FINAL OUTCOMES REPORT (NON-CONFIDENTIAL)

1.0 PROJECT INFORMATION

1. ERA PROJECT ID #	R0160642
2. CALL / ROUND	ERA#6
3. PROJECT TITLE	Drumheller Solar and Battery Storage Project
4. COMPANY NAME	CONCORD DRUMHELLER PARTNERSHIP
5. PROJECT TYPE (R&D, Development, Demonstration, Implementation)	Implementation
6. LOCATION (primary location the project took place by address, land description, or GPS coordinates)	51.44545105397687, -112.66972454104254
7. PROJECT START DATE	March 6, 2019
8. PROJECT COMPLETION DATE	May 31, 2025
9. TECHNOLOGY READINESS LEVEL (TRL) AT PROJECT INITIATION	7
10. TRL AT PROJECT COMPLETION	9
11. JOBS CREATED	70 FTE (during construction) / 1 FTE (ongoing operations)
12. GHG EMISSIONS REDUCED (Project-level: annual, cumulatively by 2030 and by 2050)	Annual: 14,246 tC02e (2025) Cumulative by 2030: 93,754tC02e Cumulative by 2050: 361,548 tC02e
13. TOTAL ERA FUNDING	$5,000,000

14. TOTAL PROJECT VALUE	$36,758,560
15. ERA PROJECT ADVISOR	Susan Carlisle
16. SUBMISSION DATE	August 4, 2025
17. KEY PROJECT CONTACT NAME AND EMAIL	Michael Becker michael.becker@concordgreenenergy.ca
18. QUOTE (why was ERA a pivotal funder for this project? How did ERA funding help advance on the TRL scale? Etc.)	ERA's support was pivotal in enabling the Drumheller Solar and Battery Storage Project to move from a promising concept to a fully integrated hybrid deployment in Alberta. The funding helped de-risk a new DC-coupled architecture that had not yet been tested in the Alberta market, allowing us to validate technical performance, commercial dispatch strategies, and emissions reductions under real-world conditions. With ERA's partnership, we advanced the technology integration from TRL 6–7 to TRL 9, building internal capabilities and market confidence that are now accelerating the rollout of similar systems across the province.
19. NOTABLE COMMUNICATIONS	N/A
20. IMAGE (please insert or link a photo capturing the technology for ERA publications)	

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5.0 EXECUTIVE SUMMARY

The Drumheller Solar and Battery Storage Project represents a successful deployment of one of Alberta's first DC-coupled hybrid renewable energy facilities. Located near Drumheller, Alberta, the project integrates ~22 MWdc of solar photovoltaic (PV) capacity with a 3.6 MW / 7.2 MWh lithium-ion battery energy storage system (BESS). The project was developed, constructed, and commissioned by Concord Drumheller Partnership between 2019 and 2025, with critical support from Emissions Reduction Alberta (ERA). ERA's $5 million contribution enabled the implementation of a first-of-kind commercial demonstration of DC coupled battery storage integrated directly with a utility-scale solar facility in Alberta.

The project's innovation lies not in the component technologies—each of which is commercially available—but in the hybrid integration and operationalization within Alberta's regulatory and market frameworks. The BESS enables energy arbitrage, curtailment mitigation, and potential future participation in ancillary services, providing learnings valuable to system operators, regulators, and developers alike. While solar and storage are proven technologies individually, this project is a game-changer for Alberta because it demonstrates how storage can be integrated directly with solar in a merchant, deregulated market. By enabling the capture of clipped solar energy and shifting delivery to high-value periods, the project improves utilization of renewable assets, reduces curtailment, and provides flexibility to Alberta's grid.

The project is expected to achieve annual GHG reductions of ~15,000 tCO_2e, with 9,454 tCO_2e verified in the first reporting year (Dec 2023–Dec 2024) under Alberta's TIER offset system. In addition to environmental performance, the BESS delivered clear commercial benefits by enhancing project revenues: in May 2025, for example, just three days of high pool prices (> $500/MWh) contributed nearly 65% of the battery's monthly revenue, illustrating how energy storage both enables emissions reductions and strengthens project economics.

The target customers for this technology are wholesale electricity market participants in Alberta — including large renewable asset owners, corporate offtakers, Indigenous and municipal partners, and ultimately Alberta electricity consumers who benefit from lower-carbon, price-responsive electricity. Concord Green Energy is already applying these learnings to assess additional BESS deployments across its Alberta fleet, where future hybrid projects will be designed to participate not only in energy markets, but also in emerging ancillary services under the Restructured Energy Market (REM).

Key learnings include the importance of maintaining high state-of-charge during extreme weather events, limitations of real-time clipped energy capture, and the commercial value of operational coordination between dispatch and O&M contractors. These findings have already been shared through multiple channels, including attendance at Electricity Transformation Canada 2024, the 2025 IPPSA Conference, and direct engagements with utilities, regulators, and peer developers.

6.0 PROJECT DESCRIPTION

6.1 INTRODUCTION

The Drumheller Solar and Battery Storage Project combines a utility-scale solar photovoltaic (PV) installation with a lithium-ion battery energy storage system (BESS) in a DC-coupled hybrid configuration. The project, developed and operated by Concord Drumheller Partnership, represents a significant advancement in Alberta's transition toward a lower-carbon electricity grid by integrating energy storage directly into renewable generation assets.

The solar facility consists of approximately 22 MWdc of Longi bifacial solar modules connected to 4 Sungrow 3600-UD inverters, which are grid connected at 13.5MW. The system is overbuilt by design, with a 1.6 DC-to-AC ratio to intentionally create periods of clipped solar generation—energy that exceeds the grid export limit and would otherwise be lost. This clipped energy can be captured and stored using the on-site battery, which consists of 3.6 MW / 7.2 MWh of Sungrow lithium-ion storage technology. The DC coupling architecture allows the battery to charge directly from the solar array, increasing round-trip efficiency and minimizing interconnection constraints.

This project demonstrates how a hybrid solar + battery system can participate in Alberta's power market under current regulatory conditions. While all core components (PV modules, inverters, and battery units) are commercially available and widely deployed in other jurisdictions, their integration within Alberta's grid, regulatory framework, and market structure is novel. The project provides valuable insights into:

- Dispatch strategy and performance of BESS under price volatility
- Regulatory and operational integration with the Alberta Electric System Operator (AESO) and ATCO
- Challenges and benefits of DC-coupled architecture
- Coordination of operation, maintenance, and commercial dispatch functions

Through this implementation, the project helps build the technical, commercial, and regulatory knowledge required to support broader deployment of storage-enhanced renewables in Alberta. It also provides empirical performance data to inform future policy, tariff, and market design—particularly as the province advances toward a Restructured Energy Market (REM) and expands ancillary services procurement.

6.2 BACKGROUND OF THE PROJECT

The Drumheller Solar and Battery Storage Project was initiated in response to Alberta's growing need for grid flexibility, decarbonization, and integration of renewable resources. With increasing penetrations of solar and wind, Alberta's power market faces challenges related to intermittency, curtailment, and price volatility. The Drumheller project addresses these issues by pairing utility-scale solar with on-site battery storage in a DC-coupled configuration and is one of the first of its kind in the province. The project's primary economic driver was to maximize solar energy output on a 13.5 MWac grid connection by capturing clipped energy, which is when solar generation exceeds the inverter or interconnection capacity during peak irradiance and would otherwise be wasted. By integrating a battery energy storage system (BESS) in a DC-coupled configuration, the project enables this surplus energy to be stored and discharged during periods of higher demand or higher electricity prices.

The project was originally developed by Longspur Developments, a renewable energy developer. In 2021, Concord Green Energy, a subsidiary of Concord Pacific, acquired the project and assumed responsibility for all remaining development, financing, engineering, and implementation activities. Concord has a national portfolio of renewable assets and a track record of delivering complex clean energy projects across Canada. Concord Green Energy, through the Concord Drumheller Partnership, served as the facility owner, project sponsor, and construction manager, overseeing all facets of project execution.

Concord managed a diverse team of vendors and contractors throughout the project lifecycle:

- **SunGrid Solutions Inc.** was selected as the EPC contractor for the battery system based on their experience with Sungrow equipment and track record of hybrid system integration.
- **Sungrow** supplied the battery energy storage system (BESS). Their BESS was selected for its compatibility with the site and integration advantages with Sungrow inverters already deployed at other Concord projects.
- **ATCO Electric** serves as the distribution facility owner (DFO) and owns the point-of-interconnection infrastructure that connects the site to Alberta's electricity grid.
- **The Alberta Electric System Operator (AESO)** is the system operator responsible for real-time grid operations and market clearing in Alberta's competitive wholesale power market. AESO was engaged throughout the project for approvals, data integration, and operational optimization.
- **Spark Power** was engaged for ongoing operations and maintenance (O&M) of the solar and battery systems.
- **URICA Energy Management Corp** was retained for battery dispatch and commercial optimization, leveraging market analytics to maximize revenue and system responsiveness.

