Solar + Storage Financial Analysis

SUBMITTED TO

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Executive Summary

Introduction

The District of Summerland (DoS) is conditionally awarded $6,000,000 in funding from the Federal Gas Tax Fund to support the development of a 1 MW solar array with 2 MW of battery storage. DoS has completed the initial phases of developing the planned solar+storage project and is now preparing for the next phase of study. DoS contracted Fractal Energy Storage Consultants (Fractal) to provide Financial Analysis for the proposed project. The following report contains technical and financial analysis for an AC-coupled and DC-coupled 1 MW Solar photovoltaic (PV) array and 2 MW lithium-ion battery energy storage system (BESS) project on municipally owned land within the DoS.

Methodology

Fractal applied an 8-step methodology to evaluate the recommended business models. Each step of the valuation process required deep industry and market knowledge. Figure 1 shows Fractal's process.

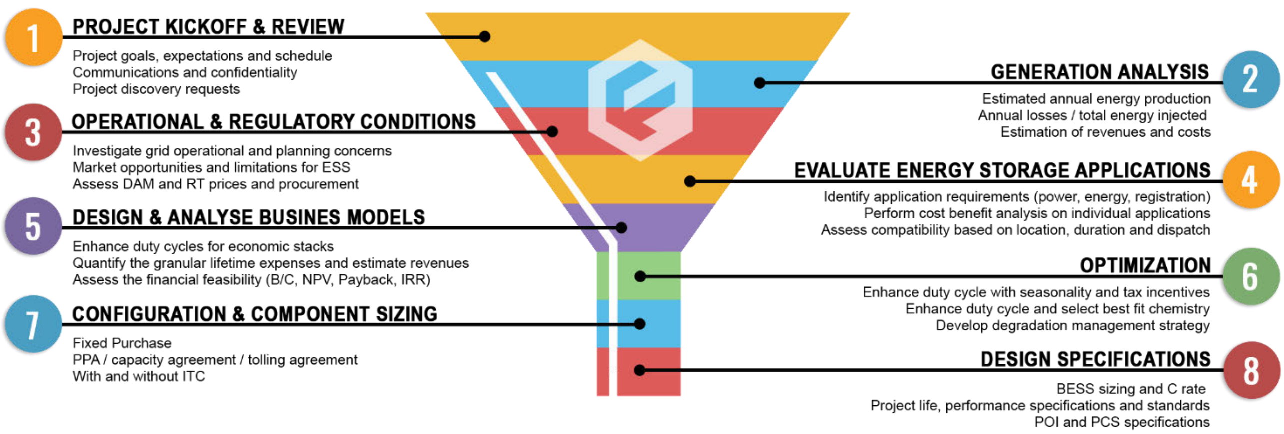

Figure 1 - Fractal Energy Storage Evaluation Framework

Key Findings

Financial Highlights

Fractal analyzed several business model variations to identify feasible options. Services were combined based on technical compatibility while accounting for revenue streams. The evaluation framework further examined combinations of chemistry, economics, size (MW-MWh) and performance to meet the business model's unique duty cycle. Table 1 shows the internal rate of return (IRR) for the solar+storage project.

Table 1 – Business Model IRR Comparison

Model	Power	Energy	IRR (without Grant)	NPV* (without Grant)	IRR (with Grant)	NPV* (with Grant)	Payback (with Grant)
Solar (PPA = $53.88/MWh)	1 MW		-0.96%	-$1,631,413	37.96%	$1,368,587	2.7
Storage Only NMC	2 MW	4.5 MWh	-0.47%	-$1,248,882	16.47%	$1,751,118	6.3
Storage Only LFP	2 MW	4.5 MWh	0.43%	-$861,208	27.39%	$2,138,792	3.9
S+S (AC) NMC	2 MW	4.5 MWh	-0.75%	-$2,880,295	19.77%	$3,119,705	5.3
S+S (AC) LFP	2 MW	4.5 MWh	-0.38%	-$2,492,621	29.68%	$3,507,379	3.6
S+S (DC) NMC	2 MW	4.5 MWh	-0.31%	-$2,434,257	30.98%	$3,565,743	3.4
S+S (DC) LFP	2 MW	4.5 MWh	0.09%	-$2,046,584	66.06%	$3,953,416	1.6

* 3% discount rate

Business Model Overview

The business model consists of a front-of-the meter (FTM), distribution-connected, 2 MW BESS in the DoS territory.

- Applications Performed:
  - Solar Energy Savings: The Solar PV generation reduces consumption of electricity from Fortis BC, resulting in bill savings from the avoidance of purchasing energy from Fortis BC.
  - Demand Charge Mitigation: The BESS charges at the flat retail rate and discharges during peak hours to reduce Fortis BC Wires Charges and Peak Supply Charges.
- Ownership: The analysis below shows a 100% equity model, owned and operated by DoS.
- Optional services can include:
  - Volt / Var: The BESS can provide feeder reliability by providing real and reactive power.
  - Resiliency: The BESS can provide optional resiliency by islanding a feeder segment for a specific duration of time (additional cost for islanding disconnect and reclosers).
  - Distribution Deferral: The BESS can provide infrastructure investment deferral by improving loading characteristics of the feeder and transformer during peak hours.

Conclusions

The current price and performance of S+S creates a window of opportunity for DoS to reduce power-supply related costs and increase reliability. Energy storage systems have a unique feature in their ability to store energy and provide fast, dispatchable power enabling wide-ranging benefits such as peak load management, investment deferral and renewable energy integration. The analysis performed in this study demonstrates that the S+S project is a technically and financially viable business model that will provide DoS with the following benefits:

1. Financial Benefits: The project provides energy savings and security by:
   - Reducing power-supply related costs
   - Hedging against future power supply cost escalation
   - Providing a cost-effective, flexible and scalable business model
2. Operational Benefits: The project provides distribution system operational benefits by:
   - Reducing wear and tear and utility equipment
   - Increasing system and customer power quality and reliability
3. Environmental Benefits: The project enables environmental benefits by:
   - Generating clean and renewable solar power
   - Enabling attainment of climate action goals and supporting renewable energy resources
4. Societal Benefits: The project supports the local economy and community by:
   - Spurring local job creation and providing ongoing opportunities for community involvement and partnerships with local businesses, schools and research organizations
   - Demonstrating innovation and regional leadership on clean energy technology

Project Analysis Background

Project Kickoff

Objective

Fractal participated in a project kick-off meeting with DoS on November 8, 2018. The purpose of this meeting was to establish the goals of the analysis and to set objectives. The kick-off meeting covered the following topics:

- Goals, expectations and desired outcomes
- Client-specific financial variables and costs
- Site information
- Milestones and deadlines

Expectations and Desired Outcomes

DoS defined the following objectives for the study:

- Purchase cost of batteries and balance of plant (BOP) components
- Replacement cost of batteries and replacement timeline
- Operation and maintenance (O&M) costs
- Lifecycle cost-benefit analysis
- Sizing confirmation and optimization
- Battery profile (energy, SOC and/or DOD)
- Sizing vs performance
- Performance profiles (site output, shifting, etc.)
- Annual system capacity
- Clipped energy savings
- Descriptions of applications and benefits
- Parameter and assumption explanation
- Visualization of economic business models (duty cycle)
- Proforma and financial metrics (IRR, NPV, Payback)
- Grant optimization
- Auxiliary load requirements
- Degradation management strategy
- Descriptions and spec sheets major components
- Assistance with RFP forms / deliverables

Project Inputs

Data Sets

The following supplementary market data was reviewed and applied in the analysis:

- Strategic Priorities Fund Capital Application Form
- Solar PV plus Battery Storage Project Pre-Feasibility Study
- DoS Integrated Solar Project System Impact and Interconnection Study (DRAFT)
- 5 Years Historical Fortis BC power purchases
- DoS 2008 Electrical Master Plan
- 2017 DoS Load Forecast
- Solar Production Estimation (PVSyst File)

Client Inputs

- COD: November 2019
- Location: Lat / Long: 49.60° N / -119.68°, Prairie Valley Substation (not finalized)
- Owner / Off-taker(s): 100% equity model, owned and operated by the District of Summerland.
- POI Voltage: 8 kV
- Interconnection Agreement (IA): Agreement and extension letter provided
- Inverter Load Ratio: Optimize DC/AC ratio during analysis

Proposed Project Sites

For the purpose of this analysis, the BESS was sited at 49.60° N, -119.68° W, as per recommendations made to the District in an Interconnection and System Impact Study completed previously during the project study. While multiple locations are being evaluated, Figure 2 shows a satellite view of the proposed location.

