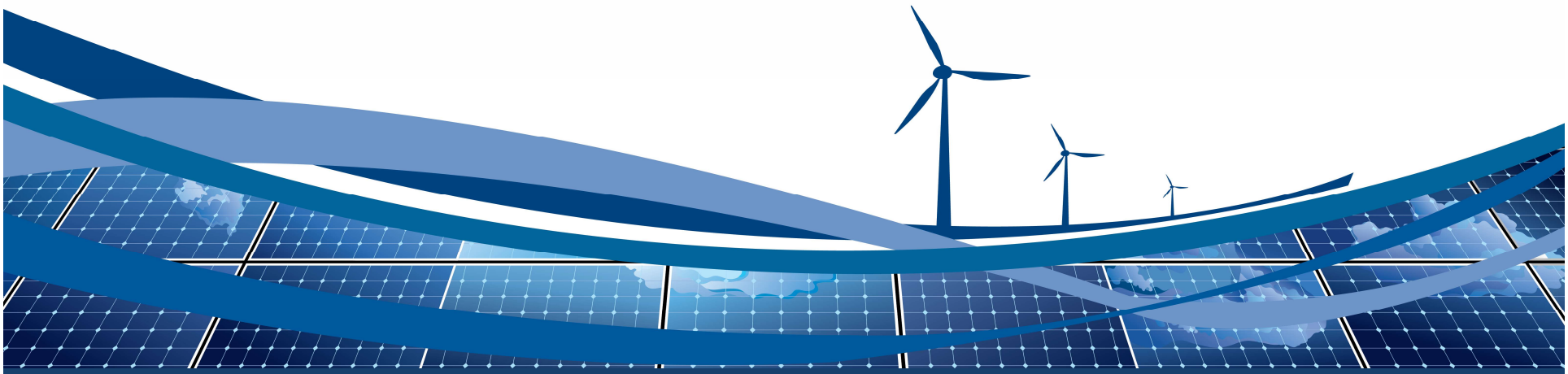

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RENEWABLE ENERGY AND ENERGY STORAGE MARKET OPPORTUNITIES

05 November 2020

Presentation to Bulk and Regional Tariff Team

Introduction and Outline

- AESO held:
  - March 13, 2020
    - Bulk and Regional Tariff Design Stakeholder Engagement 1
  - Delay for 6 months
  - September 24, 2020
    - Bulk and Regional Tariff Design Stakeholder Engagement Session 2
  - October 14, 2020
    - Joint Stakeholder Engagement session on Energy Storage and Distributed Energy Resources (DER) This presentation focused on the aspect of renewable energy and energy storage
    - Bulk and Regional Tariff Design Technical Information Session

Paula McGarrigle
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www.solasenergyconsulting.com

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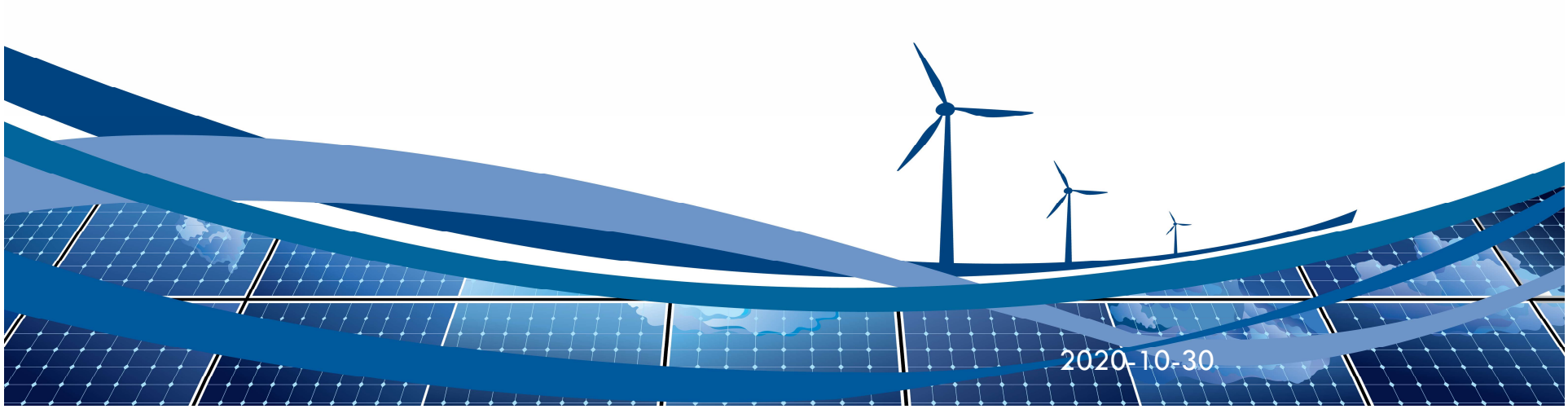
What is Storage?



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Is it a Load, Generator, Transmission facility/Substation?

- Guiding documents
  - Section 1(1)(u) of *Electric Utilities Act* (EUA)
    - Section 1(1)(bbb) of EUA
  - Section 1(1)(k) of *Hydro and Electric Energy Act* (HEEA)
    - Section 1(1)(n) of HEEA
  - *AUC's Electric Transmission Facilities Process Guidelines*
- No references to Storage in any document
- **Energy storage fits best with the definition of the EUA "substation"**

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What is Storage? – Is it a generation facility under EUA? – It's not a generator

Reference	Definition	Energy Storage
EUA "generating unit"	*component of a power plant that produces, from any source, electric energy and ancillary services, and includes a share of the following associated facilities that are necessary for the safe, reliable and economic operation of the generating unit*	Energy storage does not produce electric energy, but rather stores electric energy. Energy storage provides ancillary services, but not through the production of electricity, but rather through the injection of electricity.
	Fuel and Fuel handling equipment	Energy storage does not have fuel
	Cooling water facilities	Not applicable
	Switch yards	Switches are included in the balance of system of the energy storage system, but not a switch yard
	Other items	Energy storage balance of system are included here.

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What is Storage? – Is it a Transmission Facility, under EUA? – It's not a transmission facility.

Reference	Definition	Energy Storage
EUA "Transmission facility"	*arrangement of conductors and transformation equipment that transmits electricity from the high voltage terminal of the generation transformer to the low voltage terminal of the step-down transformer operating phase to phase at a nominal low voltage level of more than 25 000 volts to a nominal low voltage level of 25 000 volts or less*	Not applicable. Voltages in the energy storage facility are lower than those identified in this definition.
	(i) transmission lines energized in excess of 25 000 volts, *(ii) insulating and supporting structures,* *(iii) substations, transformers and switchgear,* *(iv) operational, telecommunication and control devices* *(v) all property of any kind used for the purpose of, or in connection with, the operation of the transmission facility….*	(i) Not applicable (ii) Not applicable (iii) Connects to the substation and includes transformers (iv) Includes telecommunication and control devices (v) The energy storage facility is not associated with the operation of the transmission facility.