The project proceeded through several key development milestones between 2019 and 2025, including:

- Site selection and interconnection studies
- AUC permitting and environmental assessments
- Equipment procurement and construction
- Full commissioning and integration with Alberta's grid
- Commercial operation and optimization of dispatch strategies

The hybrid architecture was selected to enable the capture of "clipped" solar energy, reduce curtailment risks, and enhance value through energy arbitrage and, eventually, participation in ancillary services. The project was also designed to be scalable and replicable across Concord's portfolio of solar assets in Alberta.

Throughout the project, Concord engaged actively with regulators, peer developers, and technical stakeholders to share lessons learned and help inform Alberta's evolving market design and regulatory approach to hybrid renewable systems.

6.3 PROJECT OBJECTIVES

As defined in the original Contribution Agreement between Emissions Reduction Alberta (ERA), the Drumheller Solar and Battery Storage Project was established to meet the following core objectives:

1. Prove the technical viability of a hybrid project on the Alberta grid;
2. Increase the understanding of the economic and commercial realities for hybrid projects in Alberta, and specifically the revenue uplift achievable from the use of a battery;
3. Mitigate the deemed financial risk of a non-firm interconnection offer by the inclusion of a battery;.

4. Bring significant financial benefits to the local community through land rent, property tax and a community benefit fund.

The fundamental objectives of the project remained consistent throughout its development and implementation. However, through operational experience and market testing, the project's priorities evolved:

- Operational optimization: The revenue uplift opportunity from the battery was achieved specifically by implementing a dispatch strategy to focus on capturing clipped energy and price arbitrage to ensure stored energy availability during high-price periods.
- Learning through implementation: The project generated insights into DC-coupling complexity, optimal state-of-charge management, and the coordination required between O&M (Spark Power) and commercial dispatch (URICA) for successful BESS operation. The size of the solar facility and BESS were optimized for cost and performance, which resulted in increasing solar from 17 MWdc to 22MWdc and refining battery sizing to 3.6MW/7.2MWh.

6.4 PERFORMANCE/SUCCESS METRICS IDENTIFIED IN THE CONTRIBUTION AGREEMENT

Success Metric	Project Target	Project Achievement	Explanation
Amount of Generation	90%	Achieved ~90% depending on month. A much large solar array was constructed than contemplated in the CA.	varying seasonally due to irradiance. and operational constraints.
Gross and Net Revenue Uplift (Power/DTS/Capacity)	> cost of battery	> cost of battery + ROI	Achieved under ERA-supported economics; significant uplift during volatile price events.
Time-shift Accuracy	>90%	Optimized time shifting based on hourly market price	Strategy evolved to align battery availability with high-price periods (>500 $/MWh).
Ancillary Services	Secure any ancillary service revenues	Not eligible due to <5 MW rating	Ongoing engagement with AESO on REM developments.

GHG Reductions	Achieve annual CO2e reduction of 14,300 T/y	Facility achieved a C02e reduction of 9,125 tC02e during 2024 (first full year of operation) based on current TIER grid emissions intensity	Offset quantification complete; verified GHG reductions submitted to Alberta Registry.
Capital Cost	Deliver project for a capital cost of $24,950,000	Delivered at ~$36.7 million; Scope adjusted to include larger solar installation	Overage approved via amending agreement.
Schedule	Deliver project and achieve final completion by October 31, 2021	Commercial operation achieved by May 31, 2025.	
Overall Battery Efficiency	Optimal charge/discharge use for maximum return in Alberta	Refined monthly based on real-time market data and clipped energy availability.	

Table 1: Performance and Success Metrics

Time shifting volume was lower than expected but price arbitrage success was stronger than expected, especially in May 2025, when three high-price days (> $500/MWh) contributed nearly 65% of the month's battery revenue. While ancillary services revenue remains out of reach for <5 MW systems under current rules, the project is positioned to benefit from Restructured Energy Market (REM) or expanded participation rules in future AESO procurements. Final capital costs came in above the original target, due primarily to scope refinement. These were addressed and approved under the second amending agreement. The project's overall performance aligns closely with its original goals and has demonstrated a replicable model for hybrid deployment in Alberta.

6.5 PROJECT CHANGES

Throughout the lifecycle of the Drumheller Solar and Battery Storage Project, the core scope, objectives, and project team remained largely intact. However, several changes were implemented and formalized through two amendments to the original Contribution Agreement, as well as ongoing engagement with Emissions Reduction Alberta (ERA). These changes are summarized below.

Assignment of Project Ownership

Following a purchase and sale, in February 2021, the project was officially transferred from Drumheller Solar Corporation to Concord Drumheller Partnership, via an Assignment and Assumption Agreement. Concord assumed all responsibilities and obligations under the original Contribution Agreement.

Contribution Agreement Amendments

Amending Agreement #1 (November 29, 2021): Updated the project completion date (from 2022 to 2023), revised the milestone schedule, and adjusted eligible and total project costs

Second Amending Agreement (May 2023): Updated the final project completion date to April 30, 2024, revised the total eligible expenses to and finalized milestone funding allocations across six key phases

Technical Scope Adjustments

The final BESS size was revised to 3.6 MW / 7.2 MWh, down from the originally contemplated 6 MW / 12 MWh. This change was made during equipment procurement and was based on supply availability, site constraints, and revised cost-benefit modeling. Despite the smaller size, the BESS still meets key project objectives for clipped energy capture and energy arbitrage. Final solar PV system capacity was increased to 22.3 MWdc, connected via 13.5 MWac of inverter capacity.

Project Timeline Changes

While the solar facility achieved commercial operation in August 2023, delays in BESS delivery and challenges with metering integration (notably the need for an ATCO meter replacement) extended full BESS commissioning to October 2024. The final milestone, focused on optimization and reporting, was completed by May 31, 2025.

6.6 TECHNOLOGY RISKS

While the Drumheller Solar and Battery Storage Project utilized commercially available solar and battery equipment, it represented a first-of-kind deployment in Alberta for a DC-coupled hybrid system, operating under real market and regulatory conditions. Several technical and integration risks were identified and managed throughout the project.

1. **DC-Coupling Integration Complexity**

Risk: The project used a DC-coupled architecture to allow the battery to capture clipped solar energy directly. This setup, while efficient, presented integration challenges between the battery, inverters, and energy management system (EMS).

Mitigation:

- The project selected Sungrow for both inverter and BESS equipment to simplify integration.
- Indie Energy was engaged to program a site-specific EMS.
- Extensive coordination between the solar EPC (DMS), the battery EPC (SunGrid), and the EMS integrator was required to ensure seamless charging/discharging control logic.
- Lessons learned include challenges in tracking and isolating purely clipped energy in real-time and ensuring charge rate stability on partly cloudy days.

Outcome: DC coupling was successfully implemented, but operational strategies shifted toward price arbitrage rather than pure clipped-energy capture due to variability in irradiance and market signals.

2. **Regulatory and Market Interface**

Risk: Alberta's regulatory environment lacked a clear framework for hybrid resources. BESS eligibility for ancillary services was limited, and telemetry/integration with the AESO was not standardized for DC-coupled facilities.

Mitigation:

- Early and continuous engagement with AESO and ATCO.
- Concord worked with ATCO to address metering integration issues, including replacement of a non-compatible meter.
- AESO data discrepancies during initial operation were identified and resolved.
- Project telemetry and SCADA were tailored to align with AESO's evolving requirements.

Outcome: The project is fully integrated and commercially operational, with active engagement informing AESO and ATCO on future hybrid project guidelines.

Equipment Procurement and Construction Delays

Risk: BESS delivery was delayed in late 2023 due to supply chain constraints, which coincided with the onset of winter conditions at a rural, steep-access site.

Mitigation:

- Construction was paused and resumed in Spring 2024.
- Additional support from local contractors was sourced to supplement
- Concord assumed a more active role in construction management

Outcome: Construction was successfully completed, but delivery and commissioning delays pushed final project completion into May 2025.

3. **Battery Sizing and Commercial Limits**

Risk: The final BESS size (3.6 MW / 7.2 MWh) fell below the AESO's minimum 5 MW threshold for ancillary services, limiting revenue streams.

Mitigation:

- Concord focused on optimizing energy arbitrage and clipped energy capture.
- Conversations with the AESO regarding revised ancillary services eligibility (under REM) are ongoing.
- Future projects may incorporate larger or modular battery configurations to increase flexibility.

Outcome: While unable to access ancillary services markets currently, the project demonstrated that smaller BESS units can still provide material economic and operational benefits.

4. **Operational Coordination Between O&M and Dispatch**

Risk: The shift from passive solar generation to an actively dispatched hybrid site introduced new coordination requirements between Spark Power (O&M) and URICA (market dispatch).

Mitigation:

- Roles and responsibilities were clarified over time.
- Regular communication and reporting protocols were established to manage maintenance windows and charge/discharge opportunities.

Outcome: Successful long-term operational handoff achieved, with learnings applicable to other hybrid sites.

5. **Equipment Failure**

Risk: We encountered an equipment failure of our main breaker on May 31, 2024 and lost production until July 11, 2024. We have had issues with equipment reliability coming out of Covid.

