Energy Storage Industry Learnings Forum
Workshop 1

September 18, 2020

Agenda

- Welcome and introduction
- Topic 1: Market opportunities in the Energy and Ancillary Services markets or other potential revenue streams
  - Paula McGarrigle
  - Travis Lusney
- Topic 1 Discussion
- Topic 2: Energy storage connection options
  - Akira Yamamoto
  - Graeme Harrison
  - Neil Cumming
- Topic 2 Discussion
- Break

Agenda

- Topic 3: Energy storage configuration options presentations
  - Dan Gustafson
  - Kipp Horton
  - Alex Nasiff
- Topic 3 Discussion
- Wrap up and next steps

Welcome and introduction

- Welcome
- Introduction

AESO Stakeholder Engagement Framework

ESILF transparency

- The ESILF recognizes not all of the AESO's stakeholders will be represented within the ESILF and to support the AESO's commitment to transparency, the following will be posted on the AESO website on www.aeso.ca:
  - Forum membership
  - Agendas
  - AESO or member presentations
  - Relevant discussion materials
  - Meeting summaries

Topic 1: Market opportunities in the Energy and Ancillary Services markets or other potential revenue streams

RENEWABLE ENERGY AND ENERGY STORAGE MARKET OPPORTUNITIES

SOLAS ENERGY CONSULTING

Presentation to AESO ESLIF

Introduction and Outline

Paula McGarrigle
Solas Energy Consulting Inc.
www.solasenergyconsulting.com

- The ESLIF workshop 1 is hosting a webinar to discuss:
  - market opportunities in the energy and ancillary services markets, or other potential revenue streams.
- This presentation focuses on the aspect of renewable energy and energy storage
  - Why is BESS integrated with RE?

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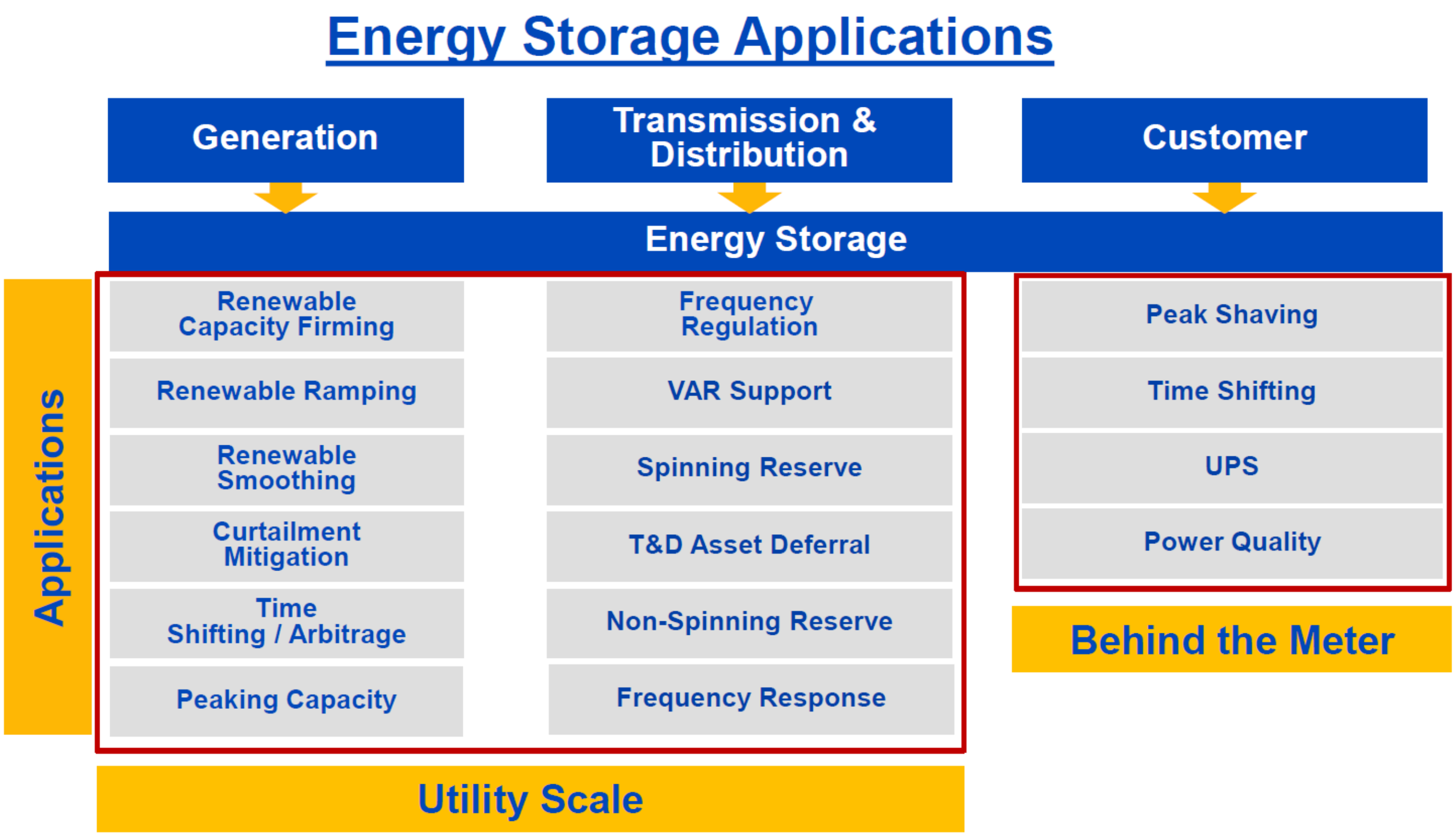
Storage is an Important Part of Alberta's Future Grid

- Curtailment of variable renewable generation is expected to increase
  - 1.3 MT CO_2e at 50% wind penetration[1]
- Reduced Operating Reserve Costs
  - PJM reduce operating reserve volumes by 50% through introduction of quick-responding storage facilities
- Reduce visual and environmental impact of transmission
- Reduce system transmission and capacity costs for load

1) GE Pan-Canadian Wind Integration Study

What is the role for batteries in Alberta?
There's 16 services identified here. Three are RE specific.



What type of Energy Storage is Best?

What kind of vehicle is best?

It depends on the application!

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There are 12 types of energy storage technologies. Here are some of their applications

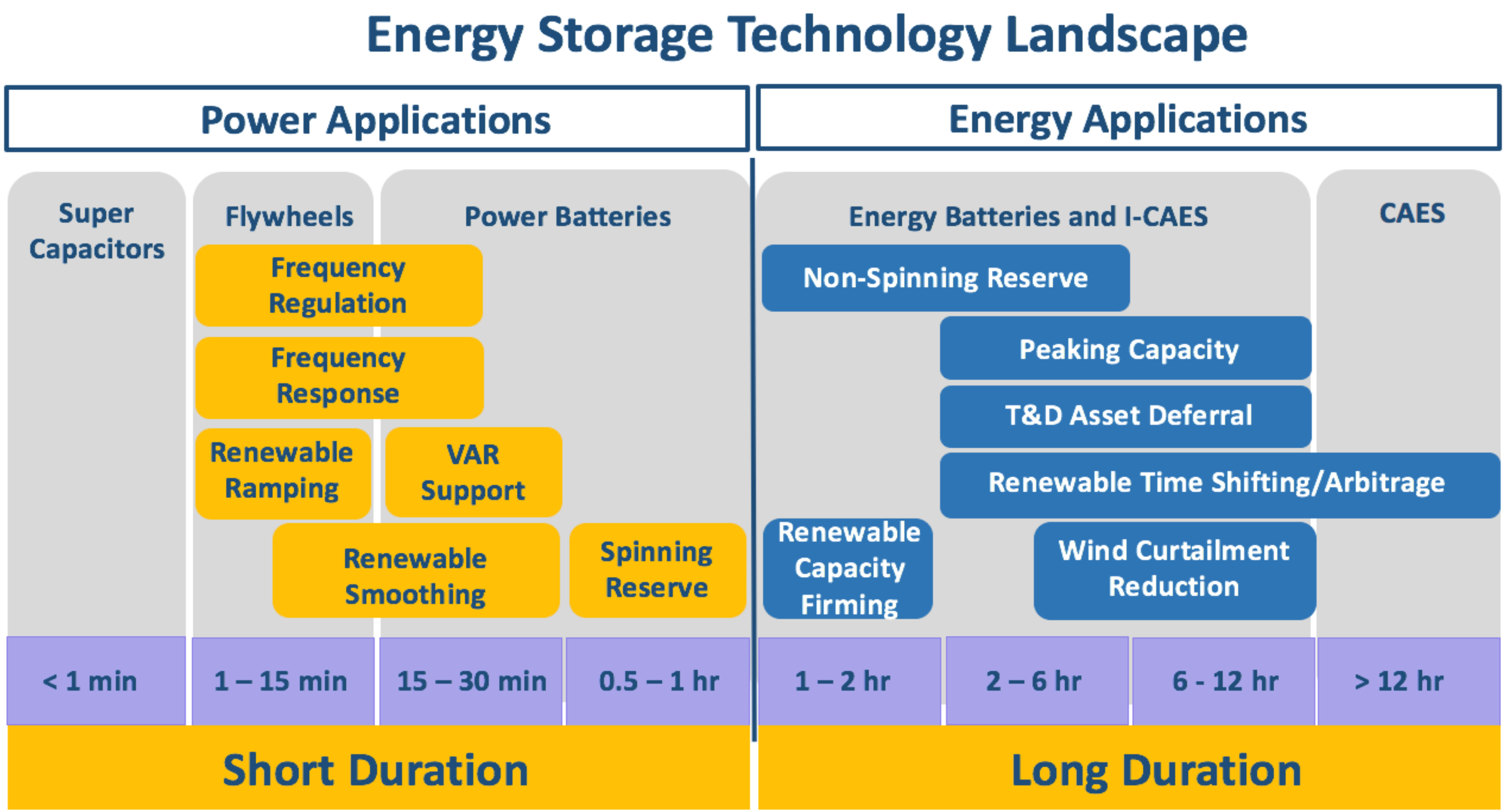

Diagram courtesy NextEra

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Today's economic attractive markets for storage in Alberta?

Today's Focus is on Operating Reserves and Customer Applications

Generation	Transmission and Distribution	Customer
Energy Storage		
Renewable Capacity Firming	Frequency Regulation/ Regulating Reserve	Peak Shaving
Renewable Ramping	VAR Support	Time Shifting
Renewable Smoothing	Spinning Reserve	UPS
Curtailment Mitigation	T&D Asset Deferral	Power Quality
Time Shifting/Arbitrage	Non-Spinning Reserve	
Peaking Capacity	Frequency Response	

Applications

Utility Scale | Behind the Meter

Key
- Attractive today: Frequency Regulation/Regulating Reserve, Spinning Reserve, UPS, Power Quality
- Unattractive today: Renewable Capacity Firming, Renewable Ramping, Renewable Smoothing, Curtailment Mitigation, Time Shifting/Arbitrage, Peaking Capacity, T&D Asset Deferral, Non-Spinning Reserve, Frequency Response, Peak Shaving, Time Shifting
- Not Available: VAR Support

Tomorrow's potentially economic attractive markets for storage in Alberta?

Tomorrow's focus expands to include more customer applications and generation

Energy Storage

Applications

Generation
- Renewable Capacity Firming
- Renewable Ramping
- Renewable Smoothing
- Curtailment Mitigation
- Time Shifting/Arbitrage
- Peaking Capacity

Transmission and Distribution
- Frequency Regulation/ Regulating Reserve
- VAR Support
- Spinning Reserve
- T&D Asset Deferral
- Non-Spinning Reserve
- Frequency Response

Utility Scale

Customer
- Peak Shaving
- Time Shifting
- UPS
- Power Quality

Behind the Meter

Key
- Attractive today
- Unattractive today
- Not Available
- Attractive Tomorrow

IF tomorrow has higher levels of curtailment, higher price volatility, high customer peak price.