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What is Storage? Is it a Power Plant or a substation under HEEA? – It's not a power plant. BEST FIT IS SUBSTATION.

Reference	Definition	Energy Storage
HEEA "Power Plant"	*facilities for the generation and gathering of electric energy from any source*	The energy storage facility does not generate electricity, but rather stores electricity. The energy storage facility does potentially gather electric energy but does not gather electricity like a conductor or collector system.
HEEA "substation"	*part of a transmission line that is not a transmission circuit and includes equipment for transforming, compensating, switching, rectifying or inverting of electric energy flowing to, over or from the transmission line*	The energy storage facility includes equipment for transforming and inverting of electric energy flowing to or from the transmission line. The energy storage facility does not include compensating equipment.

ES receives an asset ID to participate in the market (Energy and A/S)

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Maslow's Hammer – cognitive bias with a familiar tool

"I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail." –

- Abraham Maslow – 1966

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AESO Approach to Energy Storage

- Apply Demand Transmission Service to Energy Storage Charging
- Apply Supply Transmission Service to Energy Storage Discharging

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Seven (7) Components of DTS

- Bulk System Charge
  - Coincident metered demand - /MW/Month for MW at coincident peak
  - Metered energy - $/MWh of metered demand
- Regional System Charge
  - Billing capacity - /MW/Month of demand
  - Metered energy - $/MWh of metered demand
- Point of Delivery Charge
  - Substation fraction - /MW/Month based on the share of DTS over the total of all DTS and STS in substation
- Operating Reserve Charge Estimate - $/MWh to cover AESO procurement of Operating Reserves
- Transmission Constraint Rebalancing Charge Estimate - $/MWh (minimal charge)
- Voltage Control Charge - $/MWh (minimal charge)
- Other System Support Services Charge - $/MWh (minimal charge)

These charges form most of the DTS bill

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Two (2) Components of STS

- Losses Charge

  Metered Energy x Pool Price x Loss Factor

- Regulated Generating Unit Connection Cost
  - Only for regulated units - $/MW

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DOUBLE DOUBLE

Double Cream
Double Sugar

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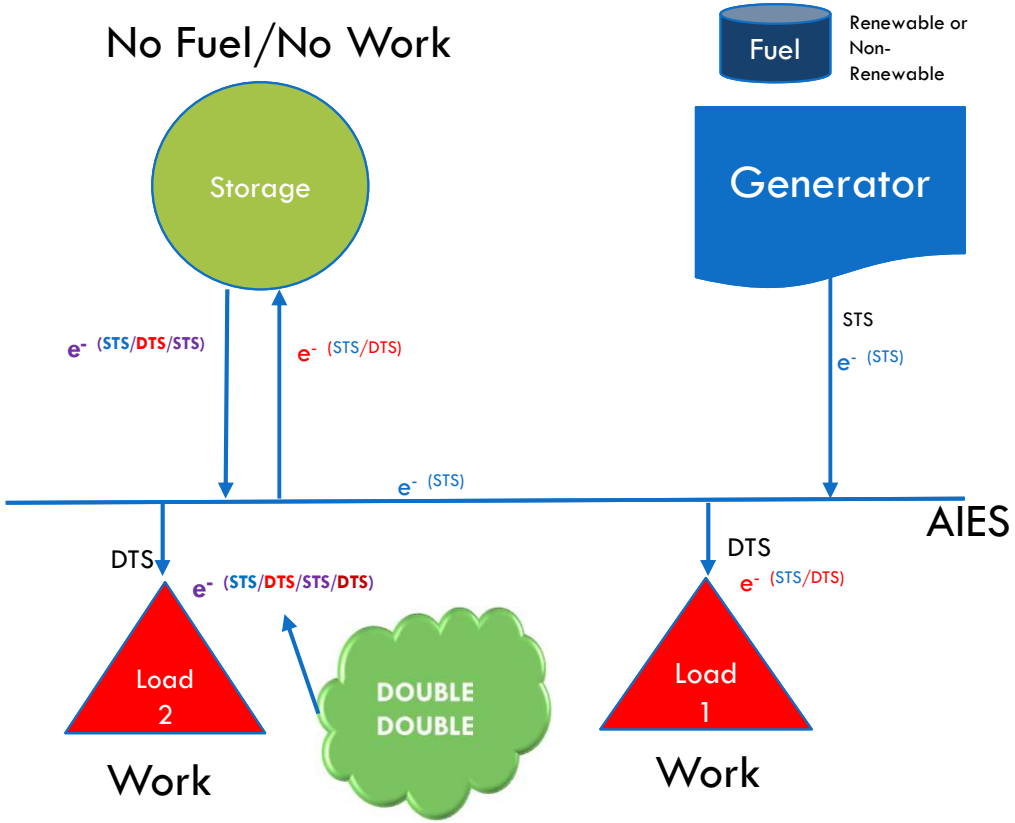
DOUBLE, DOUBLE ISSUE – UNFAIR, UNECONOMIC, UNCOMPETITIVE.
Charging DTS and STS on Energy Storage doubles up the charges on this electricity.



Generators pay STS. These electrons have paid for STS [e^{-} (STS)]

Load receives electrons that have already been loaded with STS. [e^{-} (STS)]

Then load pays DTS so the final consumed electrons have had both STS and DTS payments [e^{-} (STS/DTS)]

Energy storage currently gets charged DTS to charge (treated as a load) and the same electricity delivered back to the grid is also charged STS.
Now we have e^{-} (STS/DTS/STS)]

Load purchasing from the storage facility through the grid would now have to pay DTS, on top of electricity that has already now paid DTS, and STS twice. DOUBLE DOUBLE

Power used from energy storage has had twice the DTS and the STS applied.
This does not align with Fair, Efficient, and Openly Competitive.

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Treatment of Electrons

Electrons from the AIES

e^- (STS/DTS)

FEOC = YES

Electrons that have been through Storage

e^- (STS/DTS/STS/DTS)

FEOC = NO

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Session 1 – Option 1 identified for Storage

(as a market asset and not as a transmission asset)

AESO SUGGESTED OPTIONS	IMPACT ON ENERGY STORAGE	
1. Charge based flows DTS for inflows and STS for outflows (current tariff)	**DOUBLE DOUBLE all the time.**	

FEOC = NO

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Session 1 – Option 2 identified for Storage

(as a market asset and not as a transmission asset)

AESO SUGGESTED OPTIONS	IMPACT ON ENERGY STORAGE	
2. No DTS costs while providing "Market Services (FERC Order 841 treatment)"	**DOUBLE DOUBLE sometimes, even if you are not profitable.**	

FEOC = NO

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Session 1 – Option 3 identified for Storage

(as a market asset and not as a transmission asset)

AESO SUGGESTED OPTIONS	IMPACT ON ENERGY STORAGE	
3. **Interruptible service with lower rate, since storage can be off if transmission system is stressed.** Direct physical control by AESO, asset can be tripped off without notice (AESO has certainty) Dispatch control based on bids and offers: Financial incentive to comply (not full certainty) May not qualify for Operating Reserves or FFRSi, - incompatible with current A/S requirements	Slightly cheaper DOUBLE DOUBLE, significant uncertainty, and less control of asset.	