Mitigation:

- New breaker had a lead time of 72 weeks
- Sourced replacement parts and repaired the breaker

Outcome: Lost approximately 40 days of solar production and corresponding

7.0 PROJECT WORK COMPLETED AND OUTCOMES

7.1 METHODOLOGY

The Drumheller Solar and Battery Storage Project employed a structured development, engineering, and construction methodology consistent with utility-scale renewable energy projects, while also incorporating custom integration steps required for the hybrid DC-coupled architecture and Alberta's regulatory environment. The work was executed across six defined project milestones, as outlined in the Contribution Agreement and its amendments.

Project Development and Engineering Methodology

- **Site selection and feasibility studies**: Initial resource assessment, permitting analysis, and interconnection studies were completed under Longspur Developments and refined by Concord Green Energy post-acquisition.
- **Preliminary and detailed design**: Solar and battery system layouts were developed in tandem, incorporating geotechnical surveys, shading analysis, and capacity optimization. A 1.65 DC-to-AC ratio (22.3 MWdc to 13.5 MWac) was selected to generate frequent clipping events.

- **Interconnection planning**: The project engaged with ATCO (DFO) and AESO to navigate the interconnection and metering requirements for a hybrid facility. A revised metering approach was later implemented in collaboration with ATCO to ensure EMS compatibility.

Procurement and Construction

- **Procurement**: Equipment was sourced from tier-1 suppliers (Longi, Sungrow), with contracts awarded to Dependable Mechanical Systems (DMS) for solar EPC and SunGrid for battery EPC. Indie Energy provided EMS programming as a SunGrid subcontractor.

- **Construction sequencing**: Construction was staged to complete the solar field ahead of battery delivery. Solar was commissioned and producing power by August 2023. BESS construction was delayed due to winter access limitations and was completed in Fall 2024.

- **Commissioning**: The battery underwent unit-level and system-level testing. Final performance testing occurred in November 2024. Full integration with the AESO and EMS operation was confirmed by October 2024.

Operational and Commercial Implementation

- **Control strategy development**: The EMS was configured to enable both clipped energy capture and price-based arbitrage. URICA was engaged to provide commercial dispatch services and fine-tune market participation.

- **Operational protocols**: Monthly performance tracking was implemented, including separate reporting for solar and battery output, state-of-charge, round-trip efficiency, and revenue breakdowns.

- **GHG quantification**: The solar system has been providing direct emissions reductions since April 2023. Concord completed the TIER Offset Quantification and Verification process for eligible GHG credits.

Knowledge Sharing and Industry Engagement

- Throughout the project, Concord documented operational insights and shared them through:
    - Attendance at Electricity Transformation Canada (2024)
    - One-on-one engagement with large Alberta power producers
    - Participation in the 2025 IPPSA Conference
    - Data-sharing collaboration with the National Research Council of Canada (NRC) in May 2025

7.2 TECHNOLOGY DEVELOPMENT

The Drumheller Solar and Battery Storage Project is a commercial-scale deployment of proven technologies, specifically photovoltaic (PV) generation and lithium-ion battery energy storage, in a DC-coupled hybrid configuration. While the individual components are widely used, their integration and operation under Alberta's regulatory, market, and climatic conditions represented a first-of-kind implementation in the province.

System Configuration

- **Solar PV System**:
    - Capacity: 22.3 MWdc
    - Modules: Longi LR5-72HBD bifacial panels
    - Inverters: Sungrow SG3600UD-MV
    - Solar modules mounted on fixed tilt racking
    - Overbuild ratio of 1.65:1, designed to create regular clipping events
- **Battery Energy Storage System (BESS)**:
    - Capacity: 3.6 MW / 7.2 MWh
    - Manufacturer: Sungrow (ST2408UX-US)
    - Configuration: DC-coupled to PV array, enabling charging from clipped energy
    - Controls: Integrated EMS programmed by Indie Energy for hybrid operation
    - Housed in containerized format with HVAC and fire suppression systems

Technology Selection

All major technology components were commercially available and field-tested in other jurisdictions. The Sungrow inverter and BESS platform were selected for:

- Proven compatibility with Alberta's climate (cold temperature resilience)
- Integration simplicity due to shared vendor hardware for solar and battery
- Alignment with Concord's broader Alberta fleet, enabling shared spares and O&M procedures

The EMS required customization to accommodate DC-coupled dispatch control, clipped energy prioritization, and market-responsive charging/discharging.

Installation and Commissioning

- Solar construction began in 2022 and was completed by mid-2023. COD was achieved in August 2023, with electricity exported to the Alberta grid via a 13.5 MWac point of interconnection.
- Commissioning included:
    - Individual unit validation (charge/discharge cycles)
    - Site-wide system testing
    - Integration of EMS and telemetry with AESO and ATCO systems

- Performance testing in November 2024 confirmed functional charge/discharge capability, market responsiveness, and EMS control logic.

Operationalization

- By early 2025, the battery was being actively dispatched by URICA for daily arbitrage, with solar clipping prioritized when economically viable.
- Monthly reporting, TIER offset tracking, and optimization protocols were established.
- Initial operational insights were used to tune the battery's role—favoring high-price event readiness over automated clipping control.

7.3 PROJECT ACHIEVEMENTS, RESULTS, AND ANALYSIS

The Drumheller Solar and Battery Storage Project successfully achieved its primary objectives: proving the technical viability of a hybrid solar + BESS system on the Alberta grid, demonstrating meaningful revenue uplift through battery dispatch, and contributing operational knowledge to inform future market design and regulation.

Key Achievements

- Commercial operation of the solar PV system began in August 2023, with continuous electricity export to the Alberta grid.
- The battery was commissioned in October 2024 and began full commercial dispatch shortly thereafter.
- Revenue-generating dispatch was achieved via energy arbitrage, with the battery charging during low-price hours and discharging during price peaks.
- GHG quantification and TIER offset verification were completed and submitted, validating the system's emission displacement impact.
- Concord actively shared learnings with the AESO, ATCO, NRC, and peer developers through conferences, bilateral engagements, and data-sharing.

Operational Results

- The hybrid system captured clipped solar energy during peak irradiance events, although intermittent weather (e.g. partly cloudy days) limited the battery's ability to isolate purely "free" solar charge. Charge control algorithms were tuned to balance price signals and energy availability.
- The battery performs best during high price volatility:
    - In May 2025, the BESS discharged 22.7% of its monthly energy across just three days (May 5, 13, and 27), which accounted for 64.7% of total monthly battery revenue, with prices exceeding $500/MWh.
    - In February 2025, extreme cold and low wind supply resulted in high evening prices. However, due to snow cover and reduced irradiance, battery charge availability was limited. This highlighted the need to pre-charge the BESS ahead of forecasted market stress.
- The monthly clip rate rose with increasing irradiance, growing from negligible in February to 30%+ in May, improving clipped energy availability for the BESS.
- The EMS dispatch strategy shifted over time:
    - Initially focused on clipped energy capture
    - Evolved to maintaining a higher state-of-charge (SoC) in anticipation of high-price events
    - Resulted in better economic performance and improved alignment with pool price volatility

GHG Reductions

- The solar PV system began displacing grid electricity in April 2023.
- Based on verified offsets, the project achieved 9,125 tCO2e of emissions reductions during 2024, which was the first full year of operation.

Market and Policy Influence

- The project has contributed data and insights to:
  - AESO's ongoing REM development
  - NRC's national assessment of BESS performance in Canadian climates
  - Industry EPCs and developers considering DC-coupled hybrids
- Lessons learned around control logic, battery sizing, ancillary eligibility, and dispatch/O&M coordination have already informed follow-up projects under evaluation by Concord and others.

8.0 LESSONS LEARNED

8.1 CHALLENGES

Although the Drumheller Solar and Battery Storage Project was successfully completed and is now fully operational, the team encountered several challenges across the full lifecycle—from acquisition and design through construction and early operation. These hurdles yielded key learnings applicable to future hybrid deployments in Alberta and beyond.

1. Project Transition and Scope Refinement

The project was originally developed by Longspur Developments and acquired by Concord Green Energy in early 2021. The transition introduced schedule delays as Concord conducted due diligence, updated interconnection and permitting requirements, and re-evaluated the commercial structure. Concord undertook a comprehensive redesign, refining the battery sizing (to 3.6 MW / 7.2 MWh), EPC contracting approach, and EMS strategy. This phase added upfront time but ensured better long-term fit with Concord's Alberta portfolio and operational capabilities.

2. Site Access and Seasonal Constraints

The battery delivery and installation were delayed in late 2023 due to steep terrain and early ground freeze, making the site temporarily inaccessible for large equipment. Construction resumed in Spring 2024, with additional support sourced from local contractors. Site access constraints were documented to inform future construction planning.

3. EPC Resourcing and Integration Gaps

SunGrid, the BESS EPC contractor, encountered challenges with staffing continuity, procurement management, and on-site coordination, leading to inefficiencies and rework. Concord increased its oversight role, including design reviews and site supervision. Communication protocols were strengthened between solar, battery, and EMS teams.

4. Metering and EMS Integration

Following construction, Concord identified that the ATCO-installed revenue meter lacked the necessary data interface to integrate with the BESS EMS, delaying system operation. ATCO replaced the meter in October 2024. The EMS was then fully commissioned and integrated with the AESO and battery controls.