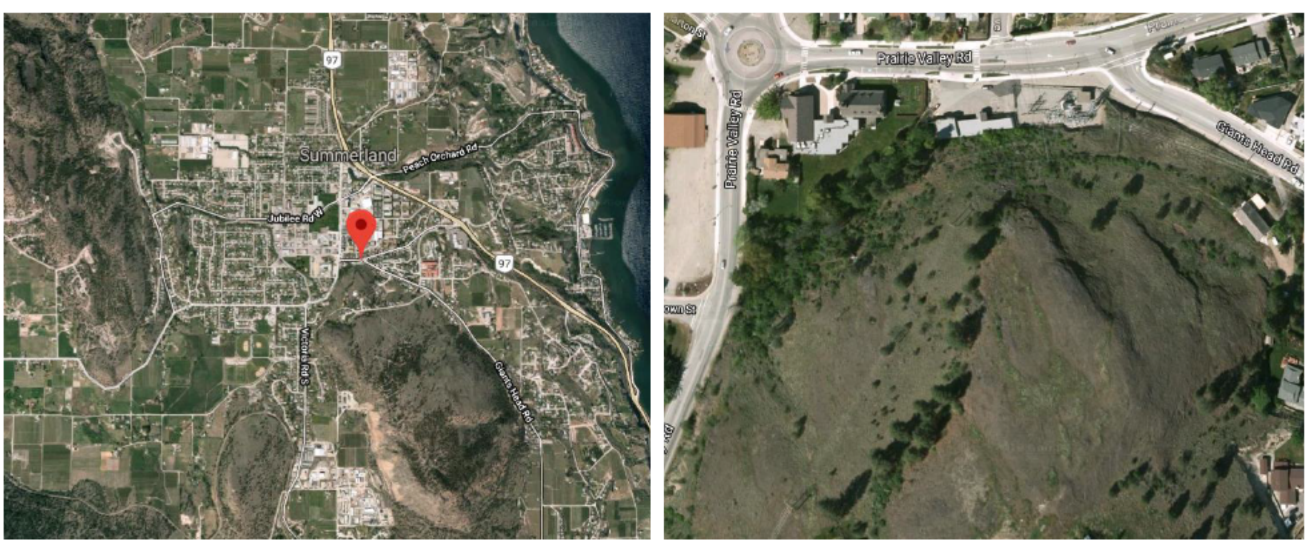

Figure 2 - Project Site Google Earth Visualizations

A high average global tilted irradiation is the most important consideration for developing a solar project. DoS has a solar potential of 1152 kWh/kWp. This is above Fortis BC's municipal average of 1077 kWh/kWp and on par with the national municipal average of 1165 kWh/kWp (data from Natural Resources Canada).

Generation Analysis

Figure 3 visualizes the anticipated seasonal solar output for a 1 MWac / 1.3 MWp solar project in Summerland.

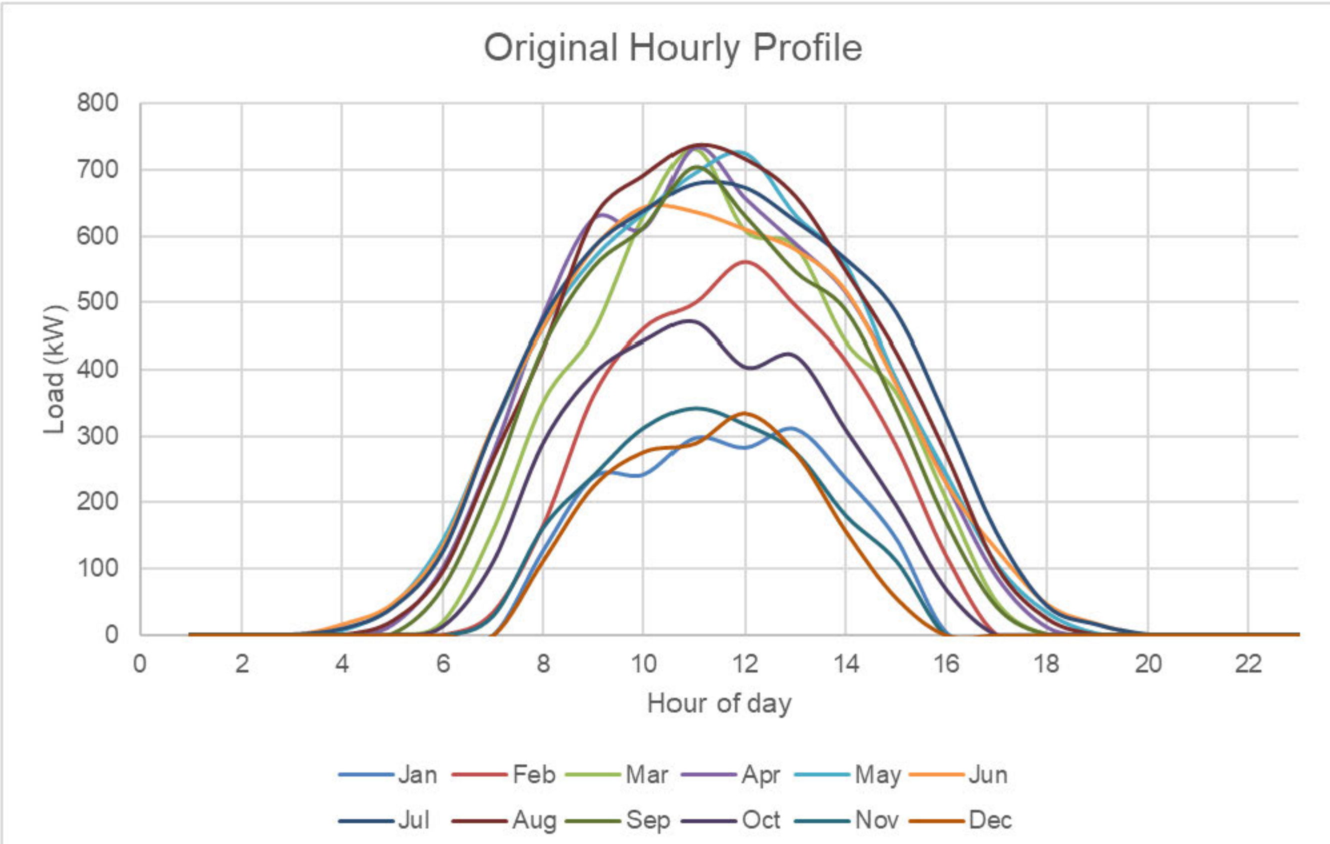

Figure 3 - Solar Capacity Analysis (Source: Fractal's Analysis)

Table 2 shows the average seasonal solar capacity in Summerland.