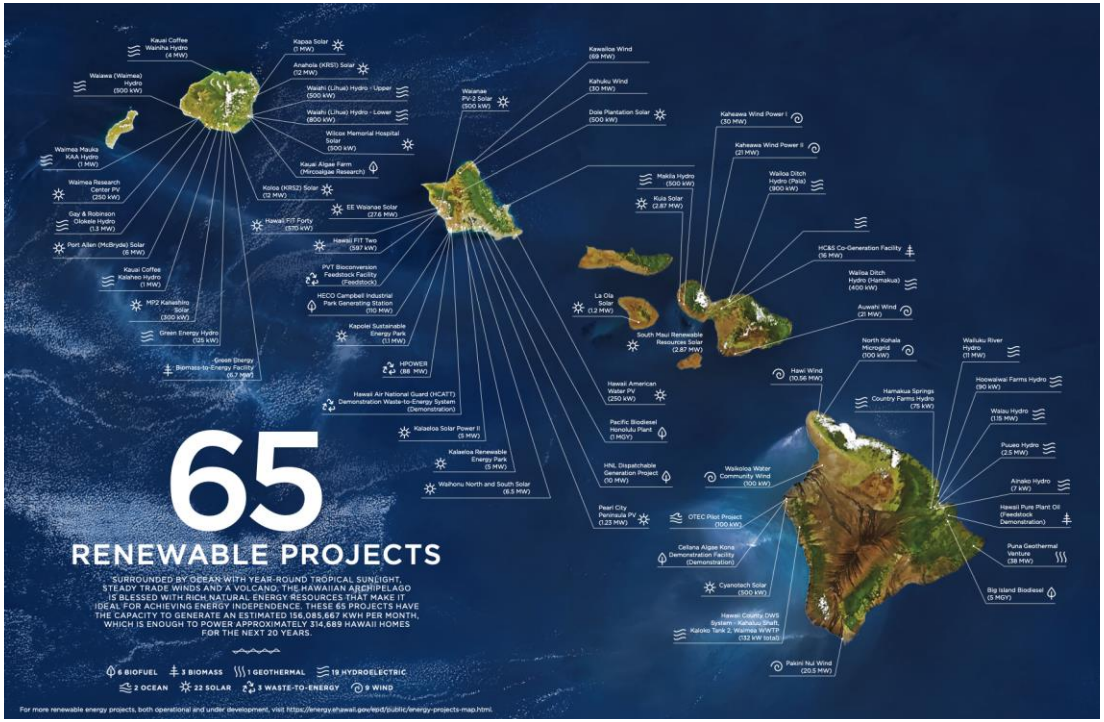
In Alberta, Energy Storage Economics will require Pancaking of Services and Revenues

What we see in other jurisdictions?

Hawai’i

- 40% RE by 2030
- 100% RE by 2045

In 2019, six large-scale projects were approved by state regulator Hawai’i Public Utilities Commission comprising 240MW of solar and 988MWh of four-hour duration battery storage that HECO said would will help to protect customers from the “volatile prices of fossil fuels". The state also has the goal of reaching 100% renewables by 2045 as well as a 2030 interim target of 40%.
Services: load shifting, frequency response, other anciliary services.
In 2020, HECO tendered 900 MW of PV along with grid services. Maui and Hawai’I projects must include energy storage.
Services: time shifting, firming, grid services.



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Barriers to Storage Deployment

- Economic Barriers
  - Technology costs continue to decline
  - Low pool price, low price volatility
  - AESO tariff is cost prohibitive
- Operational Barriers
  - Market rules for energy storage are nascent
  - T&D deferral – **require changed regs -** critical change required for ESS to play
  - Size limitations for operating reserves prohibit small initial projects

Energy Storage Opportunities in Alberta




Prepared for:
AESO ESILF Workshop 1

Power Advisory LLC

www.poweradvisoryllc.com

Background and Outline

- The Alberta Electricity System Operator (AESO) has organized the Energy Storage Industry Learnings Forum (ESILF) to gather energy storage industry leaders to discuss key learnings from energy storage integration in other jurisdictions
- The ESILF workshop 1 is hosting a webinar to discuss opportunities and barriers for energy storage
- Presentation Outline - Opportunities for ESR
  - Wholesale Market Services
  - Services to Generators
  - Services to Load Customer and Retailers
  - Services to Grid Operators

AESO ESILF

September 18, 2020

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Opportunities for Energy Storage In

- Energy Storage Resources (ESRs) are offer a wide range of services to multiple sectors of the electricity market
  - Value stacking of multiple services from a single facility is a core benefit of ESRs

- Services that ESRs can offer in Alberta by participant
  - AESO wholesale market services
  - Services to generators
  - Load customers and retailer services
  - Grid operator services

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AESO Wholesale Market Services

Service	Description	Opportunity	Risk
Energy Arbitrage	Cycle energy from low-price hours to high-price hours	AESO's energy-only market design is based on price scarcity events, where energy prices can reach the ceiling of $1,000/MWh	Cycling losses must be factored into spreads for low to high price hours Real-time prices can be difficult to predict Ceiling price events are primarily driven by unforced outages, therefore difficult to predict
Regulating Reserve	Regulating reserves balance supply and demand in real-time and maintain frequency, response time to dispatch signals can be as short as 4 seconds	Fast response capability of ESRs can respond to rapid regulation signal; AESO analysis in their 2018 energy storage report indicated ESRs could be profitable	Rapid cycling can degrade ESR asset life Managing transmission and distribution (T&D) costs an important component of profitability
Fast ramping	Not an existing product in the AESO wholesale market; however, the self-scheduled responsibilities provide benefits	As more Variable Renewable Energy Resources (VRERs) enter the AESO market, supply and price volatility will increase; fast response from ESRs can capture short-term price spikes	Will likely need to be combined with other services and may be difficult to implement (see generator services for potential options)
Contingency Reserve	Used to balance supply and demand when an unplanned outage occurs; can be provided by supply (i.e., fast ramp up) or load (i.e., demand curtailment)	ESRs can offer cost effective contingency reserve during overnight period when charging (i.e., stop charging upon demand) for practically no cost	Market prices do not justify investment; therefore must be bundled with additional services
Load Shed (LSSi)	Support import capacity since intertie lines are Alberta's single biggest contingency, must respond in 12 cycles	Only provided by loads since no generators can respond fast enough, inverter connections should be capable of providing within timelines	Difficult to value stack with other services as ESR will need to reserve capacity for LSSi (e.g., cannot offer regulating or contingency reserve in addition)

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Services provided to generators

Service	Description	Opportunity	Risk
Renewables production shifting	Hybrid projects with renewables (e.g., wind or solar) and ESRs can reduce the variability of energy delivered to the grid	Wind energy in Alberta experiences significant price suppression as the wind fleet ramps up and down together often; ESRs can shift energy to more profitable hours	The capacity and duration design of ESRs can be difficult to estimate; in addition, determining the higher price hours can be difficult
Wind ramp curtailment avoidance	Wind power ramp up management allows the AESO to curtail ramping up wind if operating generation cannot be ramped down quick enough to maintain reliability	ESRs can storage curtailed wind energy production and deliver later when no curtailment order is issued	Power Advisory expects the amount of wind ramping to be low since as fast responsive resources are added to the AESO market
Solar generation standard blocks	Forward markets for electricity focus on standard blocks of energy (i.e., 7 days for 16 hours), ESRs can be combined with solar to create standard clean energy blocks	Standard blocks with fixed cost and no fuel supply risk are a valuable product in forward markets	Forward market pricing can be volatile reducing the finance capability of the project
Flexibility for co-generation	ESRs can offer responsiveness to co-generation projects that are typically inflexible to market prices	The addition of ESRs can create an “infinite” storage arrangement with cogeneration applications	Projects would still include a large delivery of energy to the grid that is exposed to energy prices
Fast response capabilities	Addition of ESRs can increase the synchronous response capabilities for SCGT/CCGT	Allows offline gas-fired generation to participate in the contingency reserve market	Value is only for 5 to 10 minutes of quick ramp before gas-fired generation delivers energy

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Load and retailer services

Service	Description	Opportunity	Risk
Managing T&D costs	Cycling energy storage to reduce consumption to reduce T&D costs (e.g., consumption during the monthly system coincident peak, 12CP)	Alberta has significantly expanded their transmission network in the past decade, T&D costs are estimated to represent 33% to 45% of customer bills by 2023	Correctly predicting 12CP Potential changes to bulk and regional tariff design (see next section)
Energy arbitrage	Cycle energy from low-price hours to high-price hours	AESO's energy-only market design is based on price scarcity events, where energy prices can reach the ceiling of $1,000/MWh	Cycling losses must be factored into spreads for low to high price hours Real-time prices can be difficult to predict Ceiling price events are primarily driven by unforced outages, therefore difficult to predict
Enhancing power quality	ESRs can assist in enhancing power quality by removing unwanted harmonics, voltage sags, frequency changes and other power quality concerns	Alberta's has a large amount of heavy industrial loads that have higher than average power quality needs for machinery and processes	Many industrial facilities are designed to manage power quality issues or have invested in electricity system expansions to provide enhanced power quality, therefore opportunities are on a case-by-case basis
Physical hedge to spot market prices	Retailers and active loads can use energy storage as a physical hedge against real-time energy price volatility	Typical of energy only markets, Alberta's retail market is robust with a majority of customers using a third-party retailer, physical hedge is a valuable asset	Will likely need to be bundled with energy block sales, therefore limiting potential to supply other services
Consistent energy blocks for sale in forward markets	Provide energy block product to sell into forward markets	Value asset for retailers and market participants to use for hedging and trading	Must be able to deliver in real-time, may need marketing investments

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Grid operator investments

Service	Description	Opportunity	Risk
Deferral of T&D infrastructure	Energy storage can reduce peak demand loading on T&D equipment, reduce the need for investment in new capacity	While Alberta's transmission system has been significant built out, there are pockets of load growth and areas of aging infrastructure that require reinvestment	The regulatory framework must evolve to support rate-recovery for ESR investments
Power quality improvements	Power quality issues, especially near end of feeders, can be addressed by ESRs through active and reactive power management	ESRs can be sited in areas of the distribution network that can address issues with below standard power quality delivery	
Load forecast uncertainty	Load forecasts, especially medium- to long-term, can contain a significant amount of uncertainty; ESRs provide flexible and scalable solutions to optimize investments for uncertain futures	ESRs can be developed and used to manage power system needs while waiting for longer term clarity on power system planning uncertainties; the ability to add duration at a later date is an important consideration	
Load restoration	During outages or equipment failures, ESRs can be used to maintain service to customers and manage restoration	Distributed ESRs can be used to manage load restoration, especially issues caused with cold load pick-up (i.e., uncertainty regarding how much will appear after re-energization) Centralized ESRs can manage supply line or substation component outages	

Most promising opportunities

- Wholesale markets
  - Regulating reserve during non-peak hours (to reduce T&D charges, ~50% of the time)
  - LSSi, no competition from traditional generation facilities, unique aspect of Alberta electricity market
- Generators
  - Fast response capability for inflexible generation
  - Solar standard blocks for forward markets
- Load and retailers
  - Managing T&D costs + energy arbitrage
  - Standard blocks for forward markets + physical hedge for retailers
- Grid operators
  - Load forecast uncertainty + T&D deferral

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Thank you

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Discussion

Topic 2: Energy Storage Connection Options

Connection Options

ESILF Workshop 1

TransAlta™

Powering Economies and Communities

WindCharger – Hybrid facility

TransAlta™

- The first battery storage project connected to the Alberta Interconnected Electric System.
- The battery was connected as a behind-the-fence connection project.
- It is connected to an existing collector bus so that the battery can charge off of Summerview 2 wind facility.
- From start to finish the project completed the interconnection process in approximately 21 months.