5. Clipped Energy Capture Limitations

The battery control strategy initially focused on capturing only clipped energy. However, intermittent cloud cover made clipped energy unpredictable, leading to suboptimal charging behavior. The EMS and dispatch strategy were adjusted to prioritize market-driven energy arbitrage, while still capturing clipped energy when available. Operators determined that a high state-of-charge was more valuable than chasing fluctuating clipping windows.

6. Market Participation Constraints

The final BESS size (3.6 MW) is below the AESO's current minimum threshold (5 MW) for most ancillary services products, such as regulating reserves. The project focused on energy arbitrage as its core revenue stream. Concord is actively monitoring REM development and potential eligibility changes.

7. O&M and Dispatch Coordination

Unlike standalone solar assets, hybrid systems require active coordination between site operations (Spark Power) and commercial dispatch (URICA), including SoC management, curtailment mitigation, and equipment downtime. Clear role definitions and coordination protocols were developed. Ongoing collaboration ensures alignment between reliability and revenue optimization goals.

8.2 PRACTICAL LEARNINGS

The Drumheller Solar and Battery Storage Project provided a valuable test case for deploying DC-coupled hybrid infrastructure in Alberta's deregulated electricity market. Through real-world design, construction, and operational experience, Concord identified several important lessons that will guide future hybrid project development and policy design.

1. DC-Coupled Systems Require Careful Design and Realistic Expectations

While DC coupling improves round-trip efficiency and enables clipped energy capture, it introduces control complexity, especially under variable irradiance conditions. Operators must be cautious when designing systems that rely too heavily on clipped-only energy. Partial cloud cover or system lulls can result in unstable or missed charging opportunities. DC-coupled systems are viable, but dispatch strategies must prioritize price signals and flexible SoC management over purely theoretical clipped energy recovery.

2. Market Volatility Drives Battery Value in Alberta

- The battery's economic performance is strongly correlated with pool price volatility. Months with extreme weather or market tightness (e.g., May 2025) yielded disproportionate revenue relative to steady-state conditions. The most valuable days for the battery occurred during system stress — not during perfect sunny conditions. Batteries offer value well beyond clipping as they serve as real-time volatility hedges. Sizing, dispatch, and SoC strategies should prioritize responsiveness to price spikes.

3. Proactive Stakeholder Engagement is Essential

Early and frequent engagement with AESO and ATCO was instrumental in resolving interconnection, telemetry, and EMS integration issues. Neither ATCO nor AESO had clear precedents for DC-coupled hybrid sites; project-specific flexibility and technical engagement were required. Future hybrid

proponents should build in time for regulatory learning curves and maintain clear documentation and data for stakeholder review.

4. Alberta's Regulatory and Market Rules Are Not Yet Optimized for Hybrid Resources

The BESS is currently ineligible for most ancillary services due to its sub-5 MW rating. The project illuminated the gap between what hybrid systems can provide and what the current market structure allows them to monetize. REM reforms and AESO procurement modernization will be critical in unlocking the full value of hybrid assets. Engagement by developers is necessary to inform rule changes.

5. Construction Risk Is Elevated by Emerging Tech and Rural Access

The steep site access road, early winter weather, and EPC resourcing constraints compounded to delay BESS commissioning. Emerging tech deployments face greater risk when sites are remote and equipment is not yet commoditized. Strong owner-side project management, flexible construction scheduling, and contingency planning are essential for first-of-kind infrastructure.

6. Dispatch and O&M Roles Must Be Deliberately Coordinated

Unlike solar-only sites, battery operation is dynamic and requires close coordination between the asset operator (Spark Power) and the market dispatch team (URICA). Scheduling outages, managing SoC, and responding to market events must be done collaboratively to maximize value without risking reliability. Hybrid sites require a different operational model, which includes joint planning, frequent communication, and clear SOPs between technical and commercial roles.

7. Weather Impacts and Operational Challenges

During 2024, we encountered issues with periods of snow and very cold weather. These periods resulted in minimal solar output where solar modules were covered in snow. This occurred in January 2024 and against in November/December 2024. We also had an equipment failure on our main 25kV switchgear, which took the facility offline from May 31st to July 11th, 2024, which impacted annual production and correspondingly the offsets that were verified for the 2024 TIER reporting period.

8.3 ORGANIZATIONAL LEARNINGS

The Drumheller Solar and Battery Storage Project provided Concord Green Energy with a unique opportunity to develop, construct, and operate one of Alberta's first DC-coupled solar + storage facilities. The project deepened the organization's understanding of hybrid system integration and sharpened its internal capacity for future renewable-plus-storage deployments.

1. Hybrid Projects Require Enhanced Cross-Functional Coordination

Unlike standalone solar developments, hybrid facilities introduce new interfaces between commercial, engineering, operations, and regulatory teams. Concord expanded its internal coordination structure, including dispatch-O&M alignment protocols, EMS integration oversight, and stakeholder engagement frameworks. These learnings are now being applied across Concord's Alberta portfolio and are influencing design standards for future hybrid assets.

2. EPC Contractor Selection Must Prioritize Integration Experience

BESS deployments require EPCs with proven experience in not only battery installation, but also inverter integration, EMS programming, and regulatory compliance. The project underscored the need to screen EPC partners for hybrid-specific experience, especially in Alberta's context. Concord has refined its EPC prequalification and contract management processes to include integration readiness and technical resource depth as key evaluation criteria.

3. Smaller-Scale BESS Can Still Deliver Value

Despite being below the 5 MW threshold for ancillary services, the 3.6 MW BESS at Drumheller was able to deliver meaningful revenue uplift through arbitrage and clipped energy capture. This validated Concord's business case for "right-sized" batteries based on market volatility rather than regulatory eligibility alone. Future projects may deploy modular battery systems, with dispatch logic focused on price capture rather than chasing programmatic eligibility.

4. Alberta-Specific Market Design Adds Complexity

- Alberta's lack of a capacity market, combined with evolving day-ahead and ancillary frameworks, makes hybrid project planning highly site-specific. Concord invested in internal market analysis and engaged third-party advisors (e.g., URICA) to better understand dispatch pathways and price exposure. Concord now approaches battery sizing, tariff modeling, and dispatch strategy as site-customized design exercises, rather than one-size-fits-all templates.

5. Knowledge Sharing Strengthens Market Position

Actively sharing lessons learned, including challenges created opportunities for Concord to engage with peer developers, large generators, regulators, and federal agencies. Concord is increasingly seen as a leader in Alberta's hybrid storage space, which supports future funding, partnerships, and project approvals. These efforts continue post-project, including collaboration with the National Research Council of Canada and the Pembina Institute.

8.4 HIGHLIGHTS

1. First-of-Kind DC-Coupled Hybrid Facility in Alberta

Successfully developed and commissioned one of Alberta's first utility-scale **DC-coupled solar + storage systems**, combining 22.3 MWdc of solar with a 3.6 MW / 7.2 MWh battery.

2. Commercial Operation and Verified GHG Reductions

Solar PV began generating to the grid in August 2023; the battery became fully operational by October 2024. Verified GHG reductions submitted under the TIER Offset Protocol, helping validate hybrid systems as credible emissions-reduction infrastructure.

3. Clipped Energy Capture Demonstration

The overbuilt solar design (1.65 DC-to-AC ratio) created regular clipping events, and the BESS was able to capture surplus solar generation that would otherwise have been curtailed — proving the concept's technical and economic viability.

4. Price Arbitrage Optimization During Market Volatility

In May 2025, three days with pool prices exceeding $500/MWh accounted for 64.7% of total monthly battery revenue, which is a clear demonstration of how energy storage can hedge against market volatility.

5. Contribution to Policy and Market Design

The project engaged actively with AESO and ATCO, providing a real-world example of how hybrid assets integrate under current regulatory and interconnection rules. Findings are now informing market reform discussions under REM and future ancillary service design.

6. Industry Knowledge Sharing

- Concord shared project insights at:
    - Electricity Transformation Canada (2024)
    - 2025 IPPSA Annual Conference
    - Bilateral sessions with other Alberta generators

Provided access to project data and EMS interface to the National Research Council of Canada (NRC) for nationwide battery performance analysis.

7. Strengthened Organizational Capability

The project improved Concord's internal standards for EPC oversight, EMS BESS integration and Dispatch and O&M coordination. These capabilities now support Concord's broader Alberta portfolio and future hybrid development plans.

9.0 GHG BENEFITS

9.1 PROJECT BASELINE EMISSIONS

The emission reductions for the Drumheller Solar and Battery Storage Project were quantified and verified in accordance with the requirements of Alberta's *Technology Innovation and Emissions Reduction (TIER) Regulation* and the *Quantification Protocol for Solar Electricity Generation (Version 1.0, May 2008)*. The methodology followed aligns with the Alberta Emission Offset System and ensures that the reductions are real, demonstrable, quantifiable, verifiable, and surplus to existing regulations.

Greenhouse gas (GHG) emission reductions were calculated based on the displacement of fossil fuel–based electricity from Alberta's grid by renewable energy generated from the project's 13.5 MW solar array. The total emissions reductions were calculated using grid emission factors prescribed in the Carbon Offset Emission Factors Handbook and took into account both baseline emissions and project emissions, including minor on-site diesel usage and electricity consumed for operations.