Table 2 – Solar Capacity Analysis

Solar Capacity	Hour starting →																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 Jan	0%	0%	0%	0%	0%	0%	0%	0%	13%	24%	24%	30%	28%	31%	23%	14%	0%	0%	0%	0%	0%	0%	0%	0%
2 Feb	0%	0%	0%	0%	0%	0%	0%	3%	17%	36%	46%	50%	56%	50%	41%	29%	12%	0%	0%	0%	0%	0%	0%	0%
3 Mar	0%	0%	0%	0%	0%	0%	2%	16%	35%	46%	63%	73%	61%	58%	44%	36%	20%	5%	0%	0%	0%	0%	0%	0%
4 Apr	0%	0%	0%	0%	0%	2%	10%	28%	48%	63%	61%	73%	66%	59%	51%	39%	23%	9%	1%	0%	0%	0%	0%	0%
5 May	0%	0%	0%	0%	1%	5%	14%	31%	46%	57%	64%	70%	72%	63%	56%	38%	24%	11%	3%	0%	0%	0%	0%	0%
6 Jun	0%	0%	0%	0%	2%	5%	13%	32%	46%	58%	64%	64%	61%	58%	52%	38%	23%	13%	5%	2%	0%	0%	0%	0%
7 Jul	0%	0%	0%	0%	1%	4%	13%	31%	48%	58%	64%	68%	67%	62%	56%	48%	32%	15%	4%	1%	0%	0%	0%	0%
8 Aug	0%	0%	0%	0%	0%	2%	10%	27%	43%	63%	69%	74%	72%	66%	55%	43%	27%	10%	2%	0%	0%	0%	0%	0%
9 Sep	0%	0%	0%	0%	0%	0%	7%	23%	43%	55%	61%	70%	63%	55%	49%	34%	17%	4%	0%	0%	0%	0%	0%	0%
10 Oct	0%	0%	0%	0%	0%	0%	1%	11%	29%	39%	44%	47%	40%	42%	31%	20%	7%	0%	0%	0%	0%	0%	0%	0%
11 Nov	0%	0%	0%	0%	0%	0%	0%	3%	16%	24%	31%	34%	32%	28%	18%	11%	0%	0%	0%	0%	0%	0%	0%	0%
12 Dec	0%	0%	0%	0%	0%	0%	0%	0%	11%	23%	28%	29%	33%	28%	16%	6%	0%	0%	0%	0%	0%	0%	0%	0%

Load Analysis

Figure 4 and Table 3 show Fractal's demand charge mitigation results for a 2 MW / 4.5 MWh BESS. The results do not use perfect knowledge of monthly peaks, as a result the battery may completely miss peaks, while partially shaving others. These results are in line with similar projects that Fractal has evaluated.

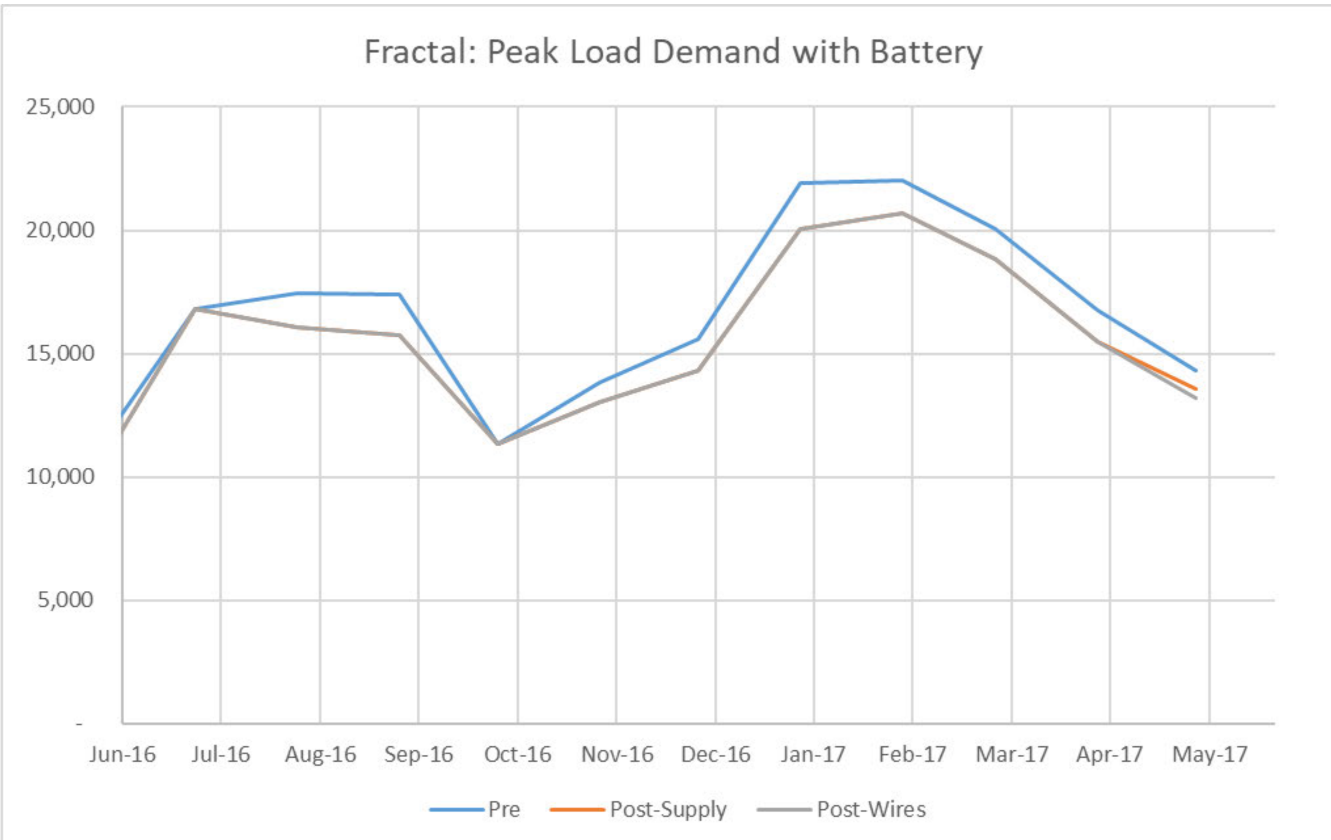

Figure 4 - Fractal: Peak Load with Battery (For a 2 MW 2.25 hr duration battery)

Table 3 - Fractal: Peak Load with Battery (For a 2 MW 2.25 hr duration battery)

kW Reduction		Supply				Wires			
Billing Period	Billing Period End	Pre	Post	Diff	%	Pre	Post	Diff	%
1	6/1/16 0:00	[redacted]	[redacted]	[redacted]	7%	[redacted]	[redacted]	[redacted]	7%
2	7/1/16 0:00	[redacted]	[redacted]	[redacted]	0%	[redacted]	[redacted]	[redacted]	0%
3	8/1/16 0:00	[redacted]	[redacted]	[redacted]	1%	[redacted]	[redacted]	[redacted]	1%
4	9/1/16 0:00	[redacted]	[redacted]	[redacted]	9%	[redacted]	[redacted]	[redacted]	9%
5	10/1/16 0:00	[redacted]	[redacted]	[redacted]	0%	[redacted]	[redacted]	[redacted]	0%
6	11/1/16 0:00	[redacted]	[redacted]	[redacted]	7%	[redacted]	[redacted]	[redacted]	5%
7	12/1/16 0:00	[redacted]	[redacted]	[redacted]	6%	[redacted]	[redacted]	[redacted]	6%
8	1/1/17 0:00	[redacted]	[redacted]	[redacted]	8%	[redacted]	[redacted]	[redacted]	8%
9	2/1/17 0:00	[redacted]	[redacted]	[redacted]	6%	[redacted]	[redacted]	[redacted]	4%
10	3/1/17 0:00	[redacted]	[redacted]	[redacted]	6%	[redacted]	[redacted]	[redacted]	5%
11	4/1/17 0:00	[redacted]	[redacted]	[redacted]	8%	[redacted]	[redacted]	[redacted]	7%
12	5/1/17 0:00	[redacted]	[redacted]	[redacted]	8%	[redacted]	[redacted]	[redacted]	0%

Operational Challenges and Market Review

Fractal investigated operational and planning challenges. This information was considered during the business model design process.