Interconnection Options

Three paths to energization

- Energy storage projects can be connected at the distribution or transmission level.
- For distribution connected project, the Distribution Facility Owner (DFO) manages the connection to the transmission system. The project developer works directly works with the DFO to connect to their distribution system.
- There are two connection options for transmission level projects:
  - <u>New interconnection</u>
    - Requires transmission studies of various connection options identified by the AESO.
    - Involves a longer process to select the preferred alternative and regulatory applications for Needs Identification Document (NID) and transmission facility applications.
  - <u>Behind-the-Fence interconnection</u>
    - Proposes a connection to an existing connection point – less process to study options and a simpler path to regulatory approvals.
    - Shorter lead time, less infrastructure required if there is sufficient capacity that already exists to accommodate the project.

WindCharger Experience

The Good,

- From System Access Service Request (SASR) submission to energization, the process was completed in 21 months.
  - This occurred when the AESO was still in the process of developing its Short Term Market Implementation requirements.
  - The pandemic had its impacts on the project and created unanticipated challenges.

WindCharger Experience

The Bad,

- Finalizing the Functional Specification created uncertainty, increased costs and took additional time to resolve.
  - The AESO released its Short Term Market Implementation Requirements document as the project was in the Functional Specification stage.
  - The requirements in the functional specification increased project costs – went from an expectation of one meter on the battery to three meters on top of the existing meters on the high side of the transformer.
  - The time spent to resolve the issues with the functional specification added to the scope of the project just as we entered into the construction phase.

WindCharger Experience

The Ugly.

- The need to add meters happened a few months prior to the planned in-service date and in the midst of the pandemic
  - Some of the equipment required to meet the functional specification couldn't be procured in time due to the impact of the pandemic on global supply chains.
  - We had to delay the in-service date and reconsider the approach to minimize project delays.

Lessons Learned

- The technical requirements are clearer now that the AESO has issued is guidance on energy storage requirements but the requirements on energy storage projects should be further review to optimize/rationalize the requirements for energy storage projects.
- The AESO has worked on and consulted on Energy Storage previously (assessing the potential for and understanding the technology) but it is arguably more important for the AESO to focus on the technical requirements to provide a path to new technology integration.
- Such an approach shifts away from the theoretical to the practical which reduces uncertainty for developers and helps to reduce barriers to entry and allows developers to better manage projects and costs.

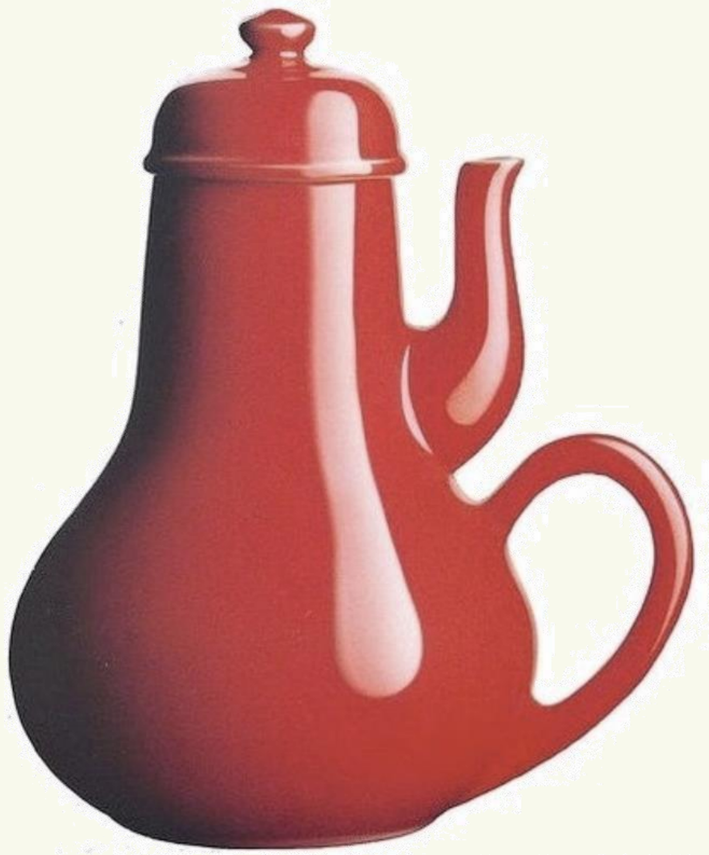
Click to edit Master text styles

- Second level
  - Third level
    - Fourth level
      - Fifth level

TransAlta™

Powering Economies and Communities





Why don’t teapots look like this?

NUTANA

Collaborative DER Site Selection

The value of a DER to the distribution network depends in part on its location.

Sub-Optimal DER Location

Collaborative DER Site Selection

Network Reliability Declines

A DER that creates DFO liability at one site may create DFO value at a different site.

Example: Solar DER

Liability Drivers

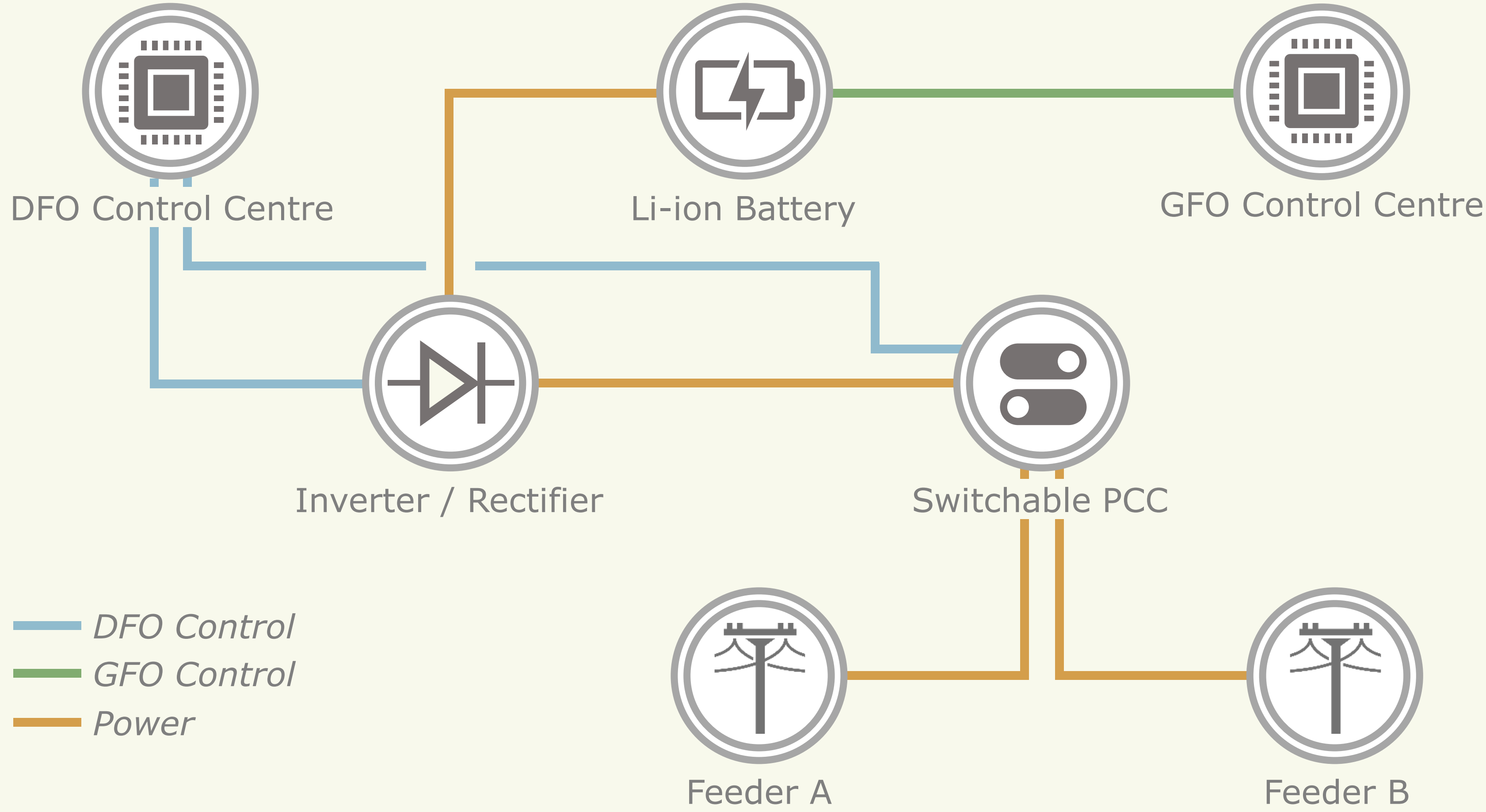
- Exports variable, unpredictable power
- Increases feeder dynamic voltage range
- Ride-through capabilities limited by IEEE 1547
- Lack of inertia exacerbates excursions
- Inverter can create harmonic distortions
- Can create undetected islands

Value Drivers

- Reduces substation workload
- Can compensate for voltage drop on long feeders
- Inverter offers var source and sink control point
- Inverter generates new network data streams

DERs with additional capabilities (e.g. storage) can create even more DFO value at certain sites.

Example: Battery DER



Through collaboration and creative thinking, GFOs and DFOs can make site selection a win-win.

Questions?

ENERGY STORAGE CONNECTION OPTIONS

Neil Cumming

ESILF Workshop #1
September 18, 2020

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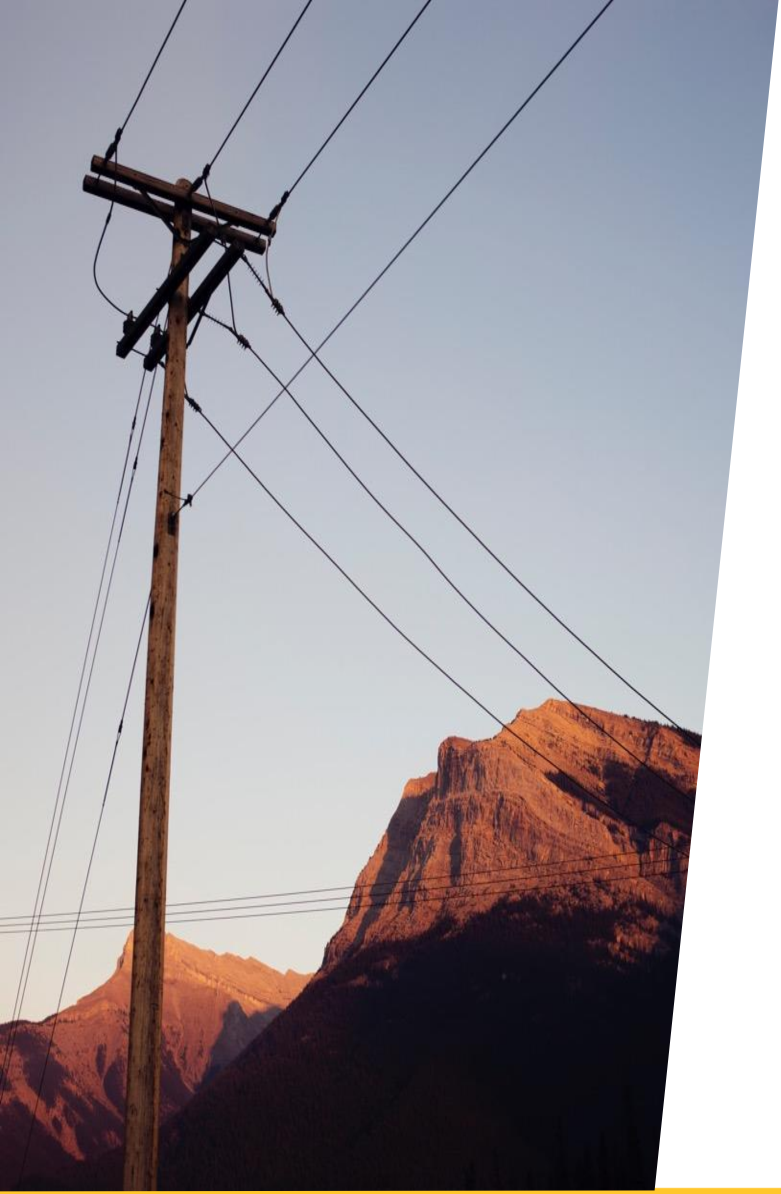
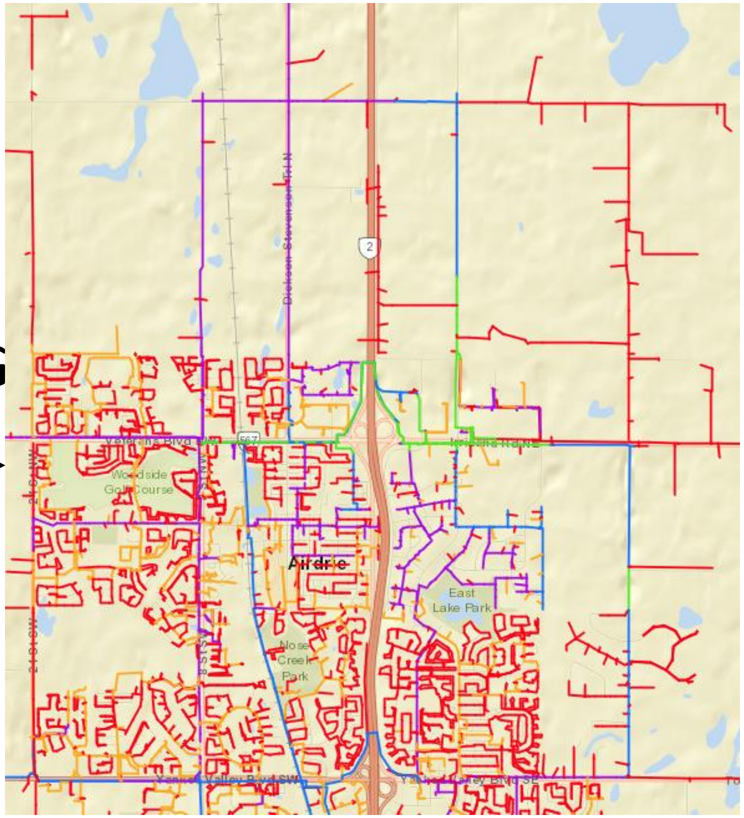