An independent third-party verification was conducted by MICONE Consulting Inc., an accredited verifier under ISO 14065:2013 and certified by the Standards Council of Canada. The verification process included:

- A review of the Offset Project Plan and data sources
- A site visit to assess equipment and data collection systems

- A detailed audit of fuel consumption records, electricity generation and consumption, and emission calculations
- An evaluation of internal controls and data management practices

The verified net GHG emissions reductions for the reporting period (December 4, 2023 – December 31, 2024) amounted to **9,454 tonnes CO_2e**. This includes:

- Electricity Generation (Baseline Emissions): 9,506.67 tCO_2e
- Project Emissions (Operations and Fuel Use): 51.55 tCO_2e
- Net Reductions: 9,454 tCO_2e

The verification conclusion was *positive*, with all findings confirming that the GHG statement is free from material misstatements and in compliance with all applicable standards and regulatory criteria. The emission reductions achieved by the project are now eligible for registration within Alberta's Emission Offset Registry.

9.2 PROJECT EMISSIONS

The Drumheller Solar and Battery Storage Project's operational emissions are minimal, consisting primarily of:

- Diesel combustion for backup generator(s) used during battery commissioning, inverter firmware updates, or temporary outages.
- Electricity drawn from the grid during periods when battery systems or plant controls required external power (e.g., night hours, maintenance periods).
- Ancillary activities such as limited vehicle fuel use and equipment startup during construction demobilization.

Relevant Sources, Sinks, and Reservoirs (SSRs):

Source/Sink/Reservoir	Included	Description
Grid electricity consumption	Yes	Small volumes consumed when solar and battery were offline or inactive
On-site fossil fuel combustion	Yes	Diesel used for backup and maintenance activities
Solar electricity exported	N/A	Displacement source, not emission-generating
Land use or biogenic carbon	No	Not applicable
BESS degradation emissions	No	Embodied emissions excluded from project scope (covered under lifecycle LCA)

Table 2: Relevant Sources, Sinks, and Reservoirs

Quantification Approach:

The project followed the conservative quantification principles outlined in the *TIER Regulation* and the *Carbon Offset Emission Factors Handbook*. Project emissions were calculated as follows:

- Diesel combustion was estimated using actual fuel purchase and consumption records, applying standard emission factors from Alberta's emissions factor handbook.
- Grid electricity draw was recorded using SCADA and meter logs during non-generating hours and commissioning periods. A conservative assumption of grid carbon intensity was applied.
  For the 2023–2024 verification period (Dec 4, 2023 – Dec 31, 2024), the total project emissions were calculated at 51.55 tonnes CO_2e, representing less than 0.6% of the total displaced emissions.
  These emissions were deducted from the gross displacement to derive net verified emissions reductions.

Conservativeness and Accuracy:

- A conservative approach was applied throughout, ensuring that any uncertainty in minor emission sources resulted in an underestimation of benefits.
- Emissions factors were based on standardized and jurisdiction-approved references, ensuring consistency with Alberta's offset framework.

9.3 EMISSIONS REDUCTION IMPACT

Year	Baseline Emissions @Year (tCO2e)	Project Emissions @Year (tCO2e)	Estimated Annual Production (if applicable)	Unit of Production	Emissions Reduction @Year (tCO2e)
2024	9,175	50	17,642	MWh	9,125
2025	14,296	50	27,492	MWh	14,246
2026	14,244	50	27,393	MWh	14,194
2027	14,182	50	27,273	MWh	14,132
2028	14,125	50	27,164	MWh	14,075
2029	14,069	50	27,056	MWh	14,019
2030	14,013	50	26,948	MWh	13,963
2031-2040	137,086	500	263,627	MWh	136,586
2041-2050	131,708	500	253,285	MWh	131,208

Table 3: Emissions Reduction Impact (2024-2050)

The table includes the following assumptions:

- The emissions reductions are based on a grid intensity of 0.52 t/MWh, which aligns with TIER but is lower than the actual grid intensity of 0.69 in 2018 and 0.63 in 2019, when the project was initiated.
- The forecast is for this project and doesn't include future solar + BESS hybrid installations. For each implementation of a similar size that is enabled due to this project, a multiple or proportionate amount of reduction can be expected.
- Degradation of solar modules and BESS has been assumed when forecasting annual production. The solar module degradation rate has been assumed at 0.4%/year, which is slightly below the manufacturer's warrantied 30 year degradation of 0.5%/year.
- In 2025, the capacity factor is forecast to be 23.2%

During 2024, we encountered issues with unusual periods of snow and very cold weather. These periods resulted in minimal solar output where solar modules were covered in snow. This occurred in January 2024 and again in November/December 2024. We also had an equipment failure on our main 25kV switchgear, which took the facility offline from May 31st to July 11th, 2024. This impacted annual production and correspondingly the offsets that were verified for the 2024 TIER reporting period.

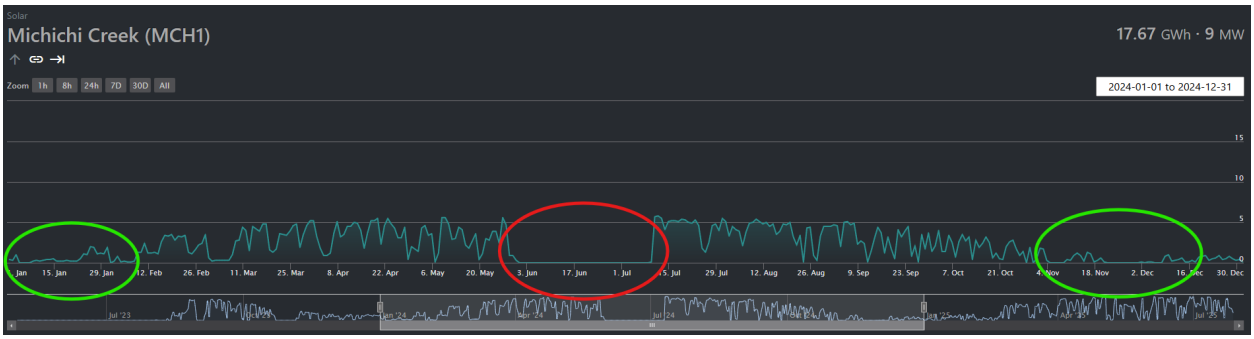

Figure 1: Project Performance

Looking into future applications of this technology, it will be dependent on electricity prices, carbon pricing, capital cost and government policy. With power prices depressed, arbitrage spreads thin, and carbon at only ~$20/tCO₂e, there's little near-term incentive for large-scale storage deployment unless it's heavily grant-supported or tied to a corporate PPA. Minimal new BESS activity beyond pilot/demonstration scale from 2025-2029. Developers (including Concord) will focus on refining designs, direct OEM procurement, and ensuring new solar builds are "storage ready." However, the current economics don't justify many final investment decisions.

Scenario	2030	2040	2050	Notes
Low	~20 kt	~250 kt	~500 kt	Perhaps 1 other small hybrid online by 2030. Limited retrofits. Slow uptake through 2040.
Base	~120 kt	~600 kt	~1.5 Mt	By 2030: 2 large hybrids (~100 MW each) + Drumheller. By 2040: ~10% of solar fleet retrofitted and 6–8 new large hybrids. By 2050: ~6 GW solar paired with storage.
High	~250 kt	~1.2 Mt	~3 Mt	By 2030: 4–5 large hybrids (~400–500 MW total) come online. By 2040: 25% of solar fleet retrofitted and widespread hybrid adoption. By 2050: majority of Alberta's solar (>8 GW) paired with large BESS.

Table 4: Emissions Reduction Market Level Forecast

The table includes the following assumptions:

- Drumheller reference: 22 MWdc solar + 3.6 MW/7.2 MWh BESS → ~15 ktCO₂e/yr avoided.
- Current solar: 1,850 MW installed (as of 2025).
- Typical new build: 100 MW solar + 50 MW/200 MWh BESS → ~60 ktCO₂e/yr avoided.
- Retrofit uplift: ~5% of site production recovered (~3–5 ktCO₂e/yr per 100 MW solar).
- Grid intensity: 0.50 tCO₂e/MWh in 2030 → 0.35 tCO₂e/MWh in 2050.
- Near-term adoption (pre-2030) constrained by low power spreads, carbon ~$20/t, and regulatory uncertainty.
- Strong growth post-2030 as carbon pricing, battery CAPEX declines, and REM ancillary products improve economics.

- Not all implementations will be DC coupled but will benefit from similar solar + storage integration
- Pre-2030: Alberta's 1,850 MW solar fleet is largely "storage-free." Aside from Drumheller, there will likely be minimal new hybrid capacity before 2030 due to weak spreads and low carbon value.
- 2030–2040: As REM reform opens ancillary products and battery costs continue to fall (~50% drop already observed), large-scale hybrids (100+ MW) begin commissioning. Retrofit opportunities for the existing fleet contribute incremental GHG reductions.
- By 2050: Storage becomes standard for new renewables. If ~6–8 GW of Alberta solar is paired with BESS, annual GHG reductions could reach 1.5–3 $MtCO_2e/yr$, an order of magnitude higher than Drumheller's ~15 $ktCO_2e/yr$.