Power Supply Challenges

1. Cost: Fortis BC currently provides bulk wholesale power to DoS for distribution. DoS is assessed the following charges and is exposed to fuel price volatility:
   - Energy Charge: Based on demand measured at Fortis BC substations located within DoS District boundaries
   - Wires Charge: Based on the highest peak over the previous eleven months and the billing month's peak
   - Peak Supply Charge: Based on the registered peak in each month
2. Sourcing: Purchasing energy solely from Fortis BC may inhibit DoS from achieving climate action objectives due to lack of sourcing influence.

Renewable Energy Challenges

1. Intermittency. Solar PV (and wind) systems are intermittent resources with output that depends on the time of day, season, and weather patterns. This variability can make it more difficult for the grid operator to predict how much additional electric generation will be required during the next hour of the day, so it becomes difficult to calculate exactly what the output of each generator should be to meet demand. Many utilities are experiencing the following operational challenges due to solar intermittency:
   - Voltage Instability. Sudden changes in generation output along with voltage inconsistencies presents service reliability challenges.
   - Increased O&M. Sudden changes in generation output result in increased operating reserve costs natural gas nomination revision costs, and increased equipment O&M costs (due to increased cycling).
   - System Upgrades. Existing and planned solar installations require system enhancements to address voltage and thermal violations.

2. Generation Mismatch. Solar PV systems have an early morning ramp, followed by a decline in the capacity towards late afternoon and evening. The DoS utility peak demand is generally in non-daylight hours of winter months making solar ineffective in meeting peak load. DoS is assessed Wires Charges and Peak Supply Charges during this period. This generation mismatch results in higher power supply related costs.

3. Low Capacity Factor. Because variable solar PV is not as controllable as a conventional power plant, its capacity factor can only be a percentage of its nameplate capacity. This makes it difficult for utility planners to incorporate it effectively into the supply stack.

Figure 5 shows the intermittency of an actual solar plant over a day.

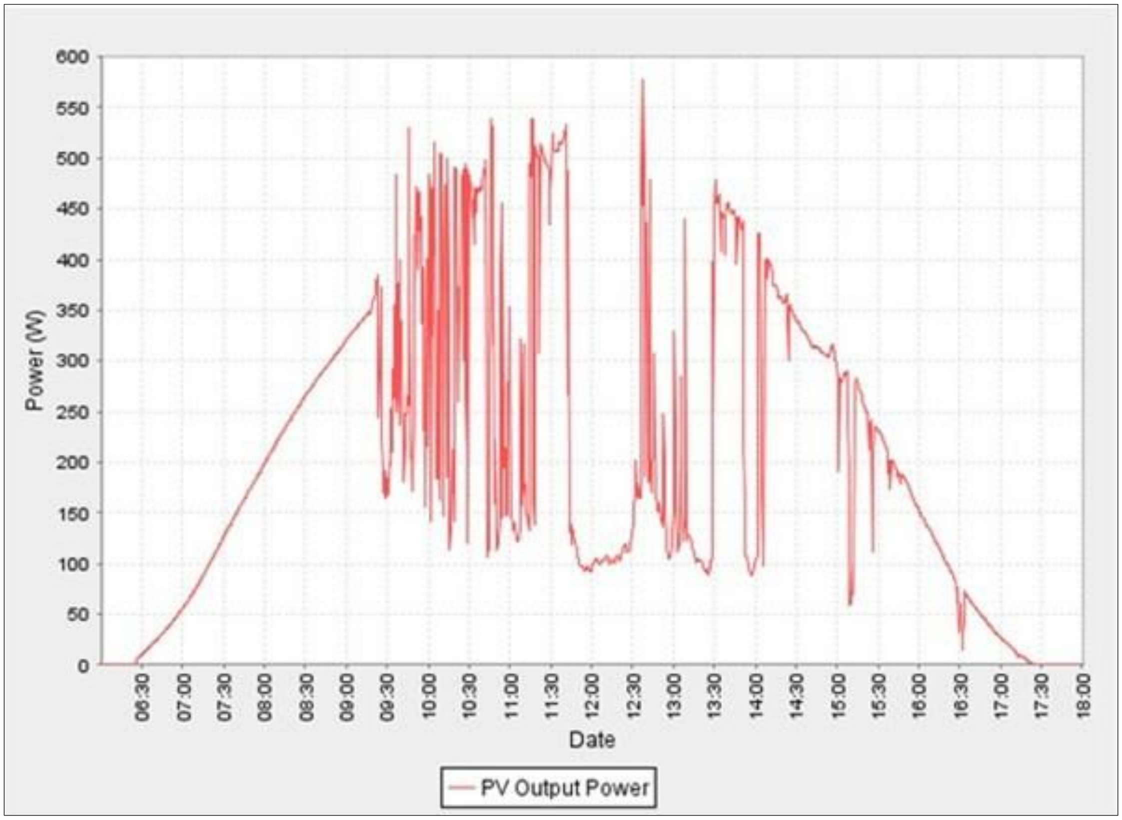

Figure 5 - Solar PV Intermittency

Business Model Analysis

S+S – AC Coupled (NMC)

A FTM AC-coupled solar+storage, distribution-connected, 2 MW BESS in the DoS territory. The chemistry is lithium nickel manganese cobalt oxide (NMC), the most common chemistry (e.g. Samsung and LGChem). The BESS performs:

- Solar Energy Savings: The Solar PV generation reduces consumption of electricity from Fortis BC, resulting in bill savings from the avoidance of purchasing energy from Fortis BC.
- Demand Charge Mitigation: The BESS charges at the flat retail rate and discharges during peak hours to reduce Wires Charges and Peak Supply Charges.

Ownership: The analysis below shows a 100% equity model, owned and operated by DoS. Optional services can include:

- Volt / Var: The BESS can provide feeder reliability by providing real and reactive power.
- Resiliency: The BESS can provide optional resiliency by islanding a feeder segment for a specific duration of time (additional cost for islanding disconnect and reclosers).
- Distribution Deferral: The BESS can provide site-specific infrastructure investment deferral by improving operational and loading characteristics of the feeder and transformer during peak hours.

Site Overview

Table 4 shows the business model parameters.

