Public Final Outcomes Report:

WindCharger: Enabling Increased Intermittent Green Generation via Wind Energy Storage

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Executive Summary

TransAlta's WindCharger Battery Energy Storage System (BESS) is Alberta's first utility-scale BESS. The project has garnered a lot of attention both from TransAlta's investors but also from the industry as a whole.

The project is 10 MW / 20 MWh in size and located in Southern Alberta, ~15km NE of the town of Pincher Creek. The project is connected behind-the-fence and directly adjacent to TransAlta's Summerview substation. The project charges exclusively from wind power generated from the nearby Summerview II wind farm, making the BESS fully renewable.

TransAlta worked closely with the Alberta Electric System Operator (AESO) and the Alberta Utilities Commission (AUC) to get this project from inception to commercial operation. This was the first utility-scale BESS to work its way through the AESO's interconnection process and the second project to get approval from the AUC.

WindCharger was successfully constructed and commissioned in less than 7 months. Construction started during the height of the COVID-19 pandemic so additional safety protocols were put in place for the construction team working at site, and successfully navigated COVID-19 related supply chain challenges and travel restrictions. TransAlta is proud to say that there were zero safety or COVID incidents for the entire duration of the project.

WindCharger has been successfully handed off from the Construction team to the Operations team. The Operations team has been working closely with Tesla on making sure all firmware upgrades are being installed in a timely manner to make sure the Megapacks remain always up to date.

WindCharger has been operating for over four months now and TransAlta's Asset Optimization team has been successful in generating revenue from the asset The AESO is opening a procurement process for a new Fast Frequency Response Pilot Project in which a new form of Operating Reserve product will be offered. This product will be exclusively for new technology, in which WindCharger will fit. TransAlta plans to participate in this pilot project, working closely with the AESO.

Project Description

- Introduction and background

  The TransAlta WindCharger project is a utility scale battery energy storage project that is connected to the Alberta Interconnected Electrical System (AIES) through TransAlta's existing Summerview wind farm substation. This is the first utility-scale battery energy storage project in Alberta. The project is a pioneer from many aspects, with technology adoption being the most obvious. Leading the integration of a new/unclassified technology type to the AESO-operated transmission was one of the most significant accomplishments associated with this project. This project will pave the way for future energy storage projects within the province.

  In concert with developing this project, TransAlta has been leading the way in driving changes to the Alberta regulatory construct, via the AUC and AESO, that will allow batteries to:

  1. Connect to the AIES

  2. Participate in the wholesale energy and operating reserves markets

  This project includes all aspects of a major capital project, including regulatory permitting efforts, stakeholder and environmental consultations, engineering, construction, commissioning and operations prior to issuance of this report to the ERA.

  WindCharger stores intermittent wind energy in 20 MWh (10 MW) of batteries comprised of the Tesla Megapack lithium-ion technology. This is the third application of the Megapack technology worldwide and will shift renewable wind energy from low demand hours (typically evening off-peak) to times when it is most needed on the Alberta electricity grid. The stored wind energy will be sold on the wholesale market in Alberta as either energy (via wind arbitrage) or ancillary services.

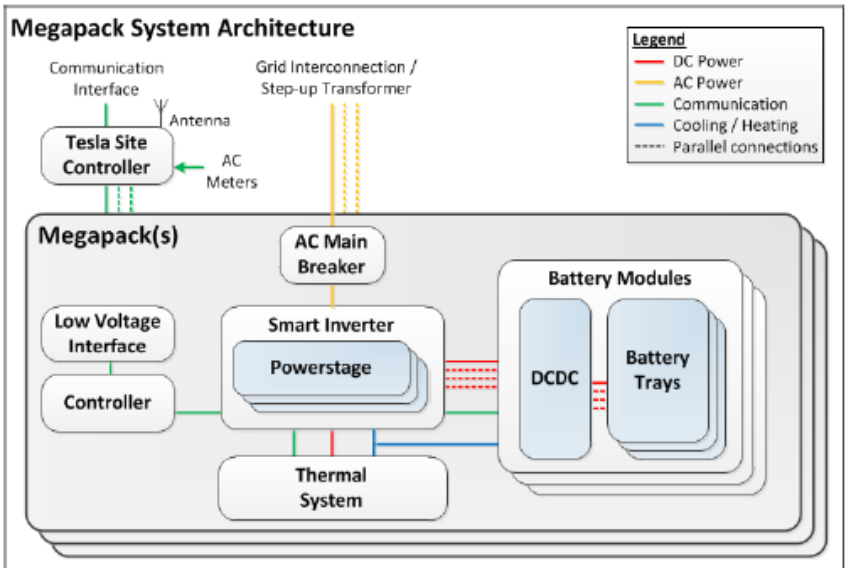
  WindCharger utilizes highly scalable technology. Lithium-ion technology enables custom sizing of storage energy (kWh) and power rate (kW). TransAlta reduced new technology risk by using an integrated product offering. Project execution risks, including cost overruns were reduced because we did not have to integrate various battery components from numerous manufacturers.