10.0 ENVIRONMENTAL, ECONOMIC, AND SOCIAL IMPACTS

10.1 OTHER ENVIRONMENTAL IMPACTS

The Drumheller Solar and Battery Storage Project contributes to Alberta's climate and environmental goals by delivering zero-emission electricity to the provincial grid and enabling better utilization of renewable energy through integrated battery storage. In addition to reducing greenhouse gas emissions, the project has low environmental impact during operations and includes commitments to minimize long-term ecological risk.

Environmental Benefits

- **Greenhouse Gas Reductions:**
  The project displaces fossil-based grid electricity, reducing Alberta's overall GHG emissions. Verified reductions for the first reporting period totaled 9,454 tonnes CO_2e, with expected annual reductions over the project's operating life.
- **Increased Renewable Energy Utilization:**
  The DC-coupled battery enables the capture of clipped solar energy that would otherwise be curtailed, improving the effective yield of the solar array and reducing the need for fossil ramping.
- **Support for Grid Stability and Flexibility:**
  By charging during periods of low demand and discharging during high demand or volatility, the battery helps smooth solar output and reduce the frequency and severity of fossil-fueled peaking generation.
- **No Water Consumption or Air Emissions During Operation:**
  The facility uses no water for cooling and generates no air pollutants, making it a clean alternative to conventional generation.

Environmental Risks and Mitigations

- **Land Disturbance:**
  As with all ground-mounted PV systems, the project required grading and disturbance of native or agricultural land. Vegetation has been re-established around arrays, and no sensitive habitats were affected. The site is subject to ongoing erosion control and vegetation management practices.
- **Battery Fire and Chemical Risk:**
  Lithium-ion batteries carry inherent fire and thermal runaway risk. This risk was mitigated by selecting a commercially certified containerized BESS with built-in HVAC, fire suppression, and battery management systems. Emergency protocols were reviewed with local first responders.
- **End-of-Life Waste and Decommissioning:**
  Concord has committed to full site reclamation at the end of the project's life, including removal of

solar modules, racking, batteries, and underground cabling. The company will follow Alberta Environment and Pars (AEP) guidelines for reclamation and will recycle or responsibly dispose of materials in accordance with industry standards.

- **Noise and Visual Impact:**
  The project is located in a rural area with no adjacent residences. Equipment noise is minimal and complies with AUC Rule 012 for allowable noise levels. Visual impacts are mitigated by the low profile of solar modules and natural screening from terrain and vegetation.

Regulatory Compliance

The project underwent a full AUC Facility Approval process, and an environmental evaluation was completed prior to construction. There have been no environmental incidents since project commissioning.

10.2 PROJECTED ECONOMIC IMPACT

The Drumheller Solar and Battery Storage Project has delivered meaningful and measurable economic benefits at the local, regional, and provincial levels. While its primary goal was to reduce greenhouse gas emissions and advance Alberta's grid modernization, the project also contributed to economic development through capital investment, employment, local taxation, and long-term operational spending.

Construction of the solar and battery systems spanned from 2022 through 2024, employing local and regional contractors, trades, and suppliers. The project created jobs in the following areas during development, construction and operation, including:

- Civil works, electrical trades, and equipment installation
- Engineering, permitting, and environmental services
- Local accommodations, logistics, and materials suppliers
- Ongoing operation and maintenance activities including dispatch

The project provides ongoing land lease payments to Town of Drumheller. It generates annual property taxes for the municipality, contributing to local infrastructure, services, and community development. Concord has committed to a community benefit fund, providing contributions to local initiatives over the life of the project.

Ongoing operations and maintenance are conducted by Spark Power, which maintains a technician presence in southern Alberta. Additional services (vegetation control, snow clearing, inspection) are sourced from nearby communities. Market dispatch and optimization is handled by URICA, an Alberta-based firm, supporting high-skilled commercial jobs.

The project strengthens Alberta's clean tech and renewable energy sector by:

- Providing a proven model for hybrid solar + storage integration
- Building local expertise in BESS commissioning, EMS programming, and hybrid dispatch
- Informing future investment decisions by Concord and peer developers across Alberta

The project's success has also enhanced the province's profile as a jurisdiction capable of supporting sophisticated energy infrastructure and innovation.

Below is an estimate of the Full-Time Equivalent (FTE) Alberta jobs associated with the Drumheller project:

Component	Installed Capacity	Estimated FTE Jobs
Solar PV (construction)	22.3 MWdc - (2.5–3.5 FTE job-years per MWdc)	55 FTE (during construction)
BESS (construction)	3.6 MW / 7.2 MWh - (2.5–4 FTEs per MW of BESS)	10 FTE (during construction)
Engineering & permitting	-	5 FTE (solar and battery)
Ongoing O&M (annualized)	-	1 FTE (annual solar and battery)

Table 5: Job Creation

10.3 RESULTED INNOVATION CAPACITY

The Drumheller Solar and Battery Storage Project has contributed to Alberta's innovation ecosystem by advancing local expertise in hybrid renewable energy systems. The project supported the training of highly skilled personnel through hands-on deployment of a DC-coupled solar + battery system, including work by Alberta-based firms such as Spark Power (O&M), URICA (dispatch optimization), and local contractors engaged during construction.

The project's implementation and operations have deepened the technical capabilities of these firms in areas such as battery commissioning, EMS programming, hybrid dispatch, and real-time market integration. It also generated knowledge products that were shared with the National Research Council of Canada (NRC) and disseminated through industry events (e.g., IPPSA, CanREA).

While no formal post-secondary partnerships were established during this phase, the project laid the groundwork for future research collaboration and workforce development in Alberta's growing clean energy sector.

10.4 SOCIAL IMPACT AND EDI OUTCOMES

The Drumheller Solar and Battery Storage Project delivered several positive social outcomes within the local community and broader region. While the project was not developed in formal partnership with an Indigenous community or equity-deserving group, it provided tangible benefits aligned with the principles of equity, diversity, and inclusion (EDI). The project was built on leased land owned by the Town of Drumheller providing stable, long-term revenue to the Town. The facility also contributes annually to the local tax base, supporting public services and infrastructure within the Drumheller region. Concord has committed to contributing to a community benefit fund over the operational life of the project, providing direct support for local initiatives and programming.

The project prioritized the use of Alberta-based contractors and service providers, supporting local job creation during development, construction, and operations. Dozens of tradespeople, technicians, and field personnel were engaged across the construction and commissioning phases. Where possible, work was sourced locally to support economic inclusion.

11.0 SCIENTIFIC ACHIEVEMENTS

The Drumheller Solar and Battery Storage Project was designed as a commercial demonstration of existing technologies—specifically, the integration of utility-scale solar PV and battery energy storage in a DC-coupled configuration tailored to Alberta's market, regulatory, and climatic conditions.

12.0 POST-PROJECT STEPS

12.1 NEXT STEPS AND FOLLOW-UP PROJECTS

The Drumheller Solar and Battery Storage Project has directly contributed to Concord's ability to scale and replicate hybrid energy systems across Alberta. Key lessons from construction, dispatch, and integration are now being applied internally and shared with industry peers, service providers, and regulatory stakeholders. Concord is actively evaluating the addition of battery storage systems (BESS) to several of its existing solar facilities in Alberta. Design refinements from Drumheller particularly in BESS sizing, EMS configuration, and interconnection planning are being incorporated into future project scopes. Since completing the Drumheller procurement, Concord has seen Sungrow BESS pricing decline by approximately 50**%** when purchased directly, significantly improving the business case for future installations.

While Drumheller's BESS was below the 5 MW threshold for ancillary services, Concord is now planning future BESS projects to participate in new REM products and AESO's evolving ancillary service markets. Concord remains engaged in Alberta's energy market reform dialogue and continues to share hybrid-specific recommendations.

12.2 PARTNERSHIPS

The Drumheller Solar and Battery Storage Project was developed, owned, and operated by Concord Drumheller Partnership, a subsidiary of Concord Green Energy. For this specific project, no formal partnerships were established with First Nations, municipalities, or postsecondary institutions.

However, Concord recognizes the value of inclusive project development and is actively pursuing partnership opportunities with Indigenous communities for future solar and battery storage projects in Alberta. The company has a strong track record of structuring renewable energy projects that create long-term benefit-sharing models with First Nations and other equity-deserving partners.

13.0 OVERALL CONCLUSIONS

The Drumheller Solar and Battery Storage Project successfully demonstrated the technical and commercial viability of integrating battery energy storage with solar generation in a DC-coupled configuration under Alberta's unique electricity market framework. As one of the first hybrid utility-scale systems of its kind in the province, the project advanced knowledge across engineering, operations, and market dispatch while directly contributing to Alberta's emissions reduction goals.

Project Outcomes

- Commissioned a 22.3 MWdc solar PV facility with a 3.6 MW / 7.2 MWh BESS, interconnected at 13.5 MWac.
- Captured and monetized clipped solar energy, improving utilization of the interconnection and increasing total site generation.