Guiding Principles

- Maximize system value/benefits for customers and minimize costs of storage integration
- Provide electric distribution service in a manner that is fair, open and not unduly discriminatory
- Maintain the safety, reliability and power quality of the AIES
- Maintain economic and affordable access to the AIES

DER Connection Process (1)

- Pre-Application / Information Gathering
  - Introduction to DER Types (DG, MG etc.)
  - Connection Process Guides
  - Hosting Capacity Maps
  - Queue Management
  - Pre-Application Consultation



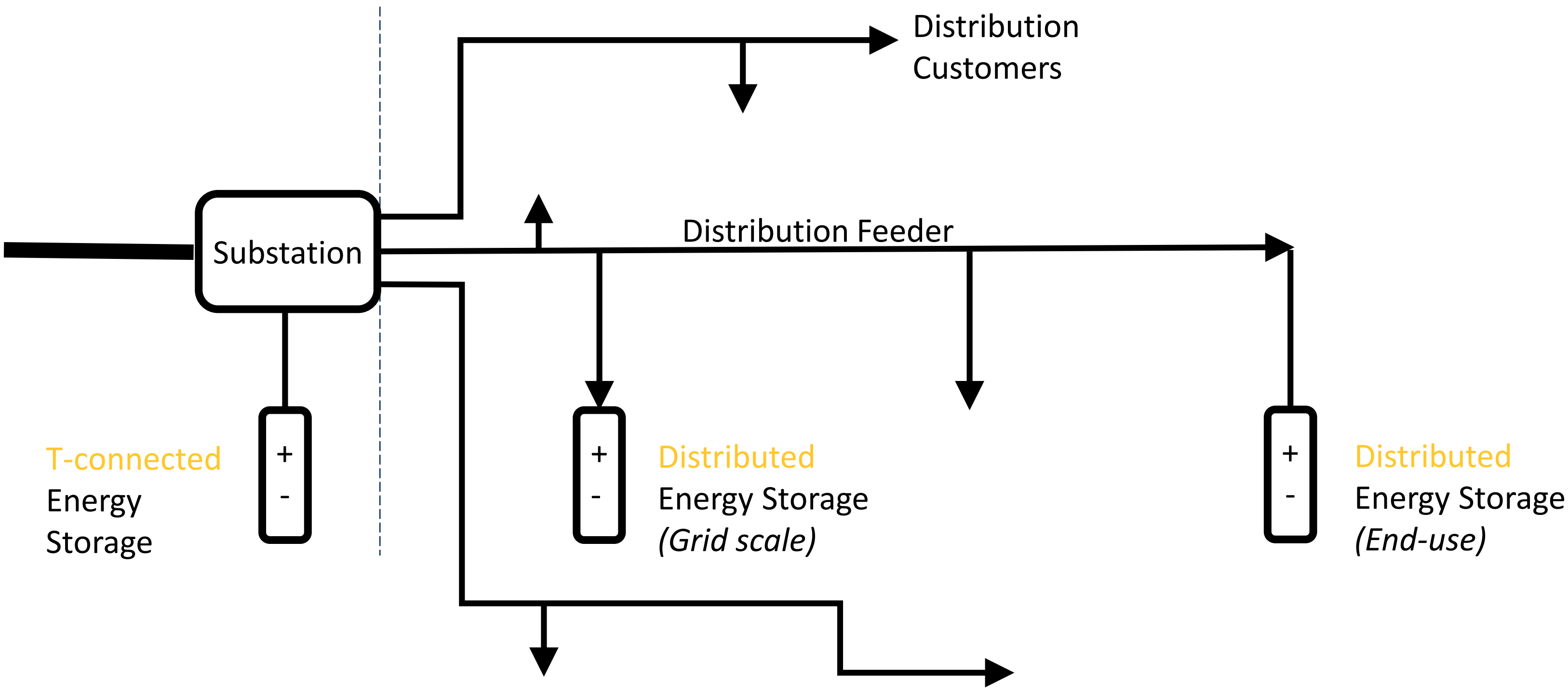
DER Connection Process (2)

- High Level Study
  - Transmission High Level Study
- Detailed Study
  - Transmission Interconnection Study
  - AESO Application
- Construct & Energize

→ High Level Study Results & Ballpark Estimate

→ Interconnection Proposal

Energy Storage Connection Options



End-Use Distributed Storage

Distributed
Energy Storage
(End-use or aggregated)

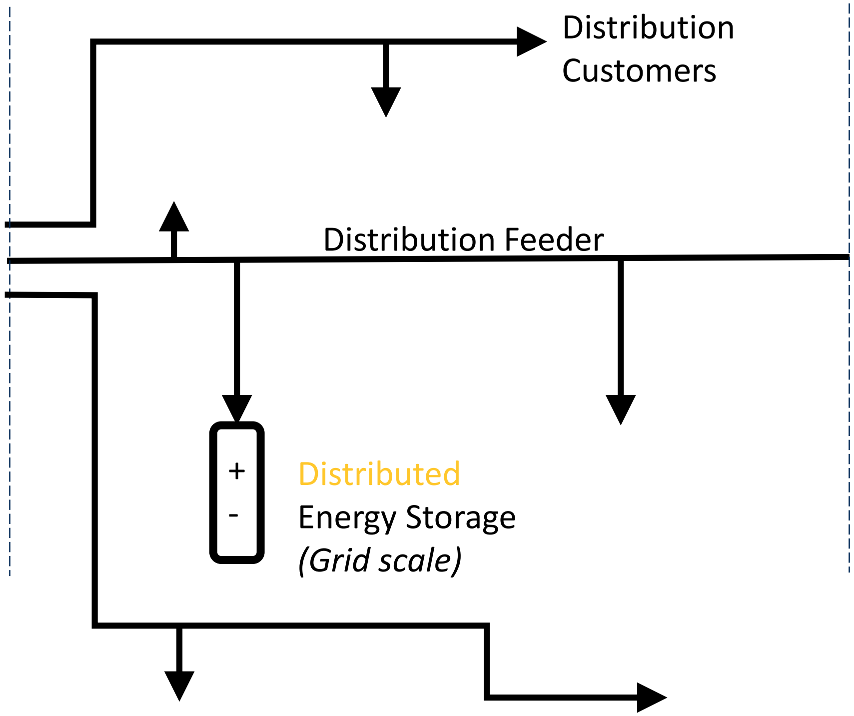
Various technologies and sizes

Meets the needs of a single customer:

- Improved reliability
- Peak demand reduction
- Energy arbitrage

Opportunity to use aggregately at grid scale

Grid Scale Distributed Storage

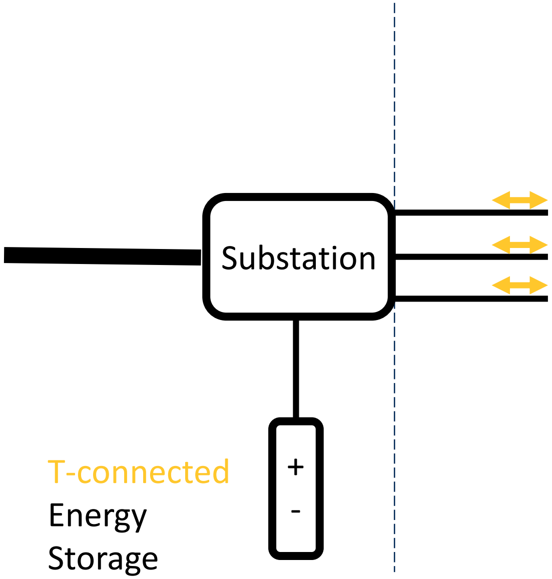


Up to 25 MW

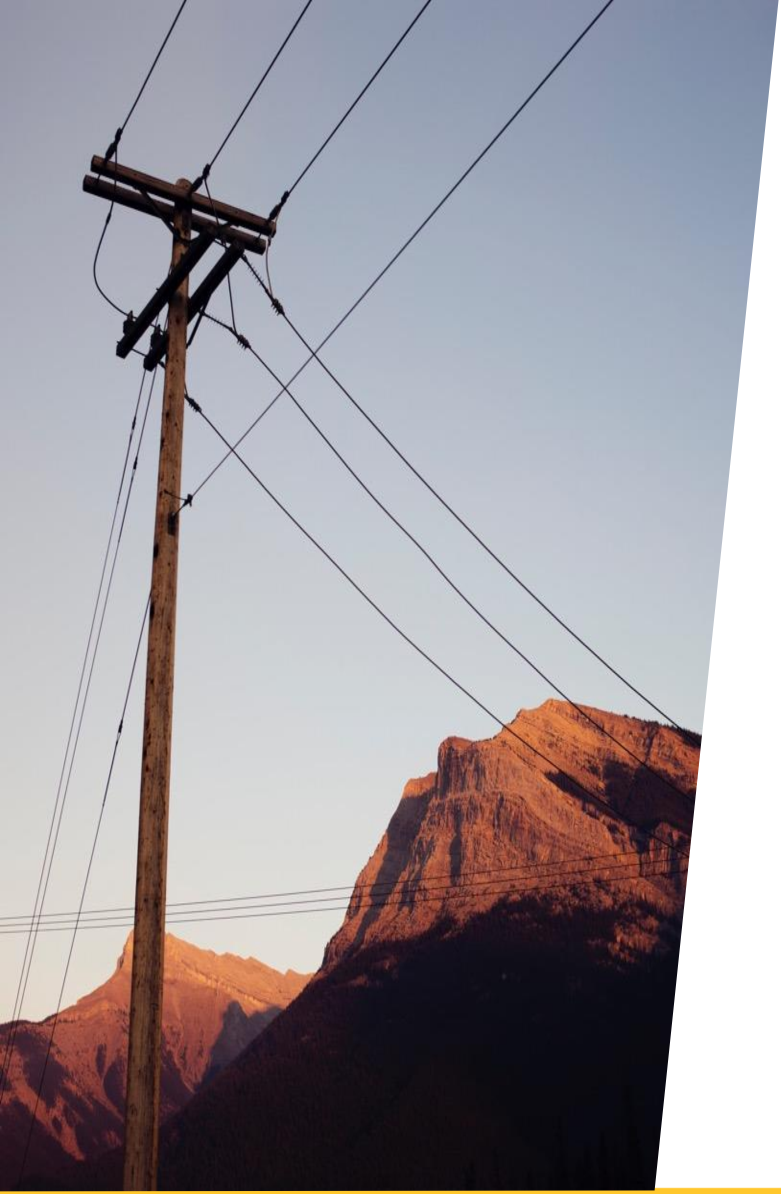
Various technologies and sizes

Provides grid/market function as well as end-use benefits

Transmission connected Storage



T / D integrated planning at feeder-level to manage aggregated energy flow



Thank You

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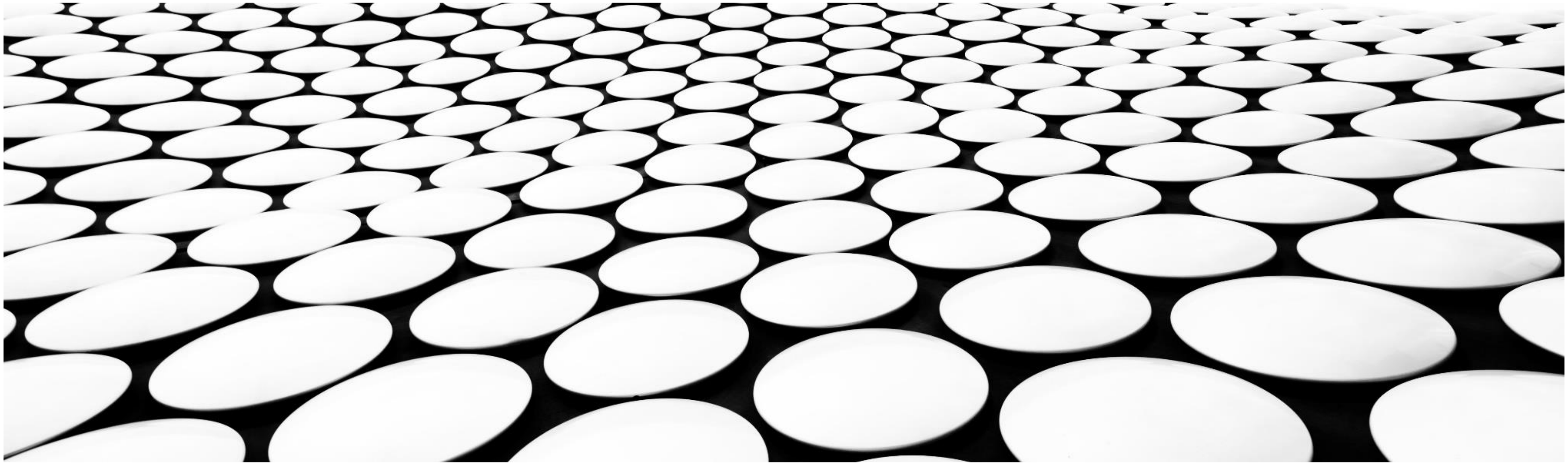
MISSION ZERO Bring it Home Preventable Injuries

Discussion

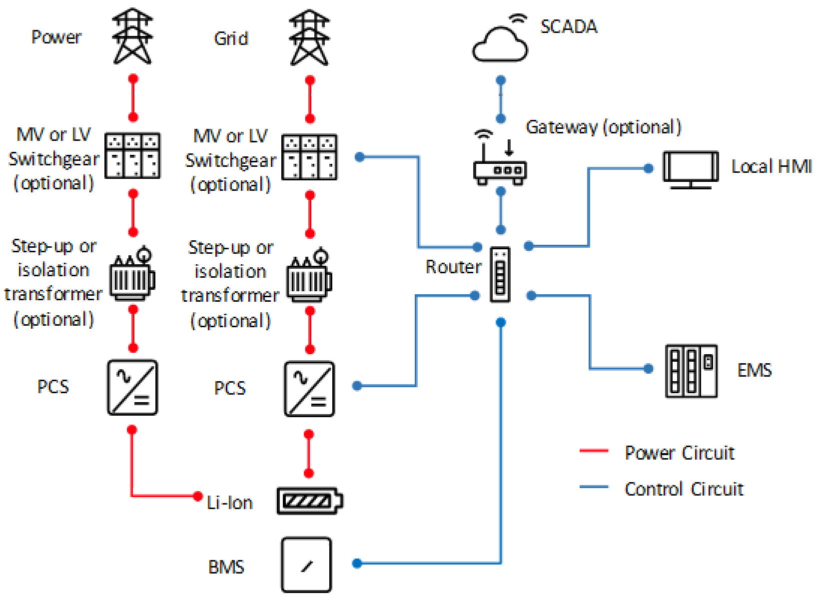
Topic 3: Energy Storage Configuration Options

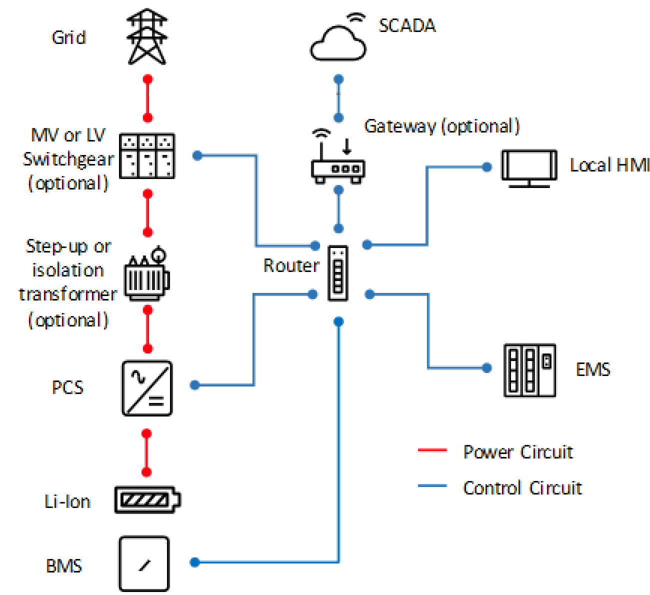
INVERTER OPTIONS

OPTIONS FOR INVERTER SYSTEMS



POWER IN; POWER OUT





PCS – Power Conversion System
- Power Conditioning System

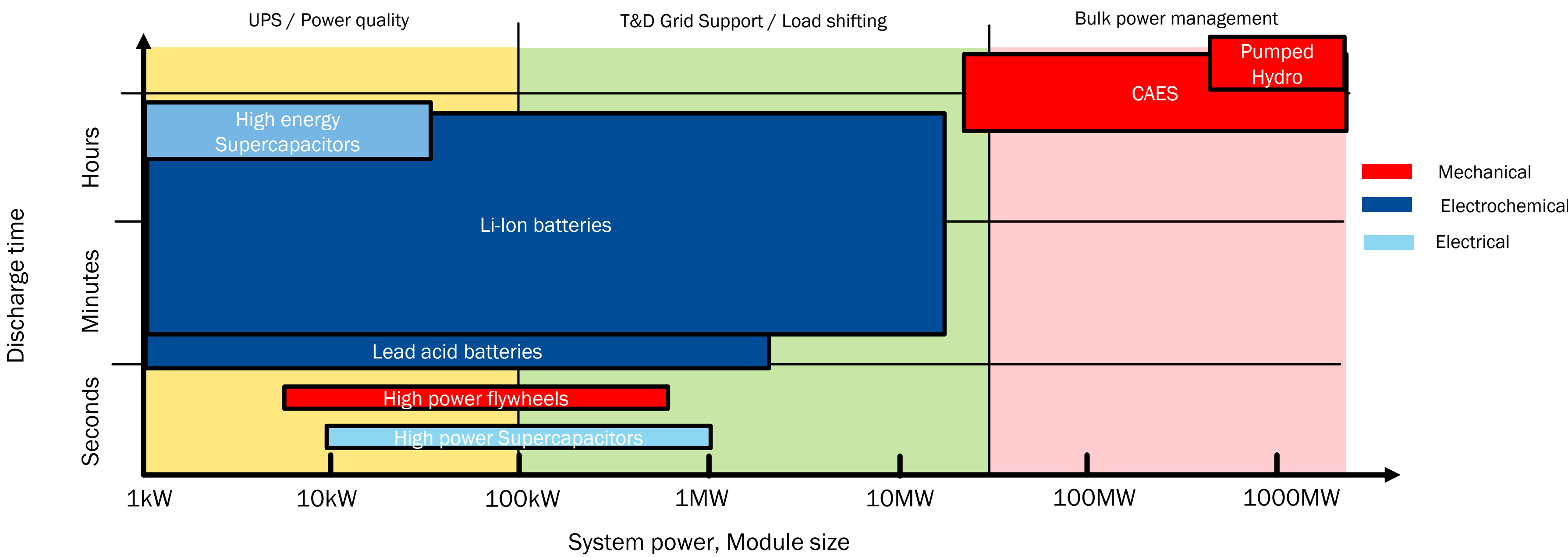
BMS – Battery Management System

EMS – Energy Management System

LV – Low voltage (<1000V)
MV – Medium voltage (>1000V)

INVERTER IS DEPENDENT ON SYSTEM REQUIREMENTS

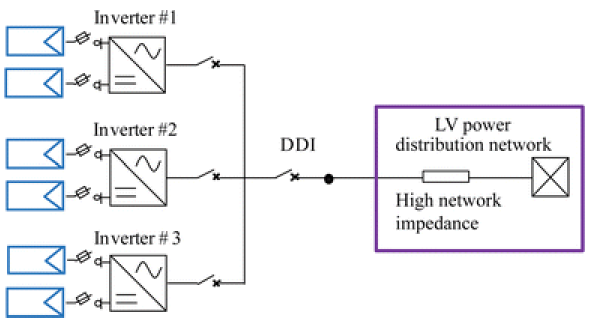
Rule of thumb:
Inverter size is dependent on power flow, (Watts)
Storage size is dependent on power storage (Watt-hours)