  The design team was challenged to develop and execute a first of kind installation of a BESS in Alberta's climate, with both extreme seasonal temperature variation and high wind conditions. The project was challenged to achieve the objectives of clean, reliable, safe and affordable power and the project successfully achieved all these metrics and delivered.

- Detailed technology description

  WindCharger is a utility scale lithium-ion battery energy storage project. It uses Megapack technology from Tesla and is the third installation of this product worldwide. The fundamental unit for energy storage is the lithium-ion cell at the heart of the product which is contained in predefined blocks to better manage safety and installation. Upstream from the blocks of cells are the electrical protection systems in place. There is a multi-level fuse system which prevents events of over-charging and over-discharging. Each component

and subsystem on the DC bus are individually fused. Battery modules are fused both on the high and low voltage side and each battery module contains a pyro fuse. These modules connect to a DC bus, through an inverter, and to a transformer, substation, and finally the AIES.



The cabinets are non-habitable and thus provide no risk of emergency workers being caught inside an enclosure with batteries. Safe operating procedures are in place for the Megapacks and Battery Energy Storage System (BESS) as a whole. Not only do the Megapacks display exceptional qualities of safety and performance but they also contain within themselves a thermal management system designed to keep the batteries performing optimally under any environmental condition. The temperature of a lithium-ion cell is a crucial aspect to its performance and Tesla provides a cell-level management of this temperature. Using sensors, Tesla can monitor the performance and temperature of the cells to ensure the system is operating optimally.

WindCharger operation is actively managed using TransAlta's Asset Optimization Team in Calgary and Wind Control Center in Pincher Creek.

- Project objectives (including the objectives from original contribution agreement and any evolution/revisions made over the course of the project)

  The project has integrated battery energy storage with Alberta's existing utility-scale wind energy resources for the purpose of selling energy and / or ancillary services to the AESO wholesale market.

  The WindCharger project is giving storage credibility in Alberta. The project will prove that storage can be implemented in a safe and reliable manner within a northern climate. The project will allow the AESO to not only create or revise rules to enable storage participation in the market, but actively learn how to include a non-traditional technology (neither a generator or a load) in the market. The province and the regulators will be able to gain valuable learnings from the project which will contribute to future rule refinement, policy creation, and program development supporting further storage deployments. Enabling storage deployment could in turn enable higher penetration of wine and solar energy in Alberta.

In addition to Alberta's existing wind farms, there is a substantial potential for wind energy growth in Alberta. This is supported by the high-quality wind resource present across much of Alberta, not to mention the political impetus to transition away from coal and mandate renewables growth. Growth of renewables requires technologies that can manage intermittency and offer support to the electric grid, WindCharger is capable of doing both.

The project will demonstrate how utility-scale energy storage can effectively shift wind energy to meet electrical demand and system need. Energy storage is a necessary enabler for higher penetrations of renewable generation in unsubsidized merchant energy markets. Integrating energy storage with wind power supports further wind development in Alberta, thus reducing the greenhouse gas (GHG) emission intensity of the Alberta grid by enabling an increased penetration of intermittent renewables relative to fossil-fuel generators. Higher volumes of future wind power facilities, combined with energy storage, will prevent high emission has peakers from being constructed in Alberta.

WindCharger site view at construction kick-off March 21,2020

- Work scope overview

#	Task	Deliverable
1	**Project Development, Scoping, and Award**	
	1.1	Develop scope of work for supplier and EPC RFP
	1.2	Develop major equipment specifications
	1.3	Develop preliminary engineering documents required for RFP
	1.4	Perform site survey and red-line as-builts
	1.5	Run battery supplier RFP
	1.6	Develop Class 3 Cost Estimate
	1.7	Negotiate contracts for battery supply and capacity maintenance agreement
	1.8	Battery and associated auxiliary equipment purchase order is placed
	1.9	Procure an EPC contractor to complete the turnkey project
2	**Permitting & Stakeholder Relations**	
	2.1	Prepare the AUC applications and receive approvals
	2.2	Consult Alberta Environment and Parks
	2.3	Progress AESO interconnection stage gates
	2.4	Prepare Municipality Development Permit and receive approval if required
	2.5	Perform WECC testing if required
3	**Engineering**	
	3.1	Preliminary engineering for RFP scoping
	3.2	Geotechnical work
	3.3	Detailed engineering and design
4	**Procurement**	
	4.1	Procure batteries
	4.2	Procure substation upgrade equipment
5	**Project Integration**	
	5.1	SAP will be loaded with the new equipment foundational data
	5.2	Training program developed to instruct maintenance and operations groups on how to properly maintain and operate the facility
	5.3	Develop a list of spare part tools, equipment, consumables & supplies & submit recommendation to TransAlta for approval
	5.4	Billing system/dispatch optimization created for generating a revenue stream
	5.5	Prepare & submit to TransAlta an annual operating plan, annual operating budget and annual capital budget
	5.6	Develop, recommend & implement all operational & administrative policies, procedures & manuals required to operate & maintain the plant
	5.7	Preventative Maintenance plans will be created and scheduled
6	**Construction & Commissioning**	
	6.1	Construction permitting