- Demonstrated successful market dispatch and energy arbitrage, with the battery consistently discharging during high-value periods and helping reduce reliance on fossil peaker plants.
- Supported the development of new organizational capabilities within Concord and among Alberta-based contractors, suppliers, and dispatch service providers.
- Delivered broad economic benefits, including capital investment of over $36 million, local job creation, and long-term property tax contributions.

Verified GHG Reductions

- For the period of December 4, 2023 to December 31, 2024, the project achieved net verified reductions of 9,454 tonnes CO_2e, as confirmed through third-party verification under Alberta's TIER regulation.
- Over its full operational life, the project is expected to reduce emissions by a similar amount each year, contributing meaningfully to Alberta's decarbonization pathway.

In addition to its direct environmental impact, the project generated practical insights that are now being applied across Concord's Alberta portfolio and shared with regulatory bodies, peer developers, and research institutions. It establishes a replicable model for future hybrid renewable projects that can respond to evolving market opportunities, cost declines, and policy reforms including Alberta's upcoming Restructured Energy Market (REM).

14.0 COMMERCIALIZATION AND TECHNOLOGY TRANSFER PLAN

14.1 PROJECT COMMERCIALIZATION ADVANCEMENTS

The Drumheller Solar and Battery Storage Project marked a significant advancement in the commercial deployment of hybrid renewable systems in Alberta. As one of the province's first DC-coupled solar + BESS facilities, the project demonstrated that integrating storage into solar assets can be executed successfully within Alberta's deregulated market framework. The system achieved full operational status, delivered consistent revenue through energy arbitrage, and validated the commercial potential of capturing clipped solar energy. Real-time dispatch, in partnership with URICA, allowed the battery to respond to pool price volatility and generate measurable revenue uplift, especially during system stress events. These achievements have built internal confidence within Concord and strengthened industry credibility around the hybrid business model. As a result, Concord is now actively advancing BESS retrofits and hybrid-ready designs for future developments across its Alberta portfolio.

Despite these successes, a number of commercialization gaps remain. Most notably, the project's battery system (3.6 MW) falls below the 5 MW threshold required to participate in Alberta's ancillary services markets. While the battery's arbitrage performance was strong, this regulatory barrier limits access to additional revenue streams that could further improve project economics. Additionally, the complexity of consistently capturing clipped energy, particularly under variable cloud cover, exposed the limits of automated charging strategies and highlighted the need for advanced EMS tuning. Finally, the regulatory and technical frameworks for hybrid metering, telemetry, and interconnection in Alberta remain non-standardized, requiring project-specific engagement with ATCO and the AESO.

Success Metric	Commercialization targets from CA	Commercialization targets after project completion	Explanation

Amount of Generation	90-95% of unconstrained grid generation	Achieved ~90% depending on month and economic opportunities. A much large solar array was constructed than contemplated in the CA.	A larger battery could ensure a greater amount of energy is stored when grid is constrained and solar generation exceeds grid capacity. However, battery discharge needs to be economic and is dependant on power pool pricing.
Gross and Net Revenue Uplift (Power/DTS /Capacity)	> cost of battery +return on investment	> cost of battery +return on investment	Achieved under ERA-supported economics; significant uplift during volatile price events.
Time-shift Accuracy	>95% of peak hourly pricing	Optimized time shifting based on hourly market price. ~95% of peak hourly pricing has been achieved but focus has been on very high-priced hours.	Strategy for time shifting focused on discharging during very high pricing (> $200/MWh), which does involve missing marginal increases in daily pricing.
Ancillary Services	Viable Revenue Stream	BESS greater than 5MW can access ancillary services	Future projects would be developed to optimize for ancillary services, especially given the reduction in battery capital costs in 2019-2022 vs. 2025.
GHG Reductions	Target annual CO2e reduction of 14,300 T/y	Facility achieved a C02e reduction of 9,125 tC02e during 2024 (first full year of operation) based on current TIER grid emissions intensity.	Future hybrid implementation would provide a proportionate amount of GHG reductions
Capital Cost	Deliver project for a capital cost of $24,950,000	Delivered at ~$36.7 million; Scope adjusted to include larger solar installation.	Future projects could be completed at a lower cost. Battery storage costs have decreased since Drumheller batteries were procured.
Schedule	Deliver project and achieve final completion by October 31, 2021	Full Commercial operation achieved by May 31, 2025.	Project changed ownership, mitigated project challenges with material/labour and optimized scope.
Overall Battery Efficiency	Optimal charge/discharge use for maximum return in specific market	Battery discharge has been optimized for maximum return in Alberta, which has included capturing price spikes of $200/MWh.	Market dynamics may change over time providing more frequent but less consequential discharge opportunities.

Table 6: Project Commercialization Advancements

14.1.1 PROJECT TECHNOLOGY ADVANCEMENTS

While the Drumheller project used commercially available components, it advanced the integration and application of DC-coupled solar + storage systems in Alberta. Over the course of the project, Concord refined the design, control logic, and dispatch strategy for hybrid systems shifting from basic clipped energy capture to price-responsive energy arbitrage. The company also overcame site-specific challenges related to EMS integration, battery commissioning, and hybrid telemetry.

These advancements have positioned Concord to more confidently deploy hybrid systems at scale. The project established an internal knowledge base that will improve future project delivery timelines, reduce integration risks, and enhance market performance. As battery costs continue to decline and market rules evolve, these capabilities will enable Concord to lead in Alberta's next wave of hybrid renewable deployments.

14.1.2 PROJECT TRL ADVANCEMENTS

At the outset of the project, the core technologies—solar PV, lithium-ion battery energy storage, and energy management systems—were individually at Technology Readiness Level (TRL) 9, reflecting proven commercial technologies. However, their integration in a DC-coupled hybrid configuration within Alberta's unique market and regulatory context was untested and closer to TRL 6–7, representing a system prototype in a relevant environment.

By project completion, the integrated hybrid system successfully progressed to TRL 9, having demonstrated full commercial operation, real-time dispatch, grid compliance, and emissions reductions. The project validated the hybrid model for Alberta, removing technical and regulatory uncertainty and paving the way for broader market deployment.

14.2 TECHNOLOGY PROVISION AND THIRD-PARTY VENDORS

The Drumheller project did not involve the creation of a proprietary technology or product to be sold to customers. Rather, the project demonstrated Concord's ability to integrate and operate commercially available solar and battery systems as part of a turnkey hybrid renewable energy facility. For future projects, Concord will continue to act as a developer, owner, and operator—delivering clean energy and grid services to the Alberta market through direct participation in the electricity pool.

Concord has developed relationships with key third-party vendors to support commercial hybrid deployments. For the Drumheller project, this included:

- **Sungrow** – supplier of inverters and lithium-ion battery energy storage systems (BESS)
- **SunGrid Solutions** – EPC contractor for battery system integration
- **Dependable Mechanical Systems (DMS)** – solar EPC contractor
- **Spark Power** – operations and maintenance (O&M) provider
- **URICA Energy Management** – commercial dispatch and market optimization services
- **Indie Energy** – EMS programming and technical integration support

These relationships will continue to support Concord's future hybrid projects, with adjustments to vendor selection and scopes as needed to align with new sites, technologies, and evolving market requirements.

14.3 COMPETITIVE SCAN

The Alberta energy storage market is becoming increasingly competitive as battery costs decline, policy clarity improves, and the AESO prepares for market reforms under the Restructured Energy Market (REM). Several independent power producers and utilities are actively evaluating or deploying battery energy storage systems, both as standalone assets and in hybrid configurations with solar or wind.

Notable competitors include Northland Power, Elemental Energy, TransAlta, and ATCO Energy Solutions, all of whom are advancing renewable or storage portfolios in Alberta. While most existing deployments are AC-coupled, Concord's Drumheller project is one of the first to implement a DC-coupled architecture, providing efficiency gains and clipped energy recovery. This design, along with Concord's integrated dispatch and O&M approach, gives it an edge in optimizing smaller-scale batteries for real-time pool price responsiveness.

The competitive landscape supports continued innovation and cost reduction but also demands operational excellence and regulatory fluency. Concord's successful delivery of Drumheller, paired with in-house experience and vendor relationship, positions the company to remain competitive in Alberta's fast-evolving storage and hybrid energy market.

14.4 MARKET AND END-USERS

Concord Green Energy's target market for hybrid renewable energy systems includes participation in Alberta's wholesale electricity pool, with the Alberta Electric System Operator (AESO) acting as the primary market interface. As an owner and operator of merchant assets, Concord generates and dispatches electricity directly into the grid, where it is purchased by load-serving entities, retailers, and large commercial consumers.

The end-users of the energy produced by Concord's solar and storage facilities are Alberta electricity consumers, including residential, commercial, and industrial customers who indirectly benefit through lower-emission, price-responsive generation. In the future, Concord may also explore direct power purchase agreements (PPAs) with large corporate buyers, municipal aggregators, or Indigenous communities seeking stable, clean energy supply.

The market is already accessible today through AESO registration and pool participation. With the lessons learned from Drumheller, Concord is positioned to reach additional end-users almost immediately, with deployment timelines for future sites estimated at 18 to 24 months from development to commissioning.