FEOC = NO

Conclusion

- The application of DTS and STS to energy storage does not comply with FEOC
- Adding DTS/STS to energy storage creates a Double Double scenario for energy to customers of energy storage.
- Energy storage is most consistent with Substation definition under the current laws/regulations
- Energy storage is heavily disadvantaged under any of the proposed tariff schemes including DTS/STS
- Energy Storage Administration fee (rather than DTS/STS) is most appropriate.
- None of the options presented by the AESO are appropriate for Energy Storage

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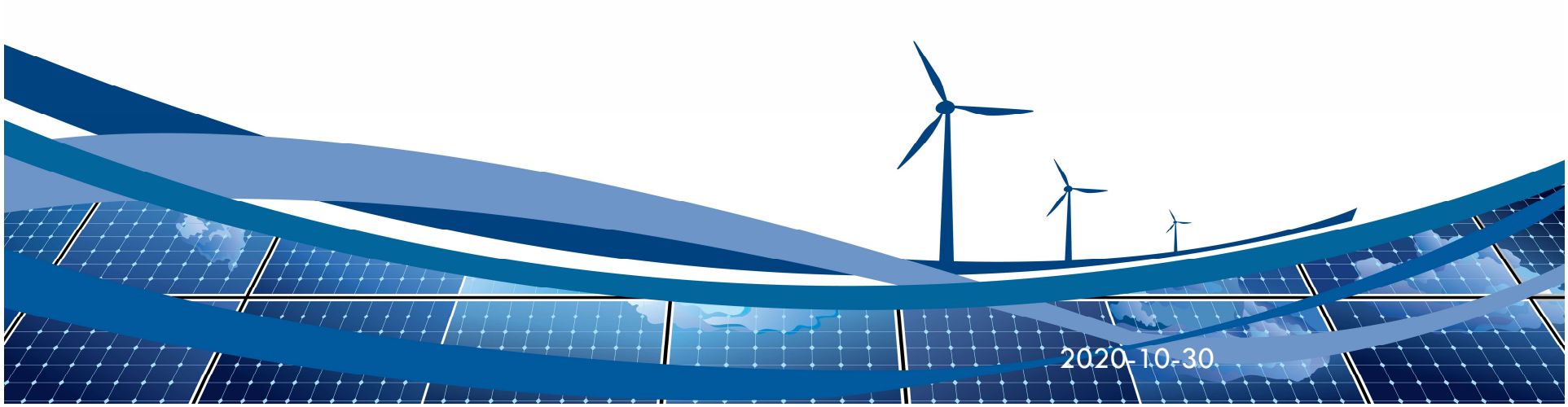
Appendix



Case Options

Generation	None	Wind	Solar			
Storage Location	At Generation	On Grid	At Customer			
Storage Timing	Standard	Perfect Forecast				
Substation Fraction	1.0	0.5	0.1			
Tariff Type	Current	FERC 841	Interruptible			
Region	NW	NE	Edmonton	Central	Calgary	South
Peak	12 CP	Regional 120 CP	System 120 - CP	System- Weekly CP		

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Case 1A: BESS ON GRID

Generation	None	Wind	Solar			
Storage Location	At Generation	On Grid	At Customer			
Storage Timing	Standard	Perfect Forecast				
Substation Fraction	1.0	0.5	0.1			
Tariff Type	Current	FERC 841	Interruptible			
Region	NW	NE	Edmonton	Central	Calgary	South
Peak	12 CP	Regional 120 CP	System 120 - CP	System- Weekly CP		

Charge during historical average low hours (HE 2,3,4,5)
Discharge during historical average high hours (HE 15,16,17,18)

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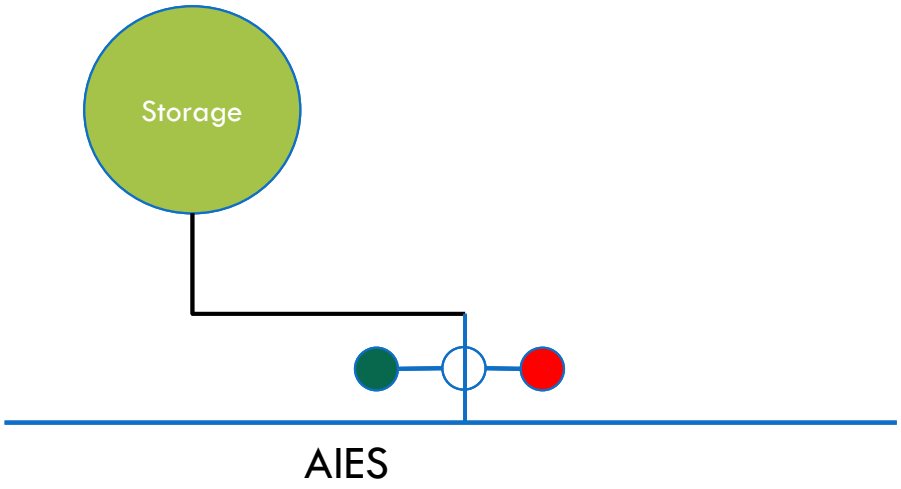
CASE 1A

Use Case: Arbitrage, Tx/Dx connected, 4 hours storage

Tariff: Current Tariff



Using 2016-2018 AESO data provided in the Tariff Bulk and Regional Impact Hourly Model

- Physical Meter
- Measurement Point
- Dispatch Point

Case Details

- 15 MW/60 MWh Storage
- 0 MW Generation
- Charge from Grid
- Discharge to Grid
- STS based on injecting near Blackspring Ridge
- DTS Substation Fraction POD equal to 1