	6.2	Move existing snow fence to the west
	6.3	Construct foundations as per Construction Work Packages (CWP)
	6.4	Receive and install auxiliary equipment
	6.5	Wiring integration of all equipment including substation upgrade and tie-in
	6.6	Test and commission each system to ensure complete operations and system performance
	6.7	Establish a punch list and work through the remaining items
	6.8	Declare Commercial Operations (COD)
7	**Project Management to Close-Out & Legal Support**	
	7.1	Manage project deliverables, risks, schedules, and invoicing
	7.2	Complete the punch list
	7.3	Obtain sign-off from Operations, Maintenance and Owner that facility has been constructed as per the agreement and handed over to operations
	7.4	Operate Asset for 2 months
	7.5	Submit final report to ERA
	7.6	Close contracts and clean-up project financials
	7.7	Obtain sign-off from ERA and receive hold-back payment

Project Outcomes and Learnings

- Overall project achievements
    - *Brought online Alberta's first utility-scale Battery Energy Storage System*

      TransAlta successfully brought online Alberta's first utility-scale BESS This success was a culmination of the achievements outlined below in this section.

    - *Worked with the AESO on approval to interconnect Alberta's first utility-scale BESS*

      Starting in 2016 when the ERA awarded TransAlta the Contribution Agreement for this project, TransAlta worked closely with the AESO to determine what market regulations would need to be altered in order to allow BESS projects within the province. The biggest hurdle to overcome is that BESS projects are not considered either a load nor a generator in the eyes of the AESO, and that had not been previously contemplated in any of the existing regulations. TransAlta provided recommendations and suggestions to the AESO market regulation team that went on to be the foundation of today's Energy Storage Roadmap. As the Roadmap was not complete in time for Commercial Operation of WindCharger, the TransAlta team had to work closely with the AESO to determine how to work within existing rules and regulations to still gain our approvals until the Energy Storage Roadmap could be released. As WindCharger was the first BESS in Alberta, there were learnings with the AESO on the technical specifications of the batteries themselves, some of the historic requirements for other fuel types didn't make sense for the BESS. By working closely together every step of the way, TransAlta and the AESO were able to make this project a success.

    - *Received the first AUC 007 approval, that included the technological specification approval, in the province for BESS*

      While WindCharger was not the first AUC 007 BESS approval, it was the first approval that included the sign-off of the technology specifications, which was arguably the most challenging part of the process. As this was the first BESS in Alberta, the AUC needed to understand the technical implications in order to grant an approval. TransAlta worked closely with the AUC from 2018 onwards to make sure all appropriate environmental and stakeholder requirements were met in advance of submitting our application as there were no BESS-specific requirements. The majority of the Information Requests were regarding the technical specifications of the technology which TransAlta was able to answer with the help of Tesla.

    - *Zero safety incidents throughout the development, construction, commissioning and operation of WindCharger to date*

      Safety is one of TransAlta's core values and we have a number of safety programs including the Total Safety Management System. This system is a combination of recognized best practices in process safety, risk management, asset management, health, safety and environmental management.

      Construction on the WindCharger project started during the peak of the COVID-19 pandemic. Stringent protocols were created in order to allow TransAlta employees and contractors to be able to work on site in a safe manner. Protocols included a daily wellness questionnaire and temperature check, as well as protocol for carpooling,

increased sanitization of touch points and how daily tailboard meetings were conducted. TransAlta is very proud to say that no safety or COVID-19 incidents occurred on the site from the beginning of construction to date.

- *Bringing online a new technology to TransAlta*

  As mentioned in the sections above, WindCharger was a first-of-its-kind technology for the province. This meant that we needed to work closely with the regulators across the province to make sure everyone was aligned in our goal of commercial operation, as well as making sure the regulators were comfortable with a new technology.

- *Bringing online a new Tesla Technology, the third installation worldwide, first in Western Canada of the Tesla Megapack*

  When TransAlta chose Tesla and the Megapack technology, there were no units commercially deployed. The WindCharger project is only the third installation worldwide. TransAlta worked closely with Tesla to understand the technology and make sure we were mitigating risks as well as setting the local Emergency Response Team up for success in the highly unlikely event of an emergency related to the batteries. Site tours of the Tesla Gigafactory were completed in order to gain confidence in the manufacturing process of the Megapacks as well as to understand the technology better before it arrived on site.