Table 4 - Parameters

General	Batteries and Balance of Plant
Power / Energy: 2 MW / 4.5 MWh	[redacted]
Configuration: AC Coupled	85% Round-trip Efficiency
Chemistry: NMC	COD: 2019
C-Rate: 0.5C	Solar PV
POI Voltage: 8.32 kV	Inverter Sizing: 1 MW
Project Life: Solar (35 yr) Storage (20 yr)	Panel Sizing: 1.3 MWp
Taxation: 0% Fed; 0% State	DC/AC: 1.3

Results

Table 5 shows cost savings across a variety of storage durations (i.e. different C-rates). Table 6 and Table 7 show project IRR for a 2.25 hour duration battery with and without the grant, respectively. Table 8 shows the year 1 revenue for BESS and solar PV.

Table 5 – Cost Savings (Sensitivity Analysis)

2 MW BESS with Different Durations (hr)								
1	1.25	1.5	1.75	2	2.25	2.5	2.75	3
$122,948	**$135,250**	**$144,169**	**$150,018**	**$162,871**	**$179,836**	**$152,853**	**$179,662**	**$96,238**

Table 6 - IRR

System Size	Duration	IRR
2 MW / 4.5 MWh	2.25-hour	-0.75%

Table 7 - IRR with Grant

System Size	Duration	IRR
2 MW / 4.5 MWh	2.25-hour	19.77%

Table 8 - Year 1 Savings

Service	Savings
BESS Cost Savings	$179,836
Solar Costs Savings	$80,551
Total Year 1 Cost Savings	$260,387

Optimized Dispatch

The model employs a practical logic for simulating the BESS charge and discharge cycle such that the BESS brings down the real peak to target peak for every 15 min interval.

The operating logic sets a target peak at 95% of the load in the first 15 minutes of every month. In subsequent intervals, the BESS discharges to bring the actual load closer to this target if the actual load is greater and charges if the actual load is lower. As the load increases during the day, the BESS at some point fails to achieve the target due to its limited duration. Consequently, the operating logic then revises the target for the rest of the month to the "missed peak", as the District will be charged for this peak even it maintains a lower peak during the rest of the month.

Therefore, the methodology allows for a rolling target peak that automatically adjusts to the actual peak for every billing period, without having knowledge of the future.

Figure 6 and Table 9 show the optimized seasonal dispatch for the business model.

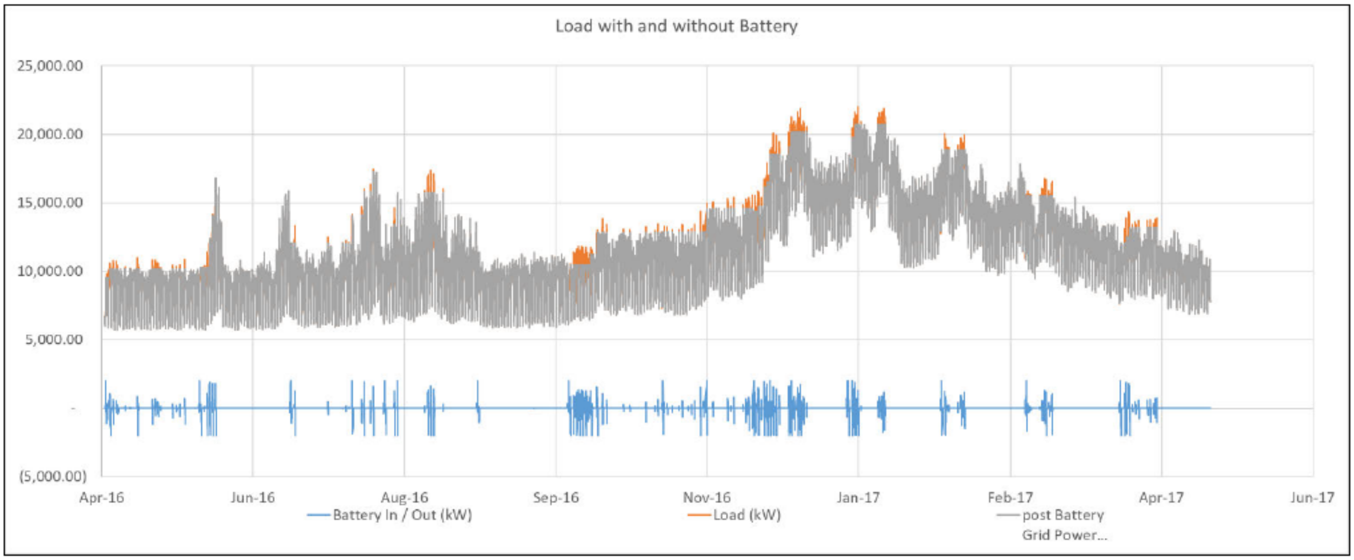

Figure 6 - Load with and without Battery

Table 9 - Seasonal Dispatch (Average Battery Power)

	Hour starting →																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 Jan	-11	-3	-12	0	0	0	0	1	59	180	98	-31	-121	-58	-32	-3	-3	42	199	130	-30	-126	-237	-151
2 Feb	12	-1	-4	1	11	30	56	37	19	43	-27	-57	-50	-21	-63	-21	0	0	50	64	3	-57	-78	0
3 Mar	11	-4	-8	0	0	1	19	59	78	52	-15	-65	-80	-61	-17	0	0	0	41	87	41	-43	-91	-58
4 Apr	-10	-1	-7	0	0	5	39	180	187	116	1	-75	-142	-204	-171	-15	0	27	39	26	23	-14	-36	-66
5 May	-18	0	0	0	0	0	9	37	91	73	44	8	-13	-46	-62	-39	-6	117	63	-32	-41	-30	-162	-73
6 Jun	-15	-5	-1	0	0	1	36	66	30	-2	1	-3	20	24	54	107	114	116	23	-66	-145	-137	-188	-119
7 Jul	-3	-6	0	0	0	0	0	14	48	65	3	0	-2	0	-17	23	96	225	57	-106	-196	-186	-48	-62
8 Aug	7	-6	-2	0	0	0	0	18	59	52	-2	2	-3	4	49	110	151	166	96	-66	-214	-245	-245	-36
9 Sep	6	-7	0	0	0	0	18	47	67	1	0	-3	3	-9	-20	-29	-31	-18	-18	-26	-1	0	0	0
10 Oct	1	-2	-5	0	0	4	21	131	221	138	102	51	20	-71	-132	-124	-65	83	170	189	-13	-186	-422	-297
11 Nov	7	5	1	1	8	26	63	23	1	6	-2	-17	-37	-35	-7	-9	-10	47	295	28	-133	-164	-176	-11
12 Dec	-117	-6	0	0	0	0	12	55	112	142	85	-6	-133	-184	-91	-27	-2	216	629	409	13	-269	-543	-549

Component Costs

Table 10 shows the capital expenditure (CAPEX) and annual operational expenditure (OPEX) included in the IRR calculation. The CAPEX includes initial battery oversize and augmentation cost, and the OPEX includes insurance, auxiliary cost, and all operating, monitoring, and maintenance cost. Soft costs are expenses related to feasibility studies, permitting and legal. [redacted]

Table 10 - CAPEX & OPEX

Battery Capital Expenditure			
Battery power	2,000	kW	
Battery energy	4,500	kWh	
Batteries & BMS	$1,872,000	[redacted]	$/kWh
Enclosure and thermal management	$360,000	[redacted]	$/kWh
Inverters, bi-directional	$213,333	[redacted]	$/kW
Balance of Plant	$400,000	[redacted]	$/kW
EPC	$133,333	[redacted]	$/kW
Electrical system upgrade	$850,000		
Grant	$0		
5 yr Warranty	$43,333	[redacted]	
Battery hard cost	**$3,872,000**		
Battery soft cost	$53,333	[redacted]	$/kW
Total battery cost	**$3,925,333**	**872.30**	**$/kWh**