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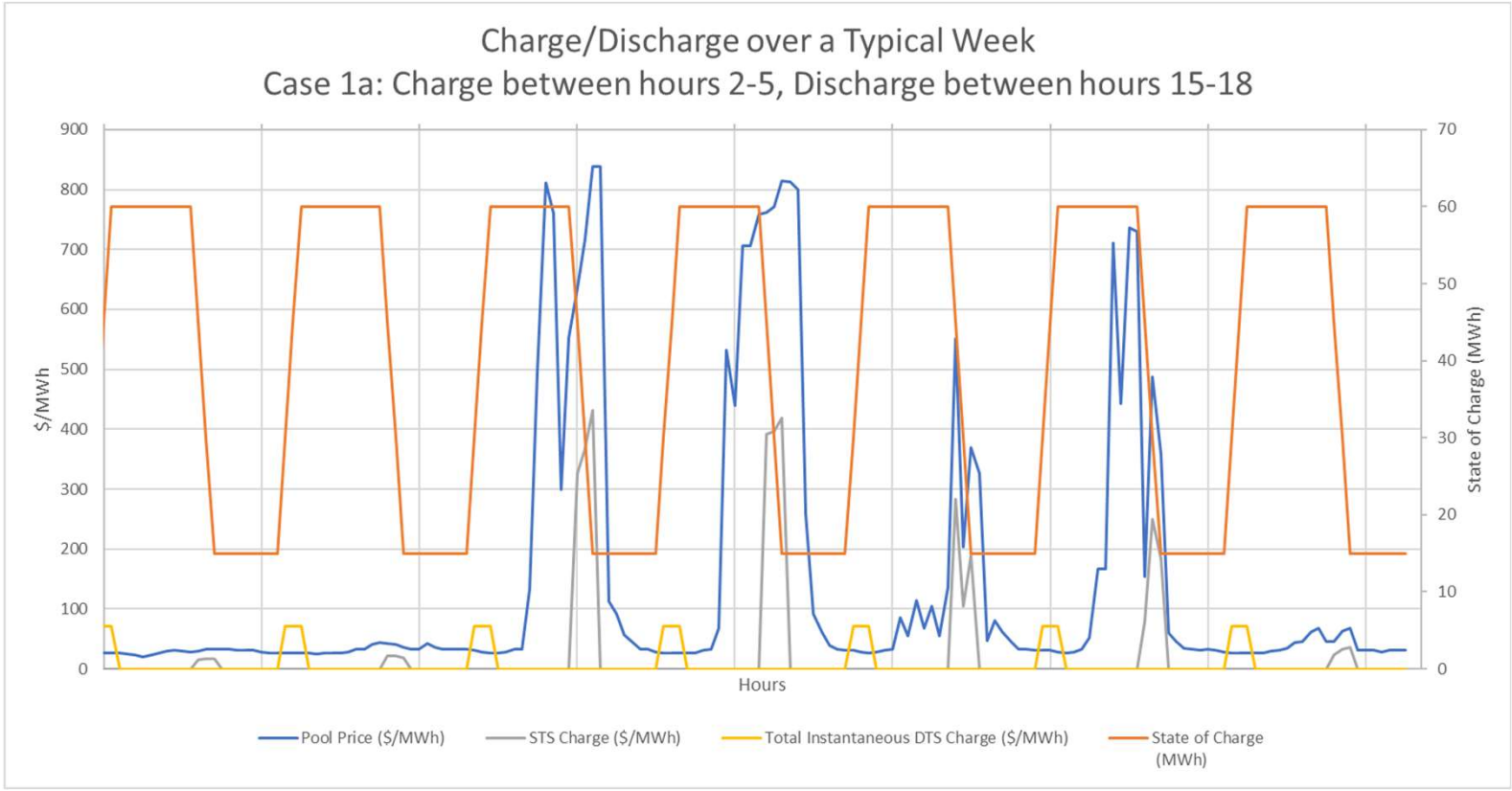
Case 1a: Production Profile & Costs



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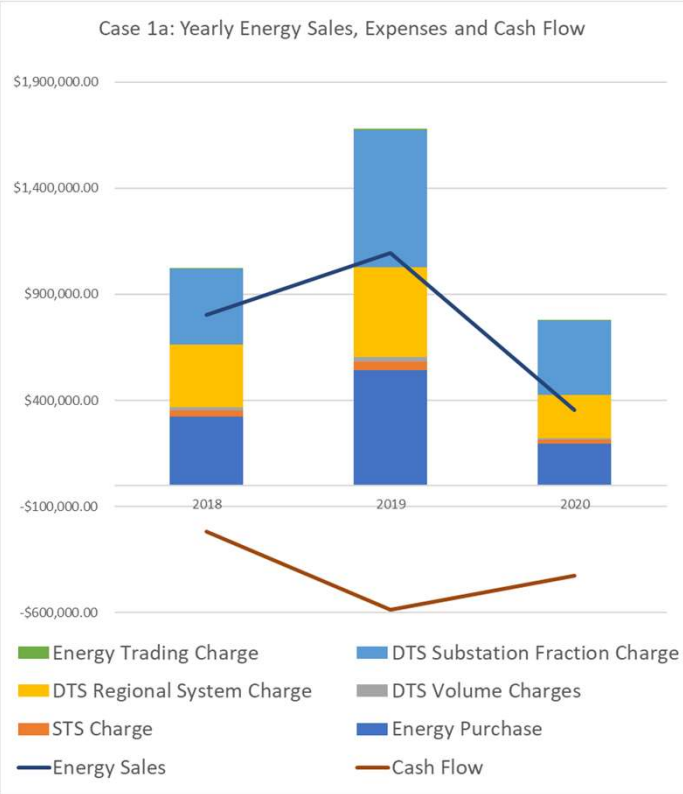
Case 1a: Current Tariff is cost prohibitive for Standalone BESS



- DTS Regional System Charge and DTS Substation Fraction Charge are the largest components of annual expense
- Simple cash flow analysis shows negative cash flow. Does not cover system costs (Energy, DTS, STS, AESO Trading Charge)

Year	Average Cost ($/MWh)	Average Revenue ($/MWh)
2018	-102	+96
2019	-97	+76
2020	-104	+60

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Case 1B: BESS ON GRID – Perfect Forecast

Generation	None	Wind	Solar			
Storage Location	At Generation	On Grid	At Customer			
Storage Timing	Standard	Perfect Forecast				
Substation Fraction	1.0	0.5	0.1			
Tariff Type	Current	FERC 841	Interruptible			
Region	NW	NE	Edmonton	Central	Calgary	South
Peak	12 CP	Regional 120 CP	System 120 - CP	System- Weekly CP		