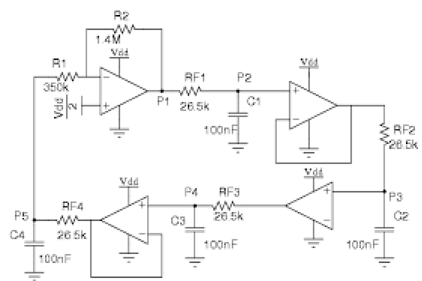


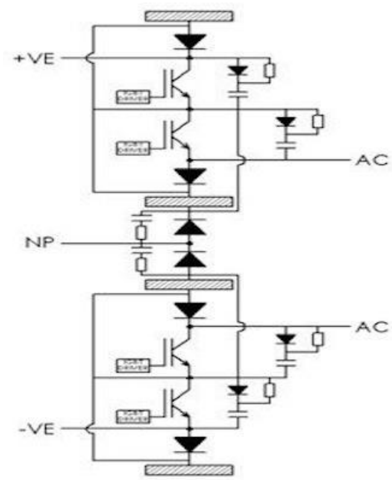
INVERTER SIZING

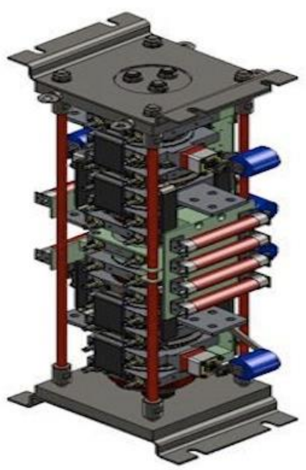
String inverters

Power inverters









Slave

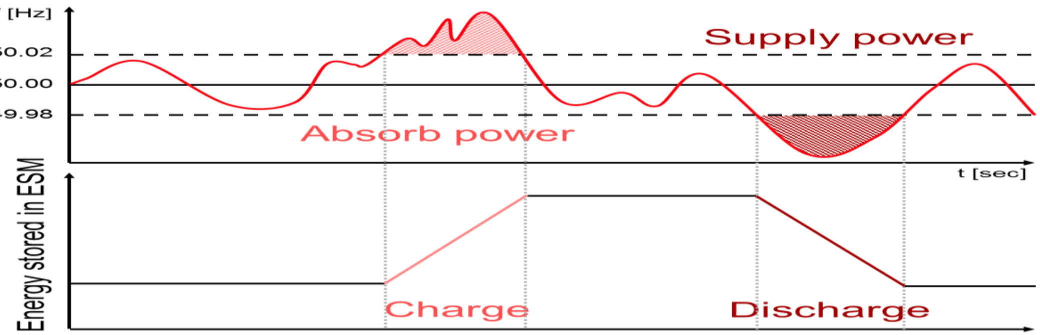
Master / Slave

COMMON CONTROL OPTIONS

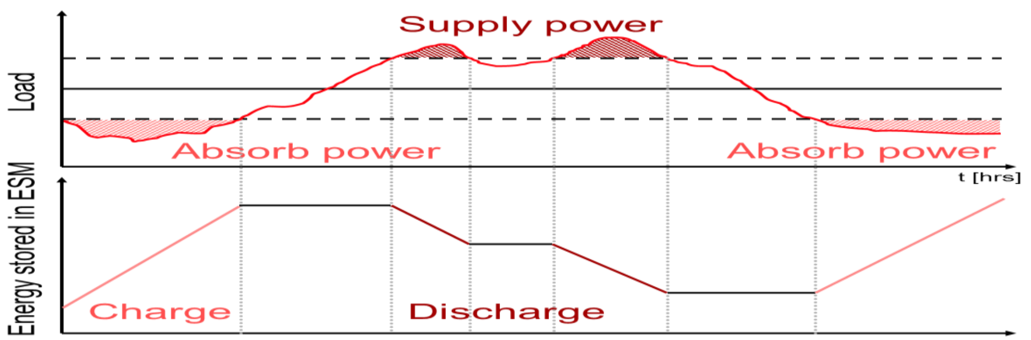
- Control mode for those solutions with storage incorporated.
- Following algorithms to be implemented:
  - Peak shaving
  - Synchronized charging for eMobility
  - Renewables integration/smoothing
  - Frequency regulation (slave configuration)
  - Voltage control
  - Load shifting
  - Total Harmonic Distortion minimization ⟹ $$\text{THD} = \sqrt{\frac{\sum_{n=3,5,7,\ldots} V_n^2}{V_1^2}}$$
  - Time scheduled charge/discharge
  - Islanding

FREQUENCY AND POWER REGULATION

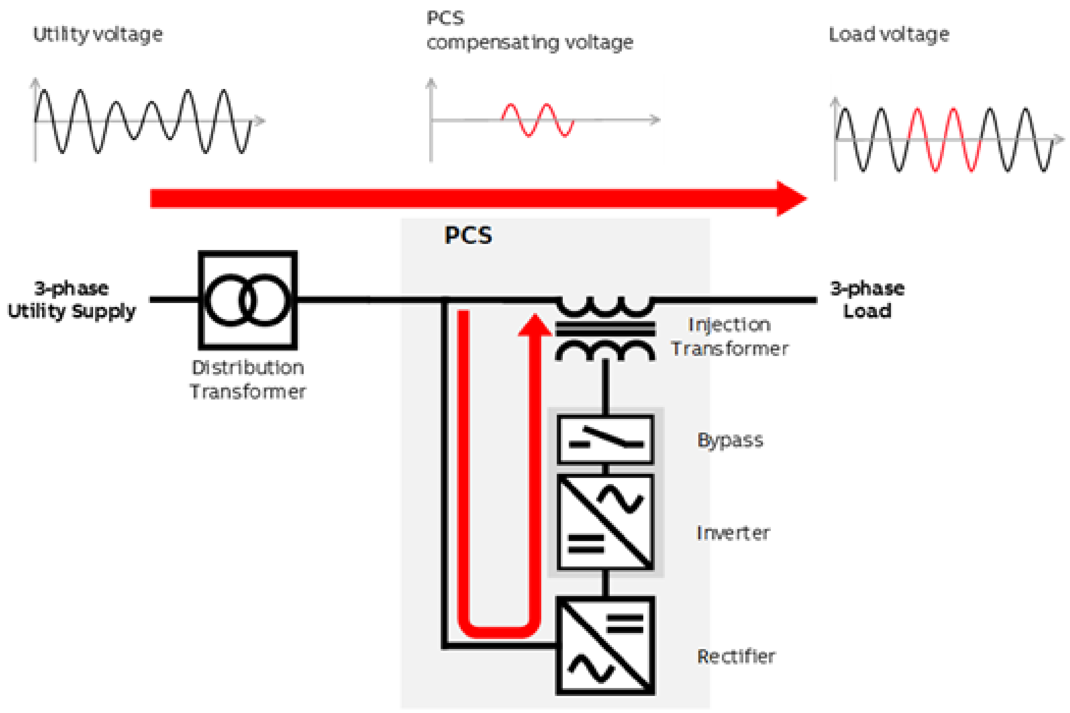
- Frequency Regulation, Load leveling
- Used close to generation



- Load Regulation, Power efficiency
- Peak load shaving



VOLTAGE SAG


Utility voltage
PCS
compensating voltage
Load voltage
PCS
3-phase
Utility Supply
Distribution
Transformer
Injection
Transformer
3-phase
Load
Bypass
Inverter
Rectifier

THANKYOU FOR YOUR TIME

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Canyon Creek
Pumped Storage Hydro Project

AESO ESILF Presentation
Sept 18th, 2020

Turning Point Generation

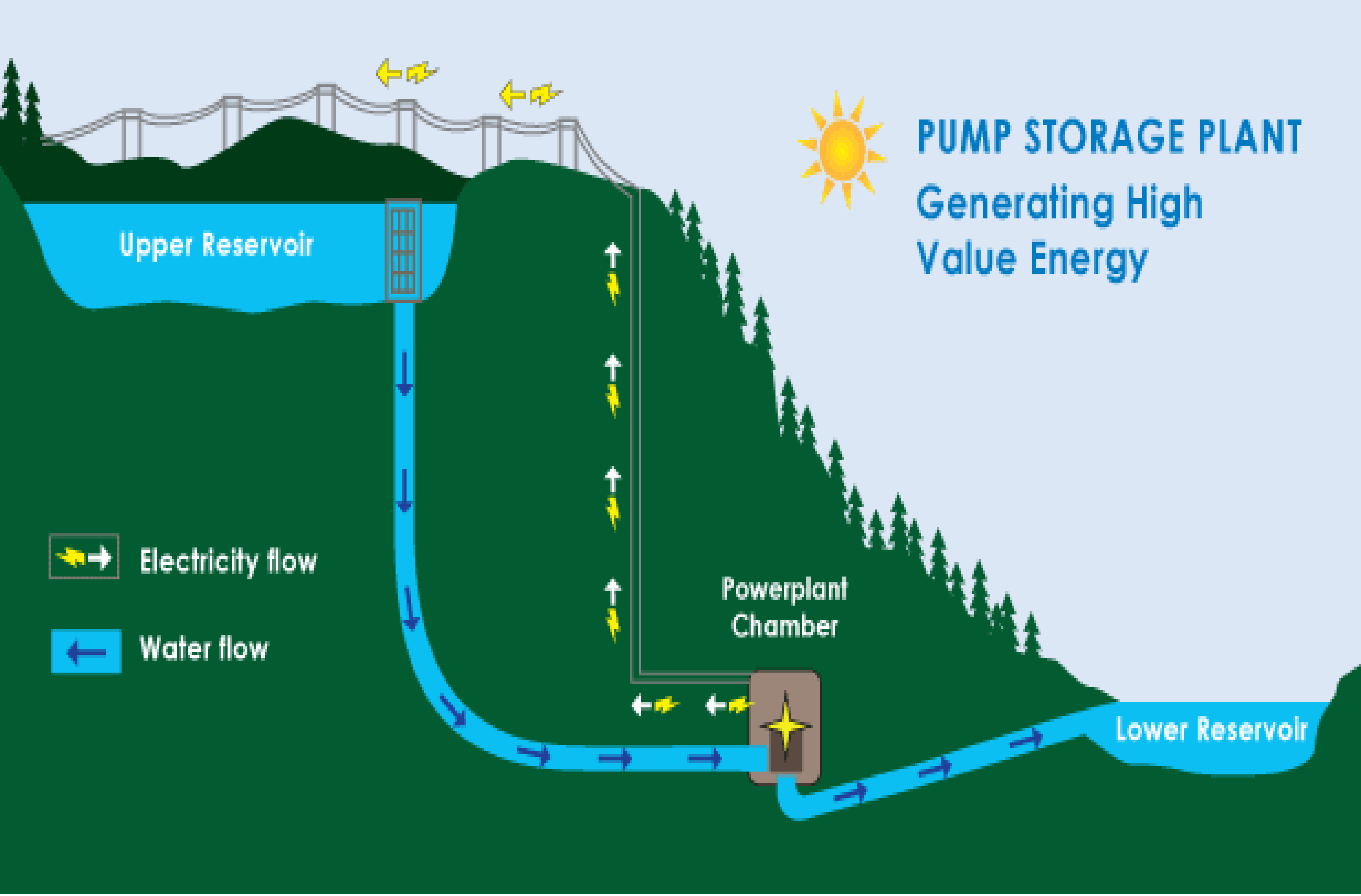
WindRiver Power Corporation

Background

- For over 10 years, WindRiver Power has been a private developer, owner and operator of hydro and wind projects in Western Canada

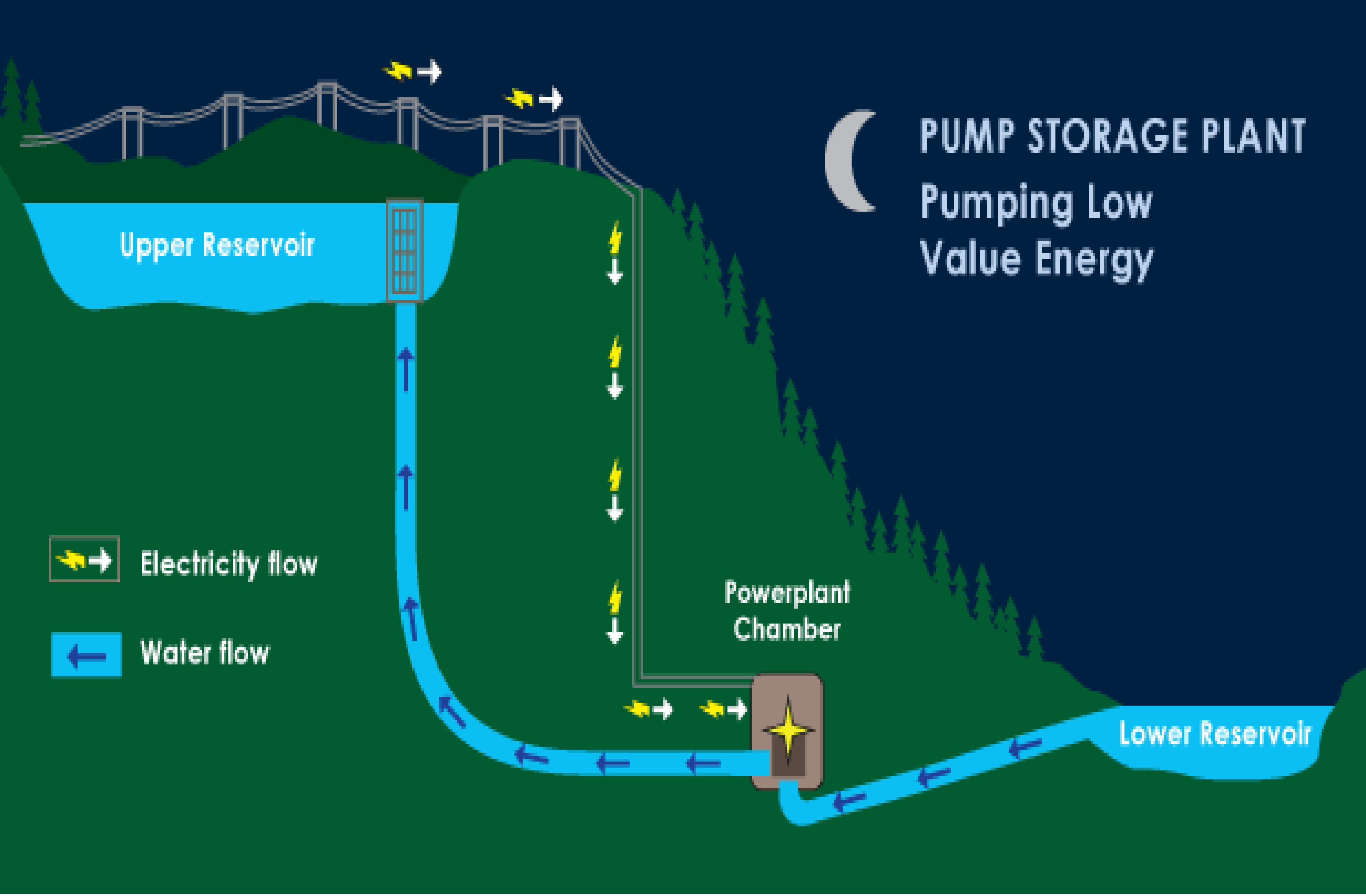
- Through our subsidiary “Turning Point Generation”, we are developing Canada’s 2nd pumped storage hydro (PSH) project, the 75 MW Canyon Creek project
  - Canada’s 1st PSH project, 175 MW Sir Adam Beck, was built at Niagara Falls in 1957