Solar Capital Expenditure			
Solar panel capacity	1,300	kWp	
Solar inverter capacity	1,000	kWac	
Capital costs			
Solar Panels	$650,000	[redacted]	$/Wp
Racking	$195,000	[redacted]	$/Wp
Inverters, with DC Disconnect, Transformers	$180,000	[redacted]	$/Wac
BOS	$195,000	[redacted]	$/Wp
Overhead for EPC, Developer	$260,000	[redacted]	$/Wp
Permits and project management	$66,667	[redacted]	$/Wac
Labor	$346,667	[redacted]	$/Wp
Installation overhead	$325,000	[redacted]	$/Wp
Electrical system upgrade	$850,000		
Grant	$0		
Land purchase and preparation	$17,333	[redacted]	$/Wp
Total solar pv hard cost	**$3,085,667**	[redacted]	**$/Wp**
Solar pv soft cost	$69,333	[redacted]	$/Wp
Total solar pv cost	**$3,155,000**	**2.43**	**$/Wp**

Annual OPEX

Battery			
Insurance	$5,957	[redacted]	% of hard costs
Monitoring & Maintenance	$40,000	[redacted]	$/kW
Total annual battery cost	**$45,957**		

Solar			
Insurance	$3,334	[redacted]	% of hard cost
Operating cost	$20,800	[redacted]	$/kWp
Total annual solar pv cost	$24,134		

Retail price of electricity ($/MWh) **95.00**

Other project annual cost

Cost	**Cost**	**Escalation**			**Accounting**
Aux load	$2,119		**0%**	of revenue	BESS

Table 11 shows the BESS degradation and average State of Charge (SOC) over the project life. Whichever degradation mechanism (Calendar Life or Cycle Life) is most limiting is applied to calculate the BESS Capacity.

[redacted]

Figure 7 shows battery degradation over the project life. [redacted] The battery's useable capacity remains constant at 100% throughout project life. [redacted]

[redacted]

S+S – AC Coupled (LFP)

A FTM AC-coupled solar+storage, distribution-connected, 2 MW BESS in the DoS territory. The chemistry is lithium iron phosphate (LFP), the 2nd most common chemistry (e.g. BYD). The BESS performs:

- Solar Energy Savings: The Solar PV generation reduces consumption of electricity from Fortis BC, resulting in bill savings from the avoidance of purchasing energy from Fortis BC.
- Demand Charge Mitigation: The BESS charges at the flat retail rate and discharges during peak hours to reduce Wires Charges and Peak Supply Charges.

Ownership: The analysis below shows a 100% equity model, owned and operated by DoS.

Optional services can include:

- Volt / Var: The BESS can provide feeder reliability by providing real and reactive power.
- Resiliency: The BESS can provide optional resiliency by islanding a feeder segment for a specific duration of time (additional cost for islanding disconnect and reclosers).
- Distribution Deferral: The BESS can provide site-specific infrastructure investment deferral by improving operational and loading characteristics of the feeder and transformer during peak hours.

Site Overview

Table 12 shows the business model parameters.

Table 12 - Parameters

General	Batteries and Balance of Plant
Power / Energy: 2 MW / 4.5 MWh	[redacted]
Configuration: AC Coupled	85% Round-trip Efficiency
Chemistry: LFP	COD: 2019
C-Rate: 0.5C	Solar PV
POI Voltage: 8.32 kV	Inverter Sizing: 1 MW
Project Life: Solar (35 yr) Storage (20 yr)	Panel Sizing: 1.3 MWp
Taxation: 0% Fed; 0% State	DC/AC: 1.3

Results

Table 13 shows cost savings across a variety of storage durations (i.e. different C-rates). Table 14 and Table 15 show project IRR for a 2.25 hour duration battery with and without the grant, respectively. Table 16 shows the year 1 revenue for BESS and solar PV.

Table 13 – Cost Savings (Sensitivity Analysis)

2 MW BESS with Different Durations (hr)								
1	1.25	1.5	1.75	2	2.25	2.5	2.75	3
$122,948	**$135,250**	**$144,169**	**$150,018**	**$162,871**	**$179,836**	**$152,853**	**$179,662**	**$96,238**

Table 14 - IRR

System Size	Duration	IRR
2 MW / 4.5 MWh	2.25-hour	-0.38%

Table 15 - IRR with Grant

System Size	Duration	IRR
2 MW / 4.5 MWh	2.25-hour	29.68%

Table 16 - Year 1 Savings

Service	Savings
BESS Cost Savings	$179,836
Solar Costs Savings	$80,551
Total Year 1 Cost Savings	$260,387

Optimized Dispatch

The model employs a practical logic for simulating the BESS charge and discharge cycle such that the BESS brings down the real peak to target peak for every 15 min interval.

The operating logic sets a target peak at 95% of the load in the first 15 minutes of every month. In subsequent intervals, the BESS discharges to bring the actual load closer to this target if the actual load is greater and charges if the actual load is lower. As the load increases during the day, the BESS at some point fails to achieve the target due to its limited duration. Consequently, the operating logic then revises the target for the rest of the month to the “missed peak”, as the District will be charged for this peak even it maintains a lower peak during the rest of the month.

Therefore, the methodology allows for a rolling target peak that automatically adjusts to the actual peak for every billing period, without having knowledge of the future.

Figure 8 and Table 17 show the optimized seasonal dispatch for the business model.

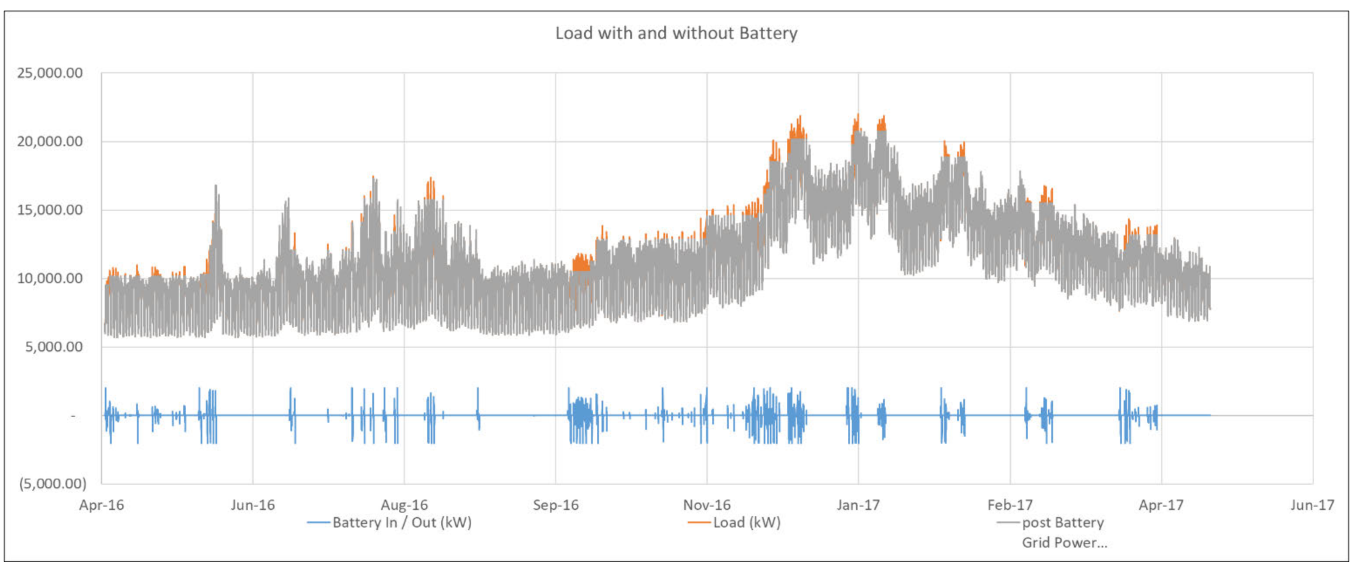

Figure 8 - Load with and without Battery

Table 17 - Seasonal Dispatch (Average Battery Power)