THIS ONE CHANGED FROM CASE 1A to 1B

Charge during the lowest hours, discharge during highest hours

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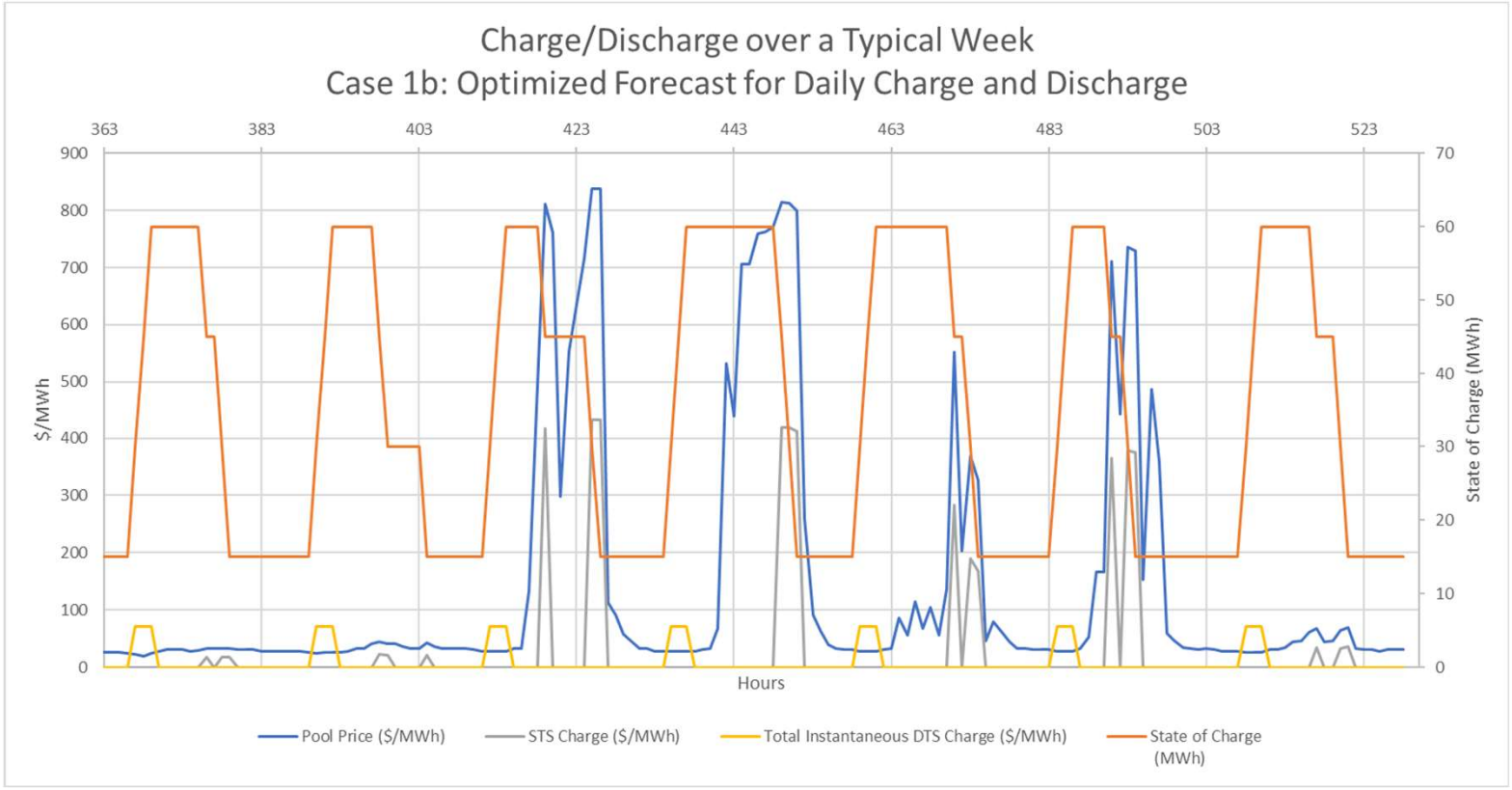
Case 1b: Production Profile & Costs



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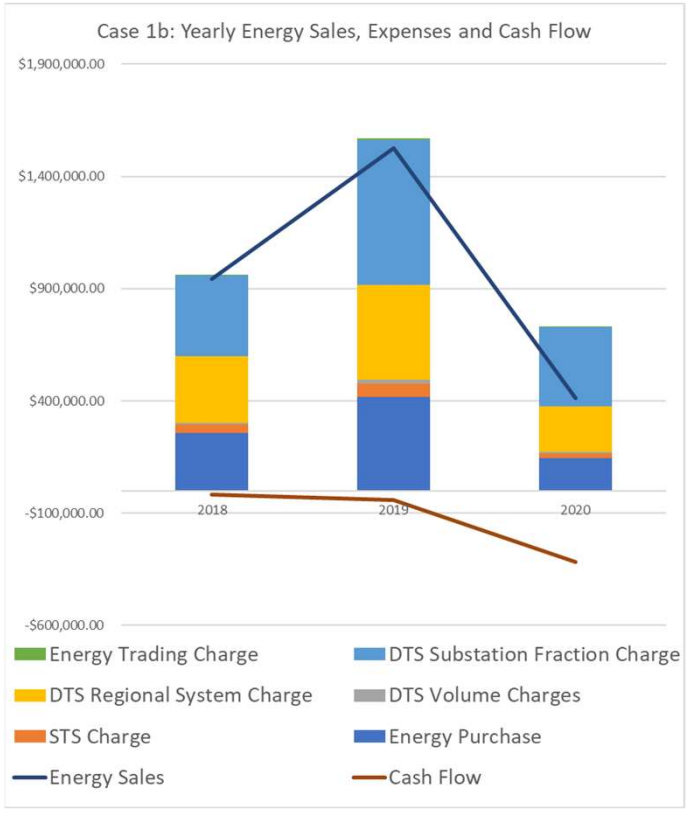
Case 1B: Perfect foresight is insufficient to make BESS economic.



- 1/3 of years has negative simple cash flow. Cashflow is insufficient for covering capital costs.

Year	Average Cost ($/MWh)	Average Revenue ($/MWh)
2018	-110	+130
2019	-107	+128
2020	-118	+86

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Case 1A: BESS ON GRID

Generation	None	Wind	Solar			
Storage Location	At Generation	On Grid	At Customer			
Storage Timing	Standard	Perfect Forecast				
Substation Fraction	1.0	0.5	0.1			
Tariff Type	Current	FERC 841	Interruptible			
Region	NW	NE	Edmonton	Central	Calgary	South
Peak	12 CP	Regional 120 CP	System 120 - CP	System- Weekly CP		

What's the impact of this?