Tesla Megapacks arriving on site in May 2020

- Technology development, installation, and commissioning description

  Through the development of the project the technical team learned and proved out many new concepts. The importance of safety was first of mind. The first and most effective way of introducing safety into your battery system is by using a non-habitable containerized solution. The design of the system as a whole is the second layer of defense against battery failure. Using multiple levels of fusing, cell monitoring, granular thermal management, and an effective battery management system to prevent overcharging and over-discharging are an important aspect of safety and performance. Finally, manufacturers have very different quality standards for battery manufacturing and testing. These standards must be rigorous enough to determine that the likelihood of cell short

circuiting is very low. Many learnings resulted from the study of performance and reliability. Lithium-ion cells require a maintained temperature around 15 to 25C. For this reason, Megapacks, as well as most other architectures, have thermal management systems contained within them. These systems require a proper design to ensure the battery will operate optimally and without damage. Thermal management is primarily done using either the circulation of temperature-regulated liquid or using forced air over a bank of cells. The design must prevent hotspots in the cells or performance and safety are at risk. In addition, TransAlta designed the system to limit the intake of electricity from the AIES. As a result, there was significant work put in to determine the electric load of the thermal management system and determine the risk of not having wind generation during an extremely cold event while the battery is low on charge. This required a historical analysis of AIES outages, wind generation, ambient temperature in the area, and battery capacity.

When running the RFP process the Alberta-specific climate conditions were important in picking our BESS technology. We worked closely with Tesla to fully understand the implications of temperature on the performance of the batteries as well as what the warranty requirements were for temperature. The Megapacks are operational in extreme cold temperatures, their heating systems just needs to be on. In order to make sure we were able to have the heating systems on/ drawing power we reviewed the power draw of the Megapacks and made sure that in the event of a no-wind situation where there were freezing temperatures we could pull from the existing Demand Transmission Service (DTS) contract at the Summerview II windfarm. This would enable us to keep the Megapacks warm and not have a 24-hour period in which the ambient temperature was consistently -40 degrees Celsius which would void the warranty.

The Megapacks were installed in a unique configuration to minimize cable lengths to the transformers and provide more flexibility in the system if one transformer or Megapack grouping requires service. There are 3 Megapacks in a horseshoe formation with a transformer within each of the 3 horseshoes. Both the Megapacks and transformers are installed on steel frames providing access for service and expansion of the Megapacks, as well as suitability to the seasonal weather and soil conditions.

Commissioning of the Megapacks was done remotely through Tesla's service group in California, with some on-site Tesla support. Remote commissioning is not typical for traditional fuel type electricity projects and requires a strong relationship with the vendor and clear understanding of who the key contacts are during the process. Having a strong SCADA and IT integration resource proved invaluable during the process as they could test the system locally to validate results.

While remote commissioning was partially the result of COVID restrictions, Tesla's normal commissioning protocol is to complete the work remotely. They are able to see the batteries on a cellular level remotely so in their opinion they are more effective and efficient at commissioning remotely. This does result in cost-savings to the project as site visits are not required to commission and the cost of travel can be avoided.

The entire work scope presented in the Project Description section above was completed as planned.

Tesla Megapacks being offloaded in May 2020

- Modelling details

  WindCharger was modelled to have a few streams of revenue. The basic plan was to charge the batteries when the pool price was low due to wind discount (high penetration of wind energy within the Pincher Creek corridor that all comes on at the same time and floods the AIES) and hold the charge until the pool price was higher and made economic sense to dispatch the battery.

  At the time of final investment for the project, the AESO had announced a new market structure to replace the existing Energy-only structure. The province was going to a Capacity Market structure, this assumption provided additional revenue value which was included in the model as there would be less volatility in the market because there would be capacity payments to incent independent power producers. In addition to this the team expected to participate in the Operating Reserve Market, specifically On-peak and Off-peak spinning reserve for Ancillary Services.

  The government changed in the province and the Capacity Market structure was disbanded and Alberta continued with its Energy-only structure. The project team worked with TransAlta's Asset Optimization team to determine a new optimization strategy for the battery. Ancillary Services revenue was expected to earn the majority of the revenue with the Optimization team capturing additional revenue in the high-volatility pool price hours through Energy Arbitrage. To date this is proving to be true.

- Results of experiments, model simulations

  No experiments were conducted for the WindCharger project. Model simulations that occurred were for the financial model. Various public and private forward-looking power curves were used to estimate expected revenue for the WindCharger project.

- Status of the technology risks at the end of the project (both retired risks and risks to be retired)

  Risks highlighted in the Final Project Plant submitted to the ERA:

  - New Technology:

  Technology risk has been managed through Tesla's ongoing monitoring of the system and through TransAlta's operations procedures. Tesla continue to provide firmware updates as they are developed and is diligent on providing any other physical updates to the Megapacks as required. TransAlta has a very robust Total Safety Management System in place and a thorough process safety review was completed for the BESS system to understand all project risks. In addition, an Emergency Response Plan (ERP) has been published and the Operations team worked closely with local emergency response to make sure that in the highly unlikely event there is an emergency at WindCharger, the first responders know how to react.