	Hour starting →																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 Jan	-11	-3	-12	0	0	0	0	1	59	180	98	-31	-121	-58	-32	-3	-3	42	199	130	-30	-126	-237	-151
2 Feb	12	-1	-4	1	11	30	56	37	19	43	-27	-57	-50	-21	-63	-21	0	0	50	64	3	-57	-78	0
3 Mar	11	-4	-8	0	0	1	19	59	78	52	-15	-65	-80	-61	-17	0	0	0	41	87	41	-43	-91	-58
4 Apr	-10	-1	-7	0	0	5	39	180	187	116	1	-75	-142	-204	-171	-15	0	27	39	26	23	-14	-36	-66
5 May	-18	0	0	0	0	0	9	37	91	73	44	8	-13	-46	-62	-39	-6	117	63	-32	-41	-30	-162	-73
6 Jun	-15	-5	-1	0	0	1	36	66	30	-2	1	-3	20	24	54	107	114	116	23	-66	-145	-137	-188	-119
7 Jul	-3	-6	0	0	0	0	0	14	48	65	3	0	-2	0	-17	23	96	225	57	-106	-196	-186	-48	-62
8 Aug	7	-6	-2	0	0	0	0	18	59	52	-2	2	-3	4	49	110	151	166	96	-66	-214	-245	-245	-36
9 Sep	6	-7	0	0	0	0	18	47	67	1	0	-3	3	-9	-20	-29	-31	-18	-18	-26	-1	0	0	0
10 Oct	1	-2	-5	0	0	4	21	131	221	138	102	51	20	-71	-132	-124	-65	83	170	189	-13	-186	-422	-297
11 Nov	7	5	1	1	8	26	63	23	1	6	-2	-17	-37	-35	-7	-9	-10	47	295	28	-133	-164	-176	-11
12 Dec	-117	-6	0	0	0	0	12	55	112	142	85	-6	-133	-184	-91	-27	-2	216	629	409	13	-269	-543	-549

Component Costs

Table 18 shows the capital expenditure (CAPEX) and annual operational expenditure (OPEX) included in the IRR calculation. The CAPEX includes initial battery oversize and augmentation cost, and the OPEX includes insurance, auxiliary cost, and all operating, monitoring, and maintenance cost. Soft costs are expenses related to feasibility studies, permitting and legal. [redacted]

Table 18 - CAPEX & OPEX

Battery Capital Expenditure			
Battery power	2,000 kW		
Battery energy	4,500 kWh		
Batteries & BMS	$1,497,600	[redacted]	$/kWh
Enclosure and thermal management	$360,000	[redacted]	$/kWh
Inverters, bi-directional	$213,333	[redacted]	$/kW
Balance of Plant	$400,000	[redacted]	$/kW
EPC	$133,333	[redacted]	$/kW
Electrical system upgrade	$850,000		
Grant	$0		
5 yr Warranty	$43,333	[redacted]	
Battery hard cost	**$3,497,600**		
Battery soft cost	$53,333	[redacted]	$/kW
Total battery cost	**$3,550,933**	**789.10**	**$/kWh**

Solar Capital Expenditure

Solar panel capacity	1,300	kWp
Solar inverter capacity	1,000	kWac

Capital costs			
Solar Panels	$650,000	[redacted]	$/Wp
Racking	$195,000	[redacted]	$/Wp
Inverters, with DC Disconnect, Transformers	$180,000	[redacted]	$/Wac
BOS	$195,000	[redacted]	$/Wp
Overhead for EPC, Developer	$260,000	[redacted]	$/Wp
Permits and project management	$66,667	[redacted]	$/Wac
Labor	$346,667	[redacted]	$/Wp
Installation overhead	$325,000	[redacted]	$/Wp
Electrical system upgrade	$850,000		
Grant	$0		
Land purchase and preparation	$17,333	[redacted]	$/Wp
Total solar pv hard cost	**$3,085,667**	[redacted]	**$/Wp**
Solar pv soft cost	$69,333	[redacted]	$/Wp
Total solar pv cost	**$3,155,000**	**2.43**	**$/Wp**

Annual OPEX

Battery			
Insurance	$5,209	[redacted]	% of hard costs
Monitoring & Maintenance	$40,000	[redacted]	$/kW
Total annual battery cost	**$45,209**		

Solar			
Insurance	$3,334	[redacted]	% of hard cost
Operating cost	$20,800	[redacted]	$/kWp
Total annual solar pv cost	$24,134		

Retail price of electricity ($/MWh) **95.00**

Other project annual cost

Cost	**Cost**	**Escalation**			**Accounting**
Aux load	$2,119		**0%**	of revenue	BESS

Table 19 shows the BESS degradation and average State of Charge (SOC) over the project life. Whichever degradation mechanism (Calendar Life or Cycle Life) is most limiting is applied to calculate the BESS Capacity.

[redacted]

Figure 9 shows battery degradation over the project life. [redacted] The battery's useable capacity remains constant at 100% throughout project life. [redacted]

[redacted]

S+S – DC Coupled (NMC)

A FTM DC-coupled solar+storage, distribution-connected, 2 MW BESS in the DoS territory. The chemistry is lithium nickel manganese cobalt oxide (NMC), the most common chemistry (e.g. Samsung and LGChem). The BESS performs:

- Solar Energy Savings: The Solar PV generation reduces consumption of electricity from Fortis BC, resulting in bill savings from the avoidance of purchasing energy from Fortis BC.
- Demand Charge Mitigation: The BESS charges at the flat retail rate and discharges during peak hours to reduce Wires Charges and Peak Supply Charges.

Ownership: The analysis below shows a 100% equity model, owned and operated by DoS.

Optional services can include:

- Volt / Var: The BESS can provide feeder reliability by providing real and reactive power.
- Resiliency: The BESS can provide optional resiliency by islanding a feeder segment for a specific duration of time (additional cost for islanding disconnect and reclosers).
- Distribution Deferral: The BESS can provide site-specific infrastructure investment deferral by improving operational and loading characteristics of the feeder and transformer during peak hours.

Site Overview

Table 20 shows the business model parameters.

Table 20 - Parameters

General	Batteries and Balance of Plant
Power / Energy: 2 MW / 4.5 MWh	[redacted]
Configuration: DC Coupled	90% Round-trip Efficiency
Chemistry: NMC	COD: 2019
C-Rate: 0.5C	Solar PV
POI Voltage: 8.32 kV	Inverter Sizing: 1 MW
Project Life: Solar (35 yr) Storage (20 yr)	Panel Sizing: 1.3 MWp
Taxation: 0% Fed; 0% State	DC/AC: 1.3

Results

Table 21 shows cost savings across a variety of storage durations (i.e. different C-rates). Table 22 and Table 23 show project IRR for a 2.25 hour duration battery with and without the grant, respectively. Table 24Table 8 shows the year 1 revenue for BESS and solar PV.