Charge during historical average low hours (HE 2,3,4,5)
Discharge during historical average high hours (HE 15,16,17,18)

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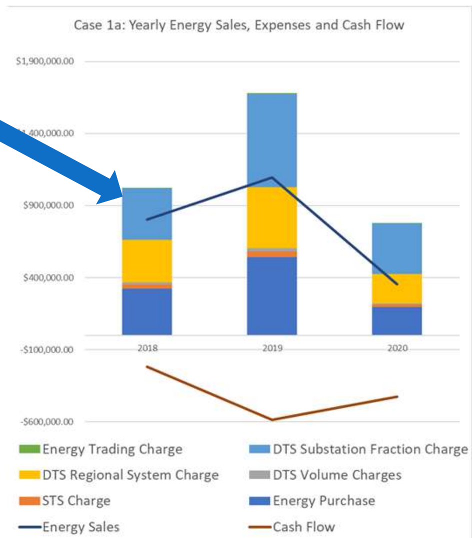
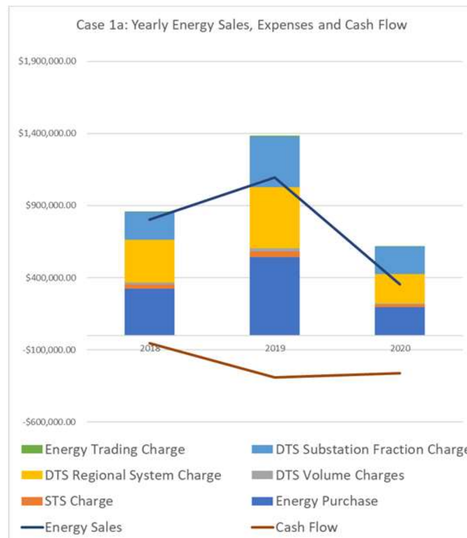
Massive DTS substation fraction costs push BESS locations to substations with other generators/loads (urban/industrial). But still uneconomic!

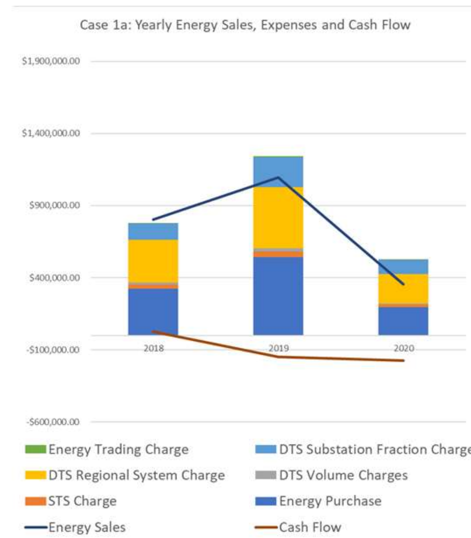
Current tariffs

Substation Fraction	**1**	**0.5**	**0.1**
Example configuration	Stand-alone TX connected	DX connected to sub with total STS and DTS contracts of 30 MW	TX connected to sub with total STS and DTS contracts of 150 MW

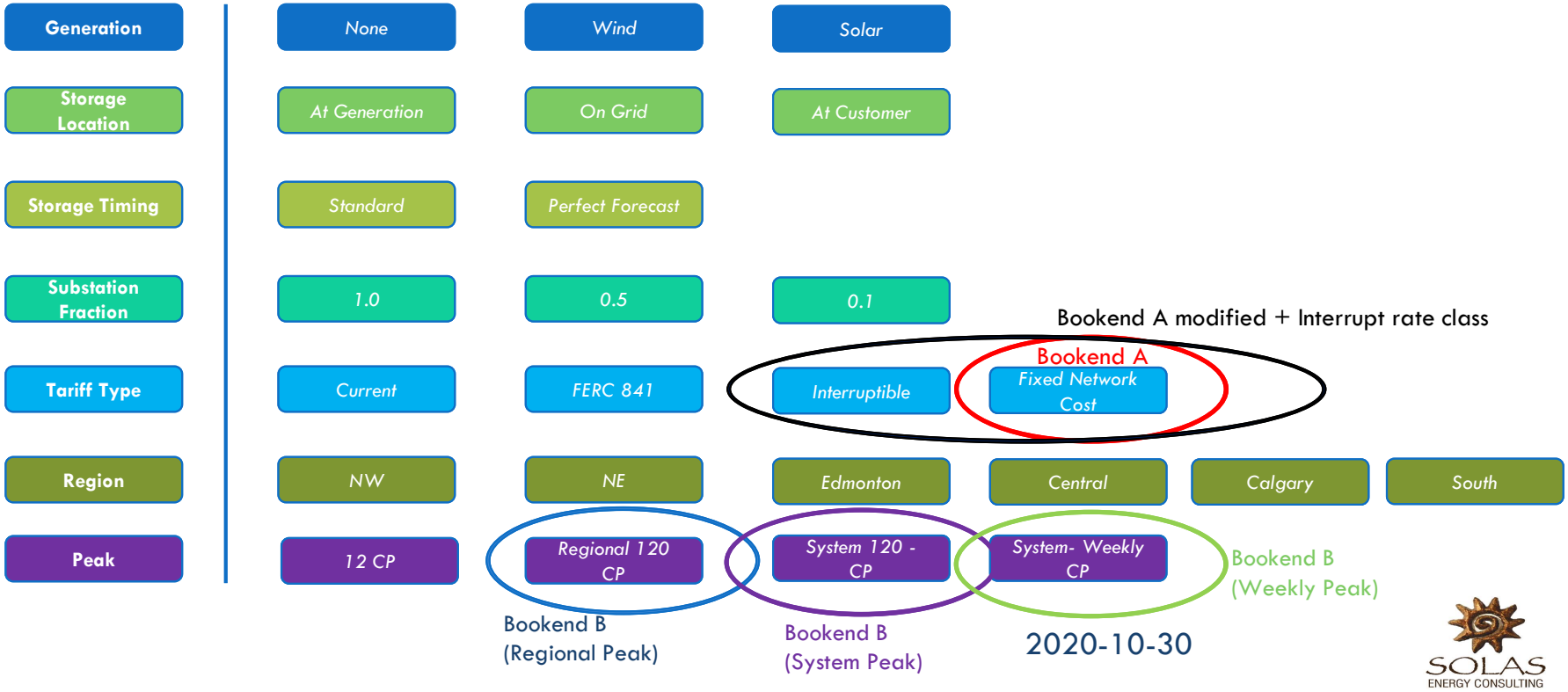
Look at DTS Substation Fraction POD Charge in each case