  - Capital Cost

  The Capital Cost for the project came in under the original approved co-funding amount. Not only did the industry pricing of batteries substantially decrease between 2016 and 2019, but TransAlta ran a formal RFP process for the battery, this provided us with competitive pricing for the batteries.

  TransAlta actively managed and optimized the project throughout. One example of the optimization was the horseshoes design, which contemplates total installed cost as well as long term operability. We also determined that the project could be housed on piles, instead of traditional concrete slabs. This also resulted in savings to the project.

Aerial Layout View (photo courtesy of Tesla)

  - Cold Weather Operation

  WindCharger has demonstrated its suitability for our cold climate through its first Alberta winter, where cold ambient were experience for sustained durations in January and February of 2021. The heaters for the Megapacks are powered by Summerview II with wind whenever possible and then use the existing DTS (Demand Transmission Service)

contract using power from the interconnected power grid when needed. There is also the option to power the heaters from the Megapack's stored energy.

- Funding Risk

We are completing the final requirements to receive the holdback payments to the project and then all expected funding will have been realized.

As previously mentioned, the project capital cost has come in under the original co-funding award in 2016, this has resulted in savings for TransAlta and allowed for the ERA to re-deploy that additional funding to other deserving projects in the province.

- Regulatory Risk & Timeline

This risk was carried throughout the project as the current market rules and connection requirements have not changed yet. The AESO has an Energy Storage Roadmap which will provide BESS-specific rules and regulations, this is expected within the next year, but WindCharger reached commercial operations following existing requirements.

The AESO Interconnection Process was followed for WindCharger, it took significantly longer than the published guidelines for times on their website. This was due to the project being a new technology for the province. TransAlta worked closely with the AESO to meet all requirements and help the AESO gain a better understanding into this new technology.

- Ongoing Operations Risk and Merchant Revenue

When this project received Internal Final Notice to Proceed the AESO had announced a new market structure to replace the existing Energy-only structure. The province was going to a Capacity Market structure, this assumption provided additional revenue value as there would be less volatility in the market because there would be capacity payments to incent independent power producers. The government changed in the province and the Capacity Market structure was disbanded and Alberta continued with its Energy-only structure. This provided a potential risk for the project economics. The project team worked with TransAlta's Asset Optimization team to determine a new optimization strategy for the battery. To date we have been able to make up the missing revenue with the volatility being seen in pool price through Energy Arbitrage and Ancillary Services.

- Discussion of any changes to the corporate structure of the company or project consortium since commencement of the project

The WindCharger Project was developed, constructed, and is operated by TransAlta Corporation. The funding received from the ERA was to TransAlta Corporation. Due to the project being considered behind-the-fence by the AESO, it was required that WindCharger be dropped down into Western Sustainable Power Inc., which was a wholly owned subsidiary of Canadian Hydro Developers Inc., which is a wholly owned subsidiary of TransAlta Renewables Inc. This drop-down happened in August of 2020.

In November 2020, an amalgamation between Canadian Hydro Developers Inc. and Western Sustainable Power Inc. occurred. This moved both the Summerview II wind farm and WindCharger into Canadian Hydro Developers. Canadian Hydro Developers Inc. is still a wholly owned subsidiary of TransAlta Renewables Inc.

With the current tariff structure, the AESO has in place, there is a disincentive for standalone BESS projects in the province. The AESO has recognized this and through the Energy Storage Roadmap plans to look into a BESS-Specific tariff structure that would more fairly treat BESS assets.

- Discussion of any advancements made toward commercialization, commercial deployment, or market adoption

  WindCharger's lithium-ion technology was already TRL level 9 when TransAlta started this project. The technology is already commercialized, with commercial deployment globally and has a strong market adoption.

  WindCharger is unique in the fact that it is a behind-the-fence project that uses the adjacent Summerview II windfarm to charge the battery. This is the first of its kind-adoption/usage of the battery technology in Canada. There has been strong industry interest in the project, and we have been sharing the project in hopes that more projects adopt the pairing renewables with energy storage to help with renewable intermittency issues.

- Description of technology advancement over the course of the project

  - Make reference to the performance/success metrics outlined in the contribution agreement

    Capital Cost / $/kwh:

    Technology costs have substantially decreased in the last 5 years for lithium-ion battery energy storage technology. Like wind and solar technologies, the first generation products capital cost were substantially more than 5 years down the road, OEM's have made major breakthroughs in order to be able to offer the products for a significantly cheaper rate which has helped a broader adoption of the technology. WindCharger utilizes the Tesla Megapack technology, when TransAlta signed the Supply Agreement with Tesla there were no Megapacks commercially deployed, WindCharger was the third installation of the Megapack technology world-wide.