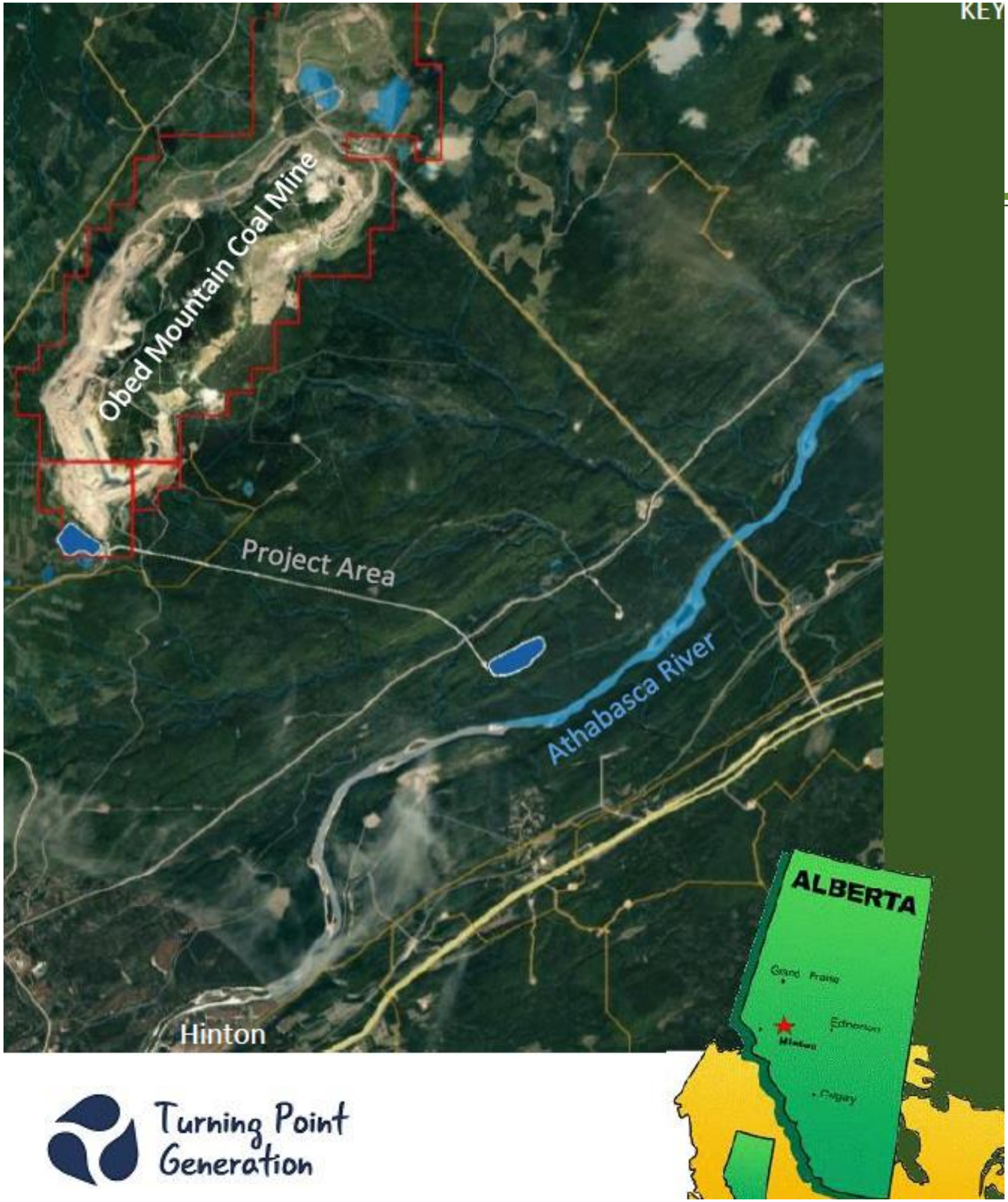
- In May 2020, we announced a partnership with TC Energy Corp to jointly construct and operate the Canyon Creek PSH project
  - Developer of the proposed 1000 MW Ontario PSH project



Turning Point Generation

WindRiver Power Corporation


PUMP STORAGE PLANT
Pumping Low
Value Energy
Upper Reservoir
Electricity flow
Water flow
Powerplant
Chamber
Lower Reservoir



Canyon Creek Pumped Hydro Storage Project

Turning Point Generation

WindRiver Power Corporation

Province of Alberta

CANYON CREEK HYDRO DEVELOPMENT ACT

Statutes of Alberta, 2018
Chapter C-2.2

1st hydro project approved by AB Legislature in 10 years

1st large-scale storage project approved in Alberta

Assented to December 11, 2018

Turning Point Generation

WindRiver Power Corporation

Canyon Creek PSH Project Overview

- Off-stream “closed-loop” design includes 2 new artificial reservoirs and buried penstock
- 75 MW of generation (discharge) and 64 MW of pumping (charge) = PHASE 1
- Up to 37 hours of storage at PHASE 1 peak discharge = approx. 2,800 MWh of storage

  OR 7 hours of storage at 400 MW of discharge = future PHASE 2

- PHASE 1 AUC permit in hand and advancing through AESO Connection Process - construction start in 2021 with commercial operations to begin in 2023
- Utilizing “brownfield” site (roads, interconnection, etc) of reclaimed open pit coal mine
- PHASE 1 capacity size optimized to leverage low cost interconnection on existing transmission line plus commercial participation in the Operating Reserve market (regulating, spinning and supplemental reserves)
- As future Alberta storage needs evolve, the Canyon Creek PSH is uniquely positioned to provide growing capacity beyond PHASE 1

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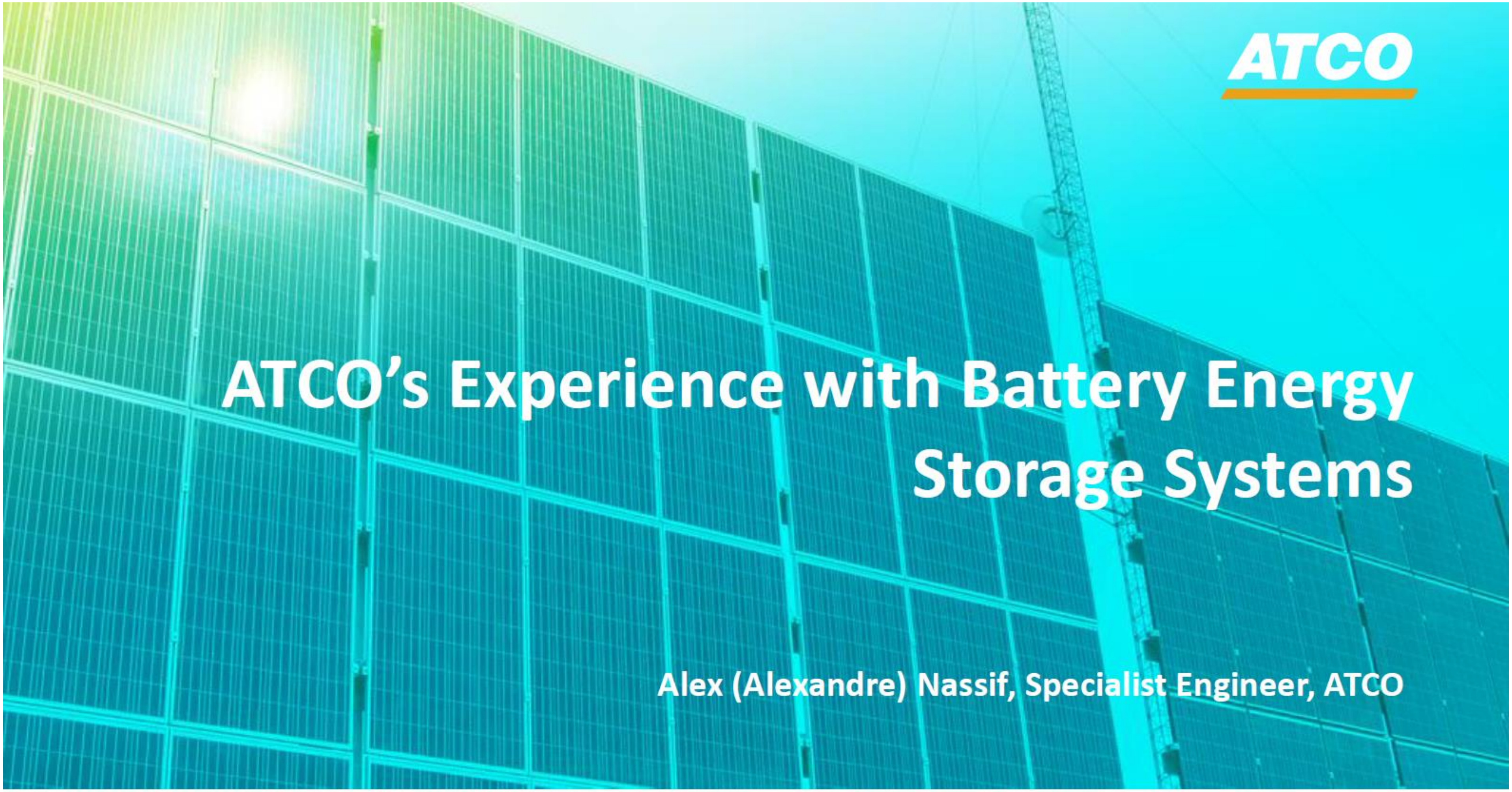


ATCO's Experience with Battery Energy Storage Systems

Alex (Alexandre) Nassif, Specialist Engineer, ATCO

ENERGY STORAGE IN DISTRIBUTION SYSTEMS

While a new paradigm, it can benefit the system by:

- Improving power quality…
- Providing voltage and frequency regulation…
- Extend asset life…
- Allowing deferring infrastructure investment…