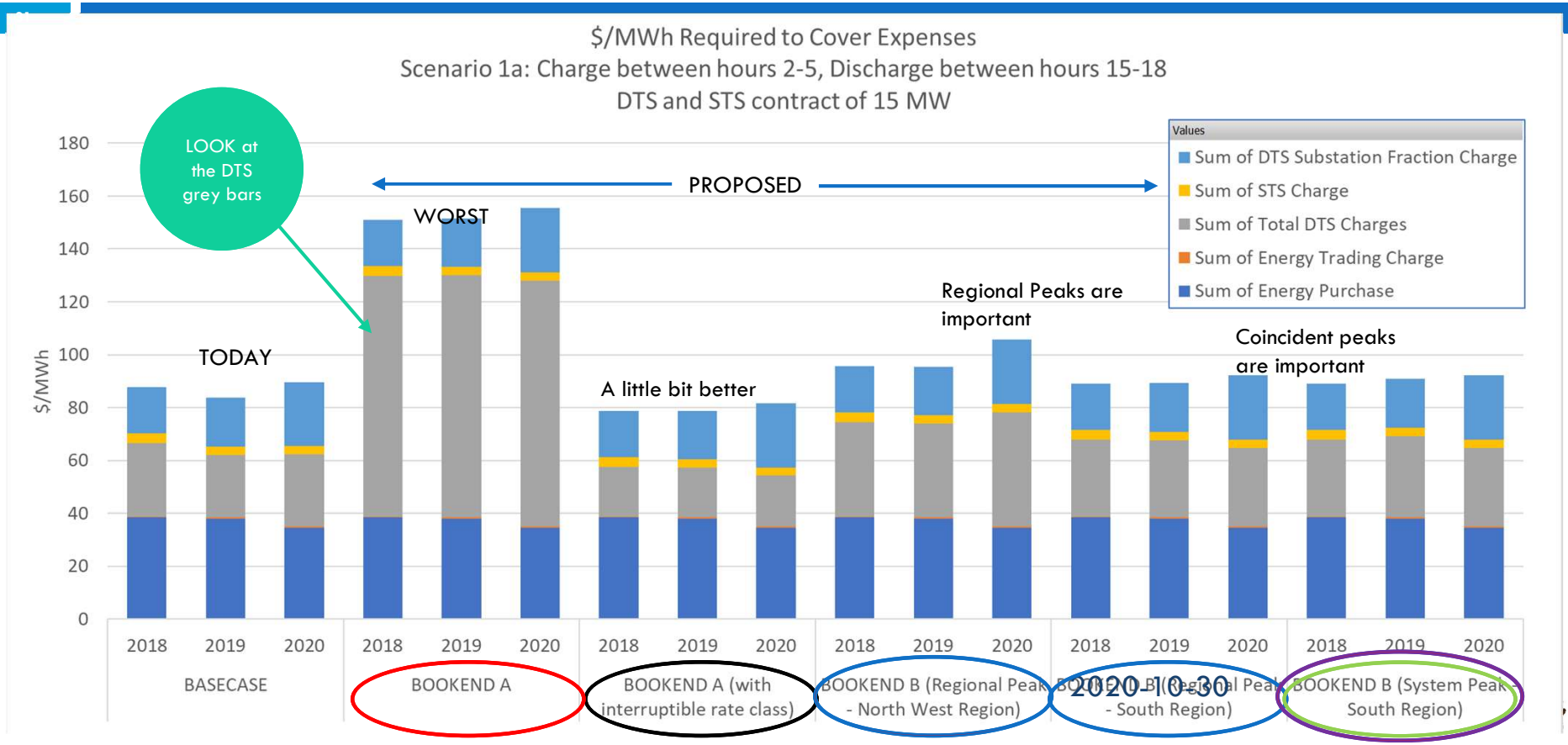




Case Options – 5 options reviewed by AESO



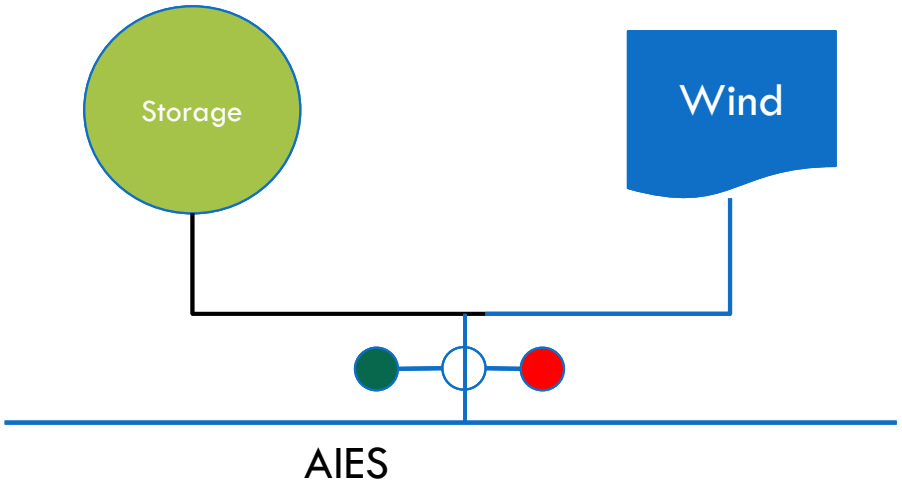
Impact of AESO Tariff Cases



CASE 2A

Use Case: BESS + Wind, Arbitrage, Tx connected, 4 hours storage

Tariff: Current Tariff



- Physical Meter
- Measurement Point
- Dispatch Point

Case Details:

- 15 MW/60 MWh Storage
- 300 MW Generation
- Transformer: 300 MW
- Charge from Wind Only
- Discharge to Grid

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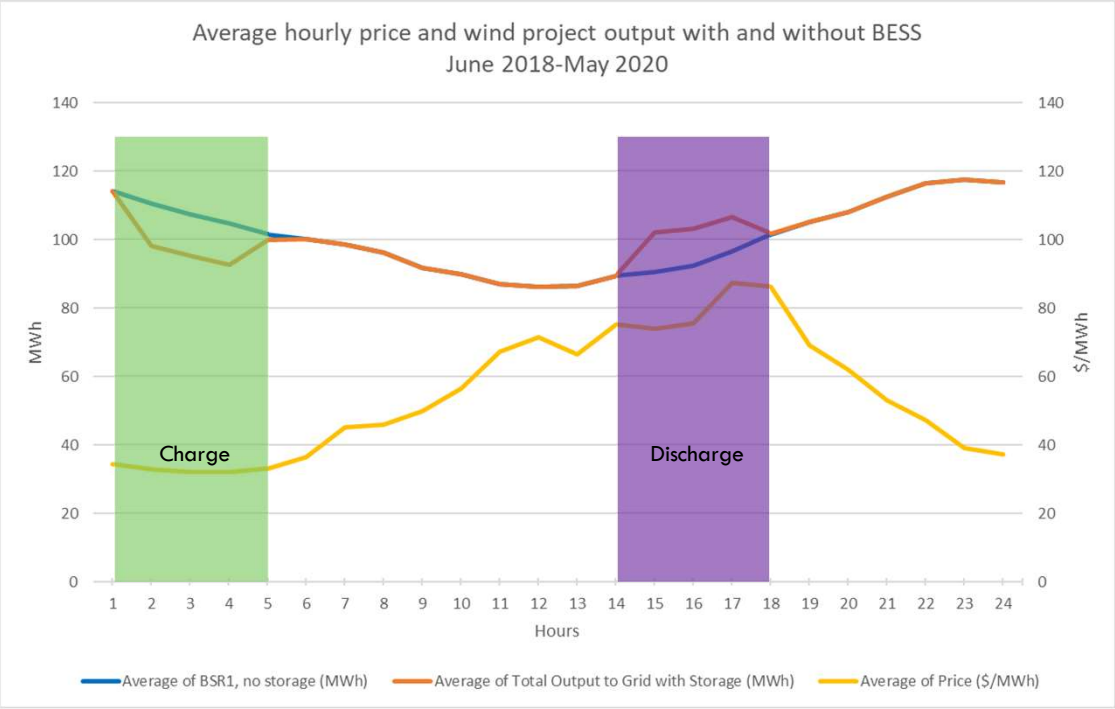
Case 2a: BESS improves revenue, but not sufficient for positive economics. Hybrid BESS has better, but insufficient, economics than standalone BESS.