    The TransAlta team also worked to find innovative ways to keep the Owner's costs and Construction costs of the project as low as possible. Using an Ep/CM model where the Owner's Engineer (BBA Engineering) did the detailed design and technical support of procurement and TransAlta directly managed the construction, instead of an EPC model, reduced construction costs of the project because TransAlta completed more oversight of the project in-house instead of paying a premium to have the EPC complete that work. This model also enabled "dynamic" response to changes; while the scope was clear the scope details were finalized in an agile format as many of the key Telsa design inputs were made available and saw updates through the project execution phase.

    Commercial Operation Date:

    The Commercial Operation date experienced minor delays from the optimal un-risked timeline from the final Amendment to the Contribution Agreement. This was due to a culmination of reasons, the biggest being: COVID, AESO System Upgrade, and minor schedule delays from optimal schedule as would be expected with the implementation of new technology. The project reached Commercial Operation on October 15, 2020.

Construction of the project started March 31, 2020; this was right at the peak of the first wave of the COVID-19 pandemic. TransAlta created strict EH&S COVID policies for any essential workers who were required to be on site. The WindCharger policies were used as a template for other construction projects in the company. Daily temperature checks and wellness questionnaires are required, as well as social-distancing protocols for daily tailboard meetings and increased frequency of disinfecting of high-traffic touch points at the site. TransAlta is happy to report there were no cases of COVID at the WindCharger site for the duration of the project.

Safety Record:

Project had zero safety incidents. Exceptional results: while there are limited comparables to BESS projects this is top tier compared to energy industry construction statistics having an average TRIF of ~ 0.6 to 1.0.

TransAlta has a very strong safety culture, Total Safety at TransAlta is our commitment to protecting our people, the public, the environment, and the company's physical assets. This commitment is a corporate responsibility for TransAlta and the personal responsibility of each employee and contractor working on TransAlta's behalf. Safe, reliable, and incident-free operations are critical to our success. TransAlta accomplishes this through the Total Safety Management System, all employees and contractors must adhere to TransAlta's safety procedures and protocols.

The WindCharger team also created a detailed Process Safety risk analysis before construction of the project commenced. This took all risks the project team could think of and quantified them and analyzed how to mitigate the risks and if the risk were to occur how that would impact the project. By completing this exercise, the Construction team was already cognizant of the risks and could work with the contractors to avoid these project risks.

One of three transformers installed on site

- Provide the technology readiness level (TRL) at the beginning of the project and at project completion

  WindCharger's lithium-ion technology was just reaching TRL level 9 when TransAlta started this project. Tesla's energy storage technology was already proven with field testing performed in California by Tesla, it was based on the proven Tesla Powerpack and Electric Vehicle (EV) technology but there were no industry installed Megapacks until just before our site became operational. WindCharger was one of the first three deployments of the Megapack technology worldwide and the first utility installation in Alberta and in a northern climate.

- Discussion of any challenges, delays or obstacles encountered during the project

  - COVID – New policies and procedures were developed for the construction site to manage daily workers, deliveries and visitors to the site. This process was well managed by the construction contractor and no incidents were recorded. Additional costs were incurred for a larger site trailer, additional PPE, cleaning supplies, and a cleaner that visited the site once during the shift and again in the evening for a complete deep clean.

  - Transformer design - The transformer vendor has designed and manufactured several transformers in the same size and voltage class. While transformer design is well established, these specific design of the transformers for the BESS application was more

unique due to the service application and the sizing was between common distribution pad mount transformers and larger transmission interconnection transformers.

- Metering - As the WindCharger project is a behind-the-fence connection, we did not expect it to have specific metering requirements with the AESO. The final metering specification were defined as first in kind with the AESO for a behind the fence BESS project.

WindCharger site construction almost complete, August 2020

- Important lessons learned, including learnings around business, government policy, regulation, commercialization, technology development, etc.

  New technology to the Province

  - AESO – As WindCharger was the first BESS in Alberta, there was a learning curve with the AESO on the technical specification of the batteries themselves, some of the historic requirements for other fuel types didn't make sense for the BESS. By working closely together every step of the way, TransAlta and the AESO were able to make this project a success.

  - AUC - As this was the first BESS in Alberta, the AUC needed to understand the technical specifications in order to grant an approval. TransAlta worked closely with

the AUC from 2018 onwards to make sure all appropriate environmental and stakeholder requirements were met in advance of submitting our application as there were no BESS-specific requirements when we started our environmental and stakeholder work for this project. The majority of the Information Requests were regarding the technical specifications of the technology.

- Emergency Response Plan – This was a new technology to not only the province but also the MD Pincher Creek. Safety is a core value of TransAlta and making sure not only our employees are trained on Emergency Response Plans (ERP), but also the local emergency response teams is critical. TransAlta created an ERP for WindCharger with input from Tesla and then made sure to train the local emergency response teams in the highly unlikely case that there would be an emergency event at the WindCharger facility.