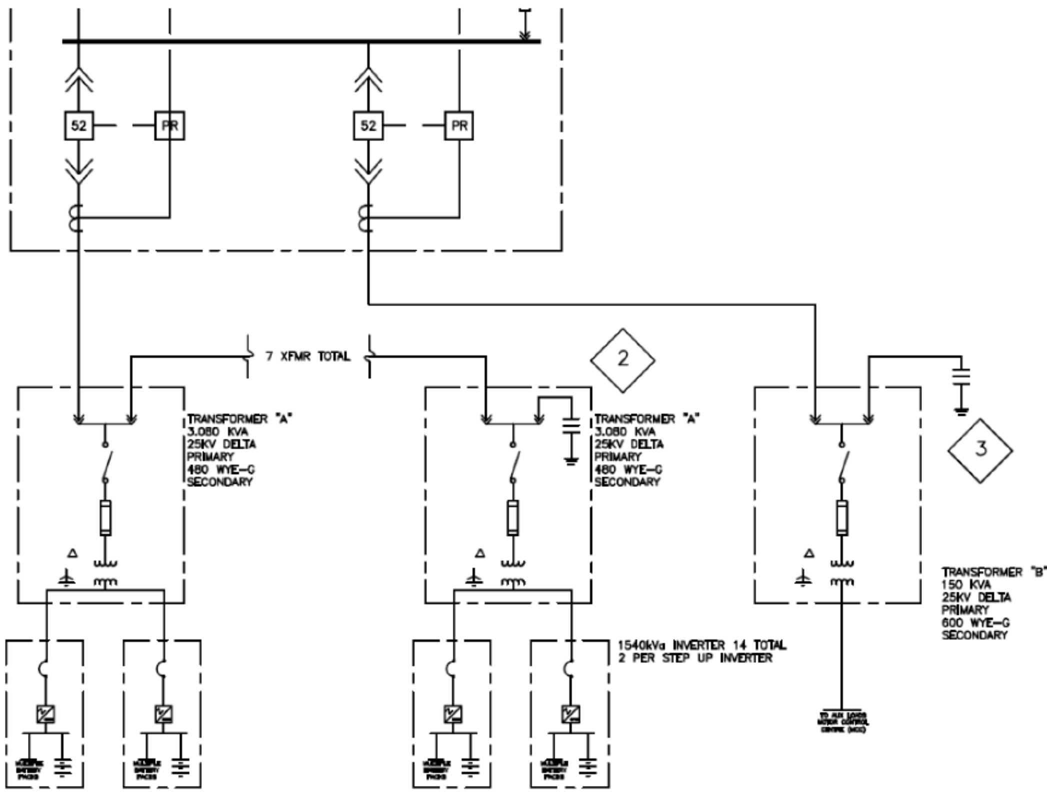
… BUT only if well managed and coordinated by the DFO.

ENERGY STORAGE IN DISTRIBUTION SYSTEMS

Customer-owned examples:

1. A 20MW/20MWh being connected to Rycroft in November.
   - Tesla battery packs (Li-Ion);
   - Delta-primary transformers (and grounding transformer);
   - Very low demand expected (1MW); Large export intended.
2. A 20MW/20MWh (BTF), Mercer Hill.
3. A 6MW/12MWh (BTF), Michichi Creek
   - In conjunction with a 13.5 MW PV farm; BESS is Li-Ion;
   - Customer was the last one in the queue and a runback is being installed;
   - Customer applied for and obtained an ERA grant to cover the cost of the BESS, to reduce/eliminate curtailment.
   - BESS and PV connected through their own step-up transformers.

SLD (SAMPLE)



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ENERGY STORAGE IN ISOLATED SYSTEMS

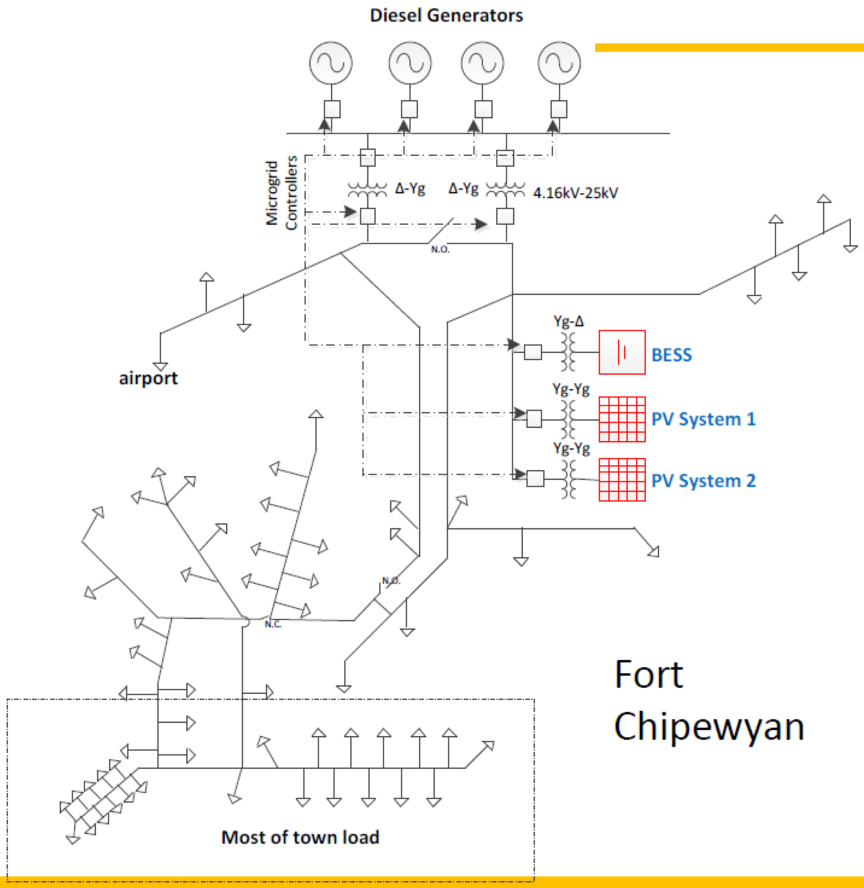
ATCO TFO-owned examples:

1. Fort Chipewyan (to save 800,000 L, or 25% of diesel / year)
   - PURPOSE / NEED: provide grid stability and expand PV hosting capacity.
   - 1.6 MW / 1.6 MWh Li-Ion BESS in conjunction with a customer-owned 2.2MW PV farm
   - *Microgrid Controller;*
   - PV and BESS stepping up to 25kV through their own transformers;
   - Operation: grid-interactive and grid-forming.

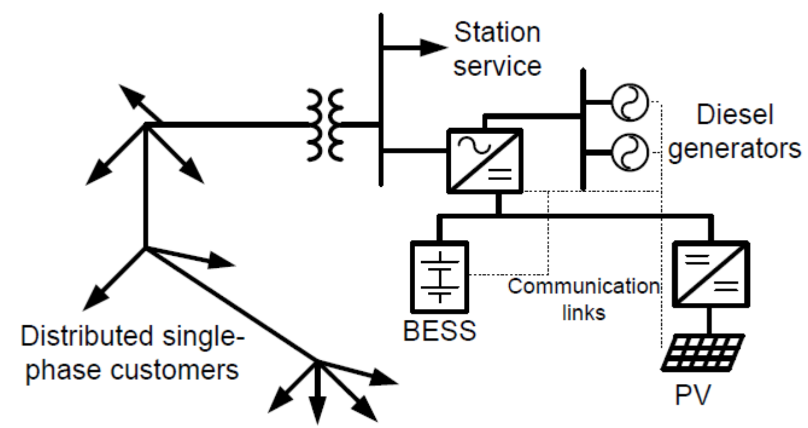
An example of infrastructure deferment (vs. installing more diesel tanks)

2. Peace Point (to save 13,000 L, or 40% of diesel / year)
   - 27.2 kW / 50 kWh Li-Ion BESS in conjunction with a 50 kW PV plant;
   - The only system DC-connected; community peak of 22kW;
   - BESS inverters controls all assets, including the diesel generator (replaces the microgrid controller)

SLDs



Fort Chipewyan



Peace Point

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ENERGY STORAGE IN TELECOM SITES

ATCO TFO-owned examples: Saddle Hills and Fawcett River

1. Purpose: eliminate diesel dependency completely and reduce emissions.
2. Li-Ion BESS in conjunction with a PV farm;
3. All DC
4. Operation: solar cycle charging.

Two examples of infrastructure deferment (alternative conducting Capital Maintenance in the generators)

ENERGY STORAGE IN DISTRIBUTION SYSTEMS

Current Trends:

1. Li-Ion Chemistry;
2. AC coupled in most cases; DC coupled only in small loads;
3. Used for energy balance and grid support;

Future Trends: influenced by technology maturity , costs, regulation.

1. Redox-Flow Chemistry for longer cycles;
2. Flywheel for frequency / voltage support (short bursts of high energy);
3. Large UPS (very quick response, large MW and small MWh) for reliability applications

Viable NWA, and considered in other jurisdictions.

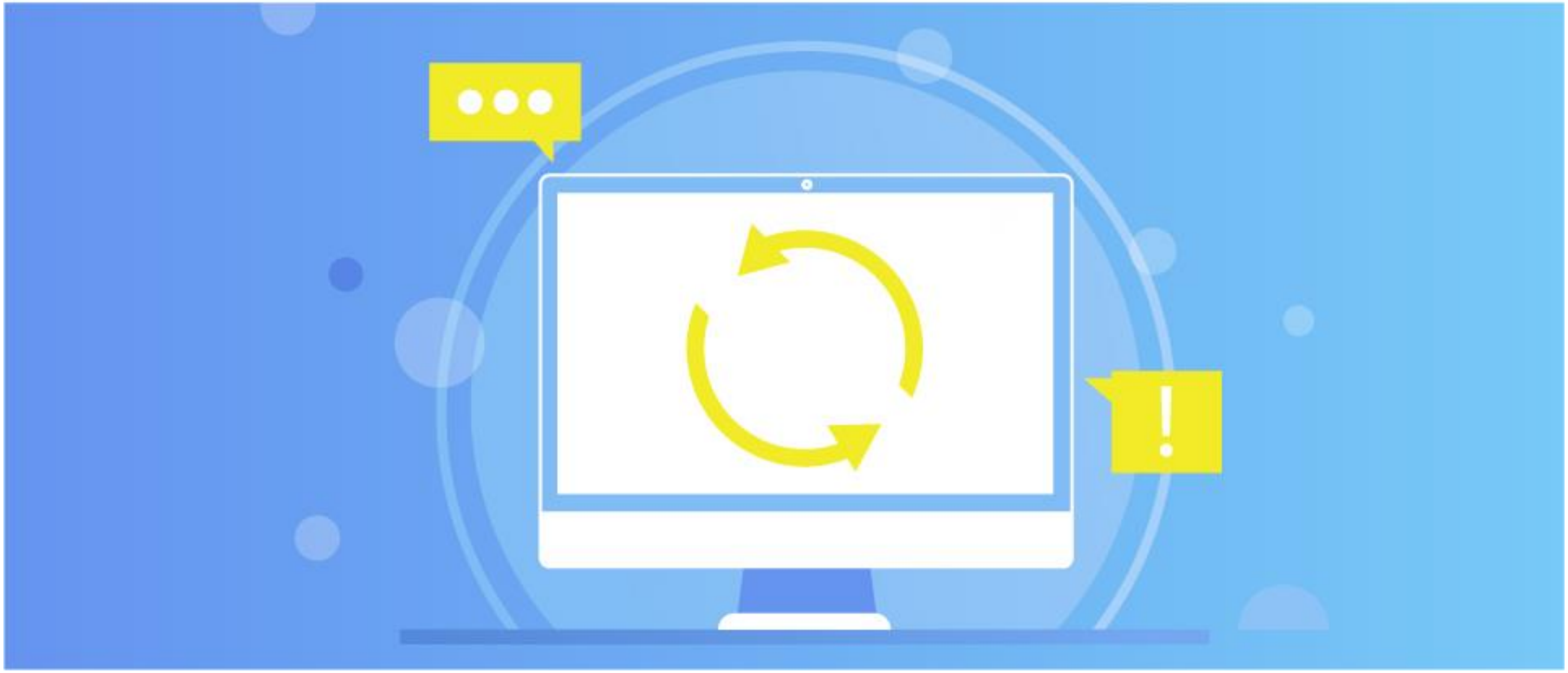
Discussion

Wrap up and next steps

- Workshop 2 topics
  - Storage as a Transmission alternative (or a Distribution alternative)
  - Sharing learnings from other jurisdictions on legislation, regulations and policy
  - Market qualification parameters, process, models and data (SCADA) requirements
- Discuss advocacy groups presence in ESILF

- **Please send your energy storage questions to:**
  - Email: energystorage@aeso.ca

Contact the AESO



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Thank you