Year: 2019	No BESS	With BESS
Total Revenue	$30.7M	$31.3M
Total STS Charges	-$1.2M	-$1.2M
Simple Cash Flow	$29.5M	$30.0M

Does not include BESS operating costs, or BESS capital costs.

No incremental DTS or STS

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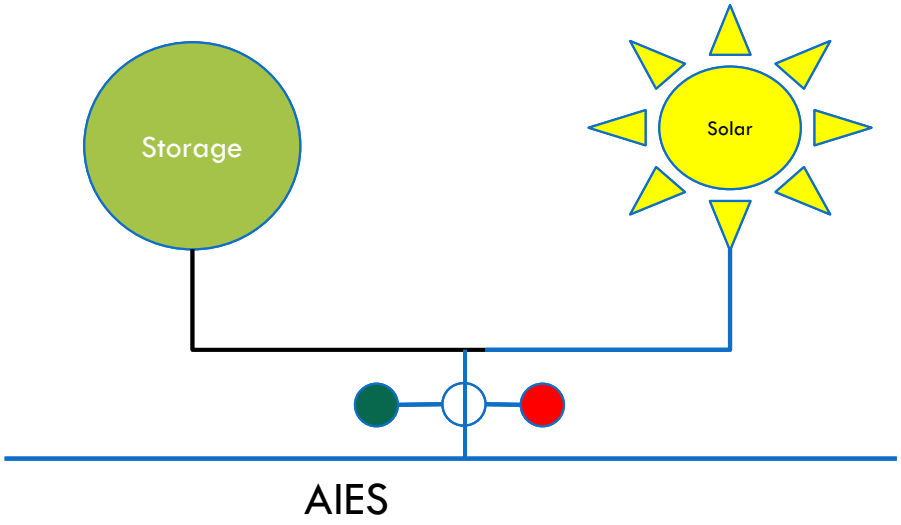
CASE 3A

Use Case: BESS + Solar, Arbitrage, Tx connected, 4 hours storage

Tariff: Current Tariff



Physical Meter
Measurement Point
Dispatch Point

Case Details:

- 15 MW/60 MWh Storage
- 300 MW Generation
- Transformer: 300 MW
- Charge from Solar Only
- Charges starting at sunrise
- Discharge to Grid starting at HE 13

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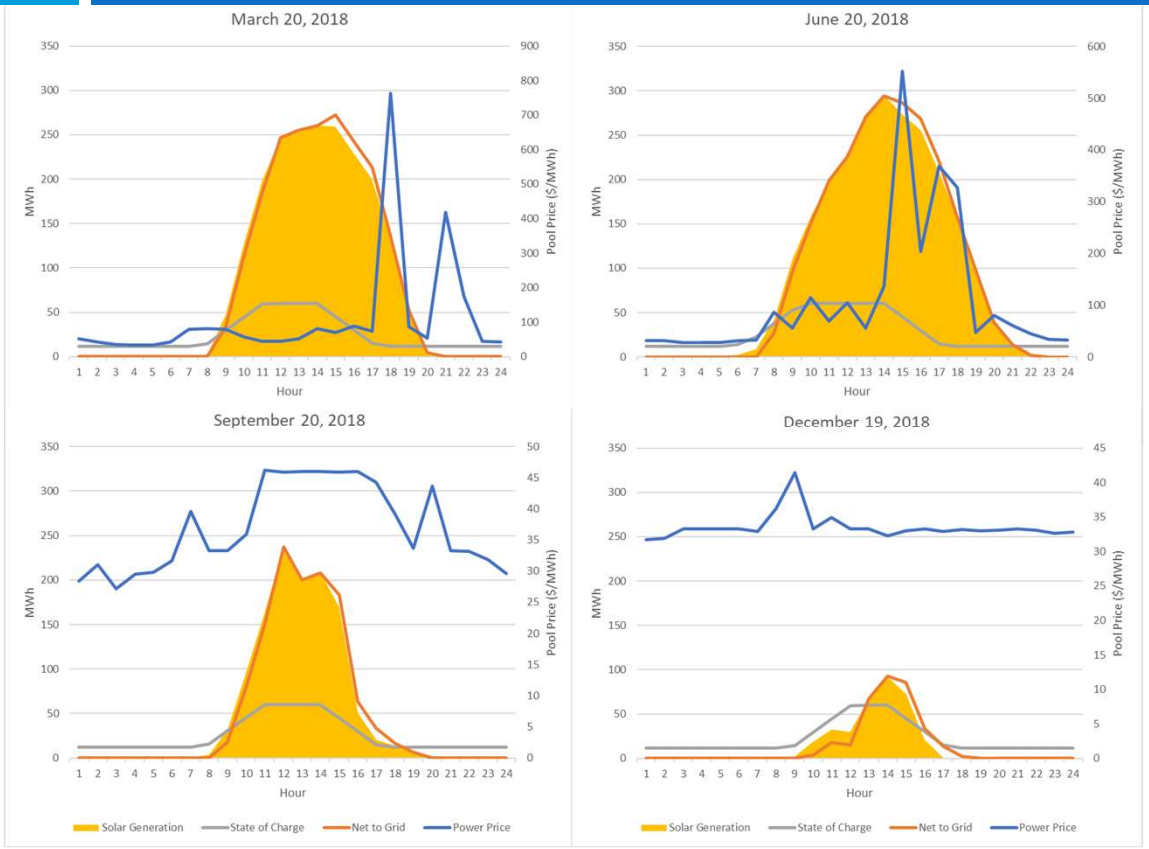
Case 3a: BESS improves revenue, but not sufficient for positive economics. Hybrid BESS has better, but insufficient, economics than standalone BESS.



Year: 2019	No BESS	With BESS
Total Revenue	$28.7M	$28.9M
Total STS Charges	-$1.1M	-1.1M
Simple Cash Flow	$27.6M	$27.8M

Does not include BESS operating costs, or BESS capital costs.

No incremental DTS or STS

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