14.5 MARKETING

As a developer and operator of utility-scale renewable energy projects, Concord Green Energy does not market a consumer-facing product. Instead, the company's marketing efforts focus on building visibility among institutional stakeholders, including regulators, investors, municipal governments, corporate offtakers, Indigenous partners, and other industry participants.

14.6 DISTRIBUTION

The technology demonstrated in the Drumheller Solar and Battery Storage Project namely, the integration of solar PV with battery energy storage, is not a product sold directly to end-users. Instead, Concord Green Energy develops, owns, and operates these assets, delivering electricity and grid services to the Alberta Electric System Operator (AESO) through direct participation in the wholesale market.

The distribution channel for Concord's energy output is the provincial transmission and distribution grid, operated by AESO and regional distribution facility owners (e.g., ATCO). Electricity generated by Concord's facilities is dispatched into the grid and ultimately consumed by Alberta's residential, commercial, and industrial customers.

Looking forward, Concord may also explore direct energy sales through power purchase agreements (PPAs) or participation in future capacity or ancillary service markets under Alberta's Restructured Energy Market (REM). No additional physical distribution infrastructure is required to access these channels; rather, access is governed by regulatory, commercial, and interconnection processes, all of which Concord is positioned to navigate based on its experience at Drumheller.

14.7 TECHNOLOGY PROTECTION

The Drumheller Solar and Battery Storage Project does not involve proprietary or patentable technology. It integrates commercially available solar PV modules, inverters, and lithium-ion battery systems, using vendor-supported energy management software and market dispatch services. As such, the technology is protected through commercial agreements, operational know-how, and regulatory participation, rather than intellectual property rights.

Concord Green Energy confirms that there are no known competing proprietary processes or patents that would limit or jeopardize the continued use, replication, or expansion of this project's technology. The system architecture and EMS strategies developed during the project are Concord's to apply and adapt across future hybrid deployments.

All key legal and commercial arrangements such as interconnection agreements, vendor warranties, and operational service contracts are in place and in good standing. If any such agreements were voided (e.g., through vendor insolvency or service discontinuation), the impact would be operational rather than structural, as equivalent replacement vendors or technologies are readily available in the market.

14.8 COST OF COMMERCIALIZATION

While the project did not involve traditional R&D or invention of new hardware, it required significant investment in engineering design, energy management system (EMS) programming, and market integration, representing a first-of-kind deployment in Alberta.

The transfer plan for future hybrid deployments will benefit from several positive cost and performance drivers:

- Replicable project design and refined construction sequencing will reduce soft costs and schedule delays.
- BESS procurement costs have dropped approximately 50% since Drumheller, greatly improving project economics.
- Established vendor relationships and internal capability (across EPC, O&M, and dispatch) reduce integration risk and cost.

Future implementation costs per site will vary by size and location but are expected to range from $20–$30 million, depending on system capacity and interconnection scope. These costs include engineering,

procurement, construction, EMS integration, and permitting. Marketing and stakeholder engagement costs are modest and internalized. No patent or licensing costs apply.

Funding for future projects is expected to come from a mix of equity, project-level debt, and federal/provincial funding programs (e.g., NRCan, Indigenous partnership capital).

Revenue potential is strong, with market-based returns achievable through:

- Energy arbitrage
- Clipped energy capture
- Future access to ancillary services and payments under Alberta's REM

Contingency planning includes internal capital reserves, conservative sizing assumptions, and flexible dispatch strategies to mitigate price volatility or technical interruptions. The company's existing ownership and operational structure allows rapid redeployment of lessons learned with controlled risk exposure.

14.9 SHORT-TERM ACTIONS

Within two years of completing the Drumheller Solar and Battery Storage Project, Concord Green Energy will undertake a number of follow-up actions to advance commercialization and replicate the hybrid model across Alberta.

Key short-term actions include:

- Deployment of BESS at existing solar sites, leveraging lessons learned from Drumheller to streamline design, permitting, and construction.
- Scaling up BESS size for future projects to qualify for ancillary services and participate fully in Alberta's Restructured Energy Market (REM).
- Direct procurement of Sungrow BESS at reduced prices (~50% lower than Drumheller), improving project economics and internal rate of return.
- Engaging with Indigenous partners and municipalities to co-develop hybrid renewable energy assets that provide local economic benefits.
- Formalizing dispatch and O&M coordination protocols across Concord's portfolio to ensure consistent performance and value optimization.

These near-term steps will accelerate the commercialization of hybrid systems in Alberta and reinforce Concord's position as a leader in renewable energy integration.

14.10 LONG-TERM COMMERCIALIZATION

Over the long term, Concord Green Energy intends to integrate battery energy storage into all future solar and wind developments in Alberta, applying the technical and commercial learnings from the Drumheller project. As Alberta's electricity market continues to evolve with increased volatility, higher renewable penetration, and new programs under the Restructured Energy Market (REM), hybrid renewable systems will become essential for delivering reliable, flexible, and economically competitive clean energy.

Concord's long-term commercialization strategy includes:

- Developing larger hybrid facilities that are eligible for ancillary services, capacity payments, and expanded market participation.
- Standardizing hybrid design and delivery processes, reducing cost and complexity across its growing asset base.
- Exploring utility partnerships and Indigenous co-ownership models to scale impact, unlock funding, and improve project alignment with community goals.
- Leveraging operational data and control logic refinements from Drumheller to enhance performance across the fleet and inform market-facing strategies.

These efforts position Concord to be a sustained leader in Alberta's clean energy transition, with hybrid systems serving as the cornerstone of its next-generation project pipeline.

15.0 COMMUNICATIONS PLAN

15.1 KNOWLEDGE SHARING DURING PROJECT

Throughout the Drumheller Solar and Battery Storage Project, Concord Green Energy actively shared knowledge and project insights with a range of stakeholders to support broader understanding and adoption of hybrid renewable energy systems in Alberta.

Key knowledge-sharing activities included:

- Bilateral engagement with the Alberta Electric System Operator (AESO) and ATCO to provide feedback on telemetry, metering, and interconnection challenges specific to DC-coupled hybrid configurations.
- Industry conference participation, including presence at Electricity Transformation Canada 2024 and the 2025 IPPSA Annual Conference, where Concord shared lessons learned on dispatch strategy, EMS integration, and project delivery.
- Regular reporting to Emissions Reduction Alberta (ERA) via milestone submissions, which were made available to other project proponents and market participants.

The primary audiences for these activities included system operators, peer developers, policymakers, technical service providers, and clean energy advocates each benefiting from Concord's real-world deployment experience and openness to share operational learnings.

15.2 KNOWLEDGE SHARING POST PROJECT

Following project completion, Concord Green Energy will continue to share key findings and technical insights from the Drumheller Solar and Battery Storage Project to support broader market understanding and inform future hybrid deployments in Alberta and beyond.

Planned post-project knowledge-sharing activities include:

- Ongoing participation in industry conferences and forums, such as IPPSA, CanREA events, and AESO stakeholder engagements, where Concord will present operational performance data and lessons learned from Drumheller.
- Continued collaboration with the National Research Council of Canada (NRC), which may include additional data contributions or case study development as part of its national battery performance research.
- Project summary and insights published on Concord's website and shared through corporate communications, including press releases, case studies, and investor presentations.
- Direct engagement with Indigenous and municipal partners, using Drumheller as a reference project to support partnership discussions for future hybrid developments.

16.0 LITERATURE REVIEWED.

Not Applicable.

17.0 DEFINITIONS

AC (Alternating Current): The form of electricity used in most grid transmission and distribution systems.
AESO (Alberta Electric System Operator): The organization responsible for the operation and planning of Alberta's electricity grid and wholesale market.
ATCO: Distribution Facility Owner (DFO) responsible for grid interconnection in the Drumheller project area.
BESS (Battery Energy Storage System): A system that stores electrical energy for later use, often used for load shifting, grid support, or renewable integration.
Clipped Energy: Solar energy generated by an overbuilt PV array that exceeds inverter capacity and would otherwise be lost if not captured or curtailed.
DC (Direct Current): The form of electricity generated by solar panels; requires conversion to AC for grid use.
DC-Coupled System: A hybrid energy system where both the solar array and the battery share a common DC bus before inversion to AC.
DFO (Distribution Facility Owner): Entity that owns and operates the distribution grid in a specific service area (e.g., ATCO).
EMS (Energy Management System): Software and control system used to optimize and dispatch energy resources such as batteries.
GHG (Greenhouse Gas): Emissions such as CO_2, CH_4, and N_2O that contribute to climate change; measured in CO_2-equivalents (tCO_2e).
O&M (Operations and Maintenance): Services related to the upkeep and performance management of the facility.
PPA (Power Purchase Agreement): A contractual agreement to buy electricity, often used for direct offtake between a producer and customer.
REM (Restructured Energy Market): Alberta's upcoming market reform initiative aimed at improving grid reliability and resource adequacy through enhanced products and services.
SCADA (Supervisory Control and Data Acquisition): The system used to monitor and control facility operations in real time.

SoC (State of Charge): A measure of the current energy level in a battery, expressed as a percentage of total capacity.
URICA: Concord's third-party commercial dispatch partner for battery optimization and market participation.