First-of-its-kind technology

- Transformer – As BESS is a unique technology compared to more traditional and commercially popular fuel types, unique transformers were required for the project. A commercially available 'pre-packaged' transformer design was not an option for the project so the Owner's Engineer, TransAlta technical staff and the transformer OEM needed to work closely together to make sure the transformer design met the project requirements.

- Batteries – As mentioned, WindCharger was the third installation of the Megapack technology worldwide and with all new technologies there are always learnings associated. The biggest learning was to make sure that we were closely engaged with the OEM during the fabrication, installation and commissioning of the project. Making sure TransAlta had a strong understanding of the technology allowed out team to de-risk the new technology concern.

WindCharger site configuration

Greenhouse Gas Benefits

- TransAlta evaluated the cost of battery production, recycling, and the savings of CO2 emissions by time shifting renewable generation to renewable energy use enabling the offsetting of higher CO2 gas and coal peaker power generation.

- Over 15 years, 26,500tCO2e will be offset from the grid intensity gradient based on design utilization.

- During production, the battery will emit 1,670tCO2e and the emissions through recycling will be 300tCO2e with a net offset of 24,500tCO2e (based on industry accepted values & calculations. These value are not specifically provided by Tesla for the MegaPacks).

- The calculated/estimated annual GHG reductions resulting directly from implementation of the completed project (i.e. not after subsequent market adoption or further commercialization activities) is provided in the table below.

	Alberta Grid Emissions Intensity (tCO2e/MWh)	Annual MWh Cycled (MWh/year)	Carbon Offset (tCO2e)
2020	0.659	667	439
2021	0.629	4000	2516
2022	0.549	4000	2196
2023	0.513	4000	2052
2024	0.475	4000	1900
2025	0.437	4000	1748
2026	0.431	4000	1724
2027	0.403	4000	1612
2028	0.395	4000	1580
2029	0.389	4000	1556
2030	0.381	4000	1524
2031	0.283	4000	1132
2032	0.274	4000	1096
2033	0.271	4000	1084
2034	0.268	4000	1072
2035	0.268	4000	1072
2036	0.268	3982	1067
2037	0.268	3964	1062
2038	0.268	3946	1058
2039	0.268	3928	1053
2040	0.268	3910	1048
2041	0.268	3892	1043

- With the BESS located behind the fence, the power used to charge the system is completely from the wind turbines at Summerview II and does not draw from the grid and more carbon intensive energy sources.

- This is a first of kind project for the Province and TransAlta so there will be more learnings on CO2e offsets as the project continues operating.

Economic and Environmental Impacts

- Description of the projected economic impacts in Alberta, including, cost savings, job creation, investment attraction, economic diversification, tax revenue, etc., based on the outcomes of the project.

    - Cost Savings: There are no overt cost savings for this project. The benefit of this project is in utilizing existing energy that isn't useful at the time it is being produced and saving it for a later time in which is adds more value to the grid.

    - Job Creation: During the peak of construction there were up to 10 workers on site at a time for ~ 5 months. For full-time job creation, about 0.5 of a FTE was created for the balance of plant work. WindCharger had more than 15,000 person-hours for the project. Development of the project was more than 4,000 person-hours and construction were the remaining 11,000 person-hours for the project.

    - Investment Attraction: Through the WindCharger project we have had numerous Alberta-based companies, including oil sands companies, approach us for an on-site customer solution that matches on-site solar/wind with a BESS. Not only does this help meet their power requirements but it also helps meet their ESG targets.

    - Economic Diversification: Through working with the AESO to get the WindCharger project online, it was identified that Alberta does not have any Operating Reserve or Ancillary Services Products that incent Battery Energy Storage Systems or fast ramping technologies in the province. TransAlta has been working closely with the AESO on a pilot for a new OS product known as Fast Frequency Response. This product is meant specifically for new fast ramping technologies such a BESS. TransAlta has provided feedback and information to help formulate the pilot. The pilot program is expected to launch in late 2021 or early 2022.

    - Tax revenue: The MD of Pincher Creek will realize a property tax revenue increase.

WindCharger completed site with Summerview wind farm in the background

- Discussion about the immediate and potential future environmental benefits (including criteria air contaminants, land use, soil, water consumption, etc.) resulting from the completed project and advanced technology.
    - By using the Summerview II wind farm to charge WindCharger, there are no GHG emissions produced when WindCharger dispatches power onto the AIES. Comparing the zero emissions power to the average grid emission intensity in Alberta, this is a more environmentally-friendly solution.
    - The land used for the WindCharger project is previously disturbed lands that have not been used for agricultural or grazing purposes for a number of years. This was a good use of previously disturbed lands for the site of the project.
    - The project utilized steel screw piles instead of a traditional slab foundation, this allows for less impact to the soil and less disturbance to decommission at the end of the life of this project.
    - There is no water consumption for this project.
- Description of how the project has resulted in increased innovation capacity in the province through training of highly-skilled personnel, knowledge development, post- secondary partnerships, research organizations, start-up companies, etc.

