids** Canada H-334576	**Natural Resources Canada** Hatch was contracted by NRCan to develop the tool. The tool can be used to analyze the cost/benefits, including fuel and GHG emission reduction, for developing and operating remote grid with diesel, wind, solar, small hydro, battery bank and other generation/storage resources. The tool enables grid planners to study several aspects including efficient control and monitoring of the diesel power plant through dispatch strategy to reduce fuel consumption and GHG emissions, improving the remote grid components efficiency and integrating demand side and demand response strategies. The tool also assists in determining the maximum penetration and use of renewables based intermittent generation, evaluating energy storage plants and analyzing generation cost including capital, fuel, O&M, emissions offset allowance and others.
2009 **Assessment of Pumped Storage Plants in Ontario** Canada	**Confidential Client** An assessment was prepared of the benefits and costs of energy storage facilities in Ontario with the focus being on pumped storage hydro. The analysis looked at the market structures to estimate the costs of buying pumping power during low power costs periods and the price at which power generated by the facility could be sold during high load periods. Market price information gleaned from the Independent Electricity System Operator's statistics was a key input to this analysis.

Years / Project	Client / Scope of Work
2009 **Energy Pathways Project – Canadian National Power Grid** Canada H-332572	**Canadian Academy of Engineering** Energy Pathways study of the National Power Grid. Hatch provided the project manager for this assignment as well as coordination of task force meetings, presentations to stakeholder groups and government agencies and preparation of reports. In addition, Hatch provided: • Analysis of the existing electrical systems in Canada, plans for adding to these systems to meet load growth and retirements and the plans for strengthening connections between provinces. • A description of the current technology for high voltage, long distance transmission lines. This covers both AC and DC technologies. • An assessment of the current technology for energy storage systems. This assessment covers hydro pumped storage, compressed air energy storage, batteries and other developing technologies.

Hatch is an employee-owned, multidisciplinary professional services firm that delivers a comprehensive array of technical and strategic services, including consulting, information technology, engineering, process development, and project and construction management to the Mining, Metallurgical, Energy, and Infrastructure sectors.

Hatch has served clients for over six decades with corporate roots extending over 100 years and has project experience in more than 150 countries around the world.

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