    As mentioned above, through working with the AESO to get the WindCharger project online, the pilot for the Fast Frequency Response AS product is expected to start in 2022. This product is meant specifically for new fast ramping technologies such a BESS. TransAlta has provided feedback and information to help formulate the pilot. The pilot

program is expected to launch in late 2021 or early 2022. New Operating Reserve and Ancillary Services products within the AESO may have the ability to incent new technology types to be built and participate within the Alberta market.

BESS technologies are providing new learnings for skilled electrical personnel across the province providing an understanding of a new technology that is seeing rapid commercial implementation.

The WindCharger project increased TransAlta's knowledge of BESS projects substantially. The BESS technology was explained to the team as a 'plug-and-play' set up where you really just need to connect it and it starts working. While this is true compared to other fuel-types, there was a lot more commissioning and integration work required than originally expected. The SCADA, IT and controls teams adapted and expanded their skills through working closely with Tesla to complete testing and confirm all settings.

While there were many learnings with the WindCharger project, the project team feels confident that we could deliver another BESS project and have less roadblocks and more efficiencies.

Overall Conclusions

The WindCharger project was successful. Like any other energy project, there were challenges to overcome but by working closely with the regulators and the OEMs TransAlta was able to successfully bring the WindCharger project online during a global pandemic. As the first utility-scale BESS in Alberta, the project has garnered a lot of positive public attention and has not only other independent power producers but also the public looking into future opportunities for BESS to not only help with renewable intermittency but also in other outside the box applications.

WindCharger site complete – Oct 2020

WindCharger & Summerview Substation – March 2021 (photo courtesy of Tesla)

Scientific Achievements

- List of all applied for or obtained patents, published books, journal articles, conference presentations, student theses, etc., based on work conducted during the project.
    - The following are articles that TransAlta was contacted to discuss the WindCharger project:
        - JuneWarren Nickle – Daily Oil Bulletin (DOB) Article – February 3, 2021
        - Independent Power Producers Society of Alberta (IPPSA) – Article -December 2020 Newsletter
        - Calgary Herald – Article – August 5, 2020
        - CBC News – April 13, 2021

Next Steps

- Discussion about the next steps for the technology/process/innovation, including potential follow-up projects.

  There is potential for an expansion in size of the WindCharger facility as well as TransAlta is looking at the rest of the existing fleet to determine if there are any other applications in which implementation of BESS makes for a solid economic business case TransAlta would consider new installation of lithium-ion BESS as well as other new BESS technologies.

- Long-term plan for commercialization of the project technology/learnings.

  There is no long-term plan for commercialization of the WindCharger battery technology as it was already TRL9 and is commercially available by Tesla. In addition the Tesla Megapack technology is highly confidential and proprietary in nature, so TransAlta does not have the ability to provide technology information, that is Tesla's sole right.

- Commercialization-related actions to be undertaken within two years of project completion.

  TransAlta will continue to be part of the AESO Energy Storage Integration Learning Forum providing direct input and feedback into the AESO's Energy Storage Roadmap they are to be releasing. This roadmap will release Energy Storage specific market regulations for future BESS projects. This is helpful as the WindCharger project had to work within the existing regulations which did not contemplate BESS and in some cases were written in a way that does not allow BESS, specifically the ability to be a load and a generator at the same time.

  As previously mentioned, the AESO FFR pilot will launch, the hope is that it will be quite successful, and this will result in it becoming a permanent product offered by the AESO.

- Potential partnerships under development with technology integrators, adopters, etc.

  While it's not considered a formal partnership, TransAlta participating in the AESO Energy Storage Integration Learning Forum has allowed us to work alongside like-minded companies also in the BESS space within Alberta. TransAlta has no formal partnerships that have been formed but we have built a good knowledge network.

Communications Plan

- Summary of key knowledge-sharing or communications activities undertaken during the project.

  A formal stakeholder relations plan was created for this project. This was a requirement of AUC application 007.

  In addition, TransAlta has met with industry publications as requested to provide interviews to discuss the WindCharger Project. A list of those publications is listed above in the Scientific Achievements Section.

- Plans for communicating information about the project, project findings, and results or the underlying technology with third parties, including a description of communication tools that will be used.

  As stated above, the Tesla Megapack technology is highly confidential and proprietary in nature, and TransAlta does not have the ability to provide technology information, that is Tesla's sole right.

  TransAlta will continue to share non-proprietary information as requested with publications and other third-parties in an effort to increase knowledge and awareness for lithium-ion BESS in Alberta.

  To date TransAlta has showcased the WindCharger project through:

  - AESO Energy Storage Industry Learning Forum Group on a few occasions,
  - Executives of TransAlta have asked to participate on panels within the renewables industry
  - Numerous articles about the WindCharger project in a variety of publications, see the Scientific Achievements section above
  - TransAlta may be presenting with BBA at the IPPSA conference in Fall 2021
  - BBA has submitted abstracts to CANREA for upcoming conferences