Table 21 – Cost Savings (Sensitivity Analysis)

2 MW DC-Coupled BESS with Different Durations (hr)								
1 hr	1.25 hr	1.5 hr	1.75 hr	2 hr	2.25 hr	2.5 hr	2.75 hr	3 hr
$123,755	$136,233	$145,221	$152,949	$164,919	$181,477	$154,598	$185,625	$98,160

Table 22 - IRR

System Size	Duration	IRR
2 MW / 4.5 MWh	2.25-hour	-0.31%

Table 23 - IRR with Grant

System Size	Duration	IRR
2 MW / 4.5 MWh	2.25-hour	30.98%

Table 24 - Year 1 Savings

Service	Savings
BESS Cost Savings	$181,477
Solar Costs Savings	$80,551
Total Year 1 Cost Savings	$262,028

Optimized Dispatch

The model employs a practical logic for simulating the BESS charge and discharge cycle such that the BESS brings down the real peak to target peak for every 15 min interval.

The operating logic sets a target peak at 95% of the load in the first 15 minutes of every month. In subsequent intervals, the BESS discharges to bring the actual load closer to this target if the actual load is greater and charges if the actual load is lower. As the load increases during the day, the BESS at some point fails to achieve the target due to its limited duration. Consequently, the operating logic then revises the target for the rest of the month to the “missed peak”, as the District will be charged for this peak even it maintains a lower peak during the rest of the month.

Therefore, the methodology allows for a rolling target peak that automatically adjusts to the actual peak for every billing period, without having knowledge of the future.

Figure 10 and Table 25 show the optimized seasonal dispatch for the business model.

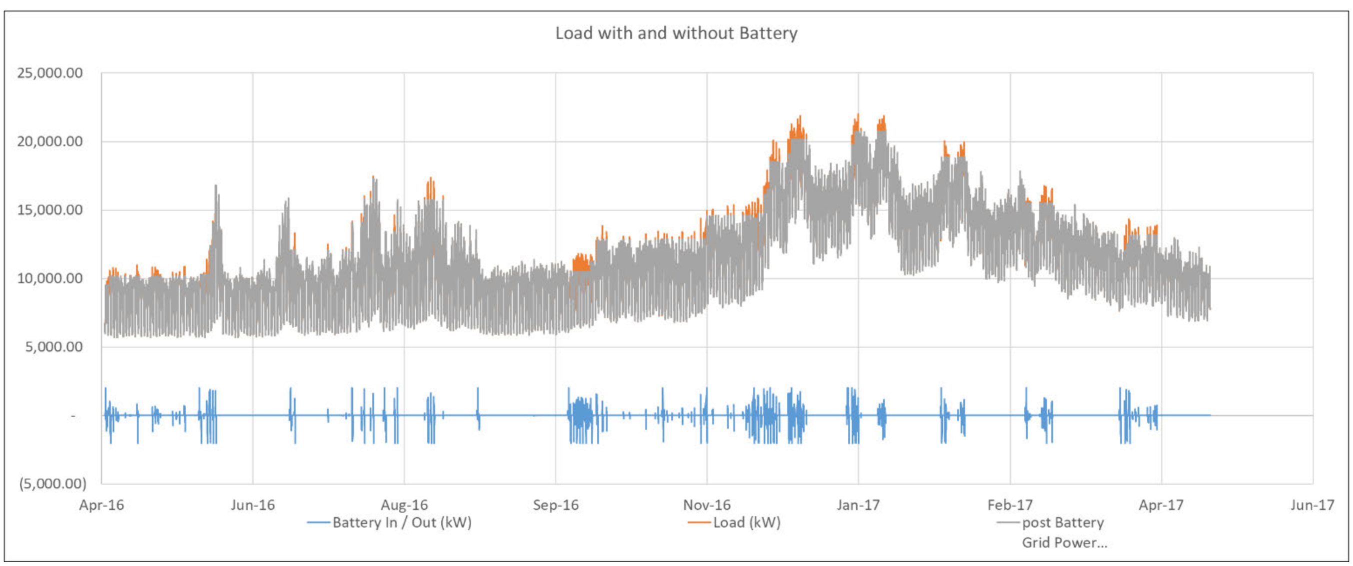

Figure 10 - Load with and without Battery

Table 25 - Seasonal Dispatch (Average Battery Power)

	Hour starting																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 Jan	-11	-3	-12	0	0	0	0	1	59	180	98	-31	-121	-58	-32	-3	-3	42	199	130	-30	-126	-237	-151
2 Feb	12	-1	-4	1	11	30	56	37	19	43	-27	-57	-50	-21	-63	-21	0	0	50	64	3	-57	-78	0
3 Mar	11	-4	-8	0	0	1	19	59	78	52	-15	-65	-80	-61	-17	0	0	0	41	87	41	-43	-91	-58
4 Apr	-10	-1	-7	0	0	5	39	180	187	116	1	-75	-142	-204	-171	-15	0	27	39	26	23	-14	-36	-66
5 May	-18	0	0	0	0	0	9	37	91	73	44	8	-13	-46	-62	-39	-6	117	63	-32	-41	-30	-162	-73
6 Jun	-15	-5	-1	0	0	1	36	66	30	-2	1	-3	20	24	54	107	114	116	23	-66	-145	-137	-188	-119
7 Jul	-3	-6	0	0	0	0	0	14	48	65	3	0	-2	0	-17	23	96	225	57	-106	-196	-186	-48	-62
8 Aug	7	-6	-2	0	0	0	0	18	59	52	-2	2	-3	4	49	110	151	166	96	-66	-214	-245	-245	-36
9 Sep	6	-7	0	0	0	0	18	47	67	1	0	-3	3	-9	-20	-29	-31	-18	-18	-26	-1	0	0	0
10 Oct	1	-2	-5	0	0	4	21	131	221	138	102	51	20	-71	-132	-124	-65	83	170	189	-13	-186	-422	-297
11 Nov	7	5	1	1	8	26	63	23	1	6	-2	-17	-37	-35	-7	-9	-10	47	295	28	-133	-164	-176	-11
12 Dec	-117	-6	0	0	0	0	12	55	112	142	85	-6	-133	-184	-91	-27	-2	216	629	409	13	-269	-543	-549

Component Costs

Table 26 shows the capital expenditure (CAPEX) and annual operational expenditure (OPEX) included in the IRR calculation. The CAPEX includes initial battery oversize and augmentation cost, and the OPEX includes insurance, auxiliary cost, and all operating, monitoring, and maintenance cost. Soft costs are expenses related to feasibility studies, permitting and legal. [redacted]

Table 26 - CAPEX & OPEX

Battery Capital Expenditure			
Battery power	2,000 kW		
Battery energy	4,500 kWh		
Batteries & BMS	$1,872,000	[redacted]	$/kWh
Enclosure and thermal management	$360,000	[redacted]	$/kWh
Inverters, bi-directional	$213,333	[redacted]	$/kW
Balance of Plant	$0	[redacted]	$/kW
EPC	$133,333	[redacted]	$/kW
Electrical system upgrade	$850,000		
Grant	$0		
5 yr Warranty	$43,333	[redacted]	
Battery hard cost	**$3,472,000**		
Battery soft cost	$53,333	[redacted]	$/kW
Total battery cost	**$3,525,333**	**783.41**	**$/kWh**

Solar Capital Expenditure

Solar panel capacity	1,300	kWp
Solar inverter capacity	1,000	kWac

Capital costs			
Solar Panels	$650,000	[redacted]	$/Wp
Racking	$195,000	[redacted]	$/Wp
Inverters, with DC Disconnect, Transformers	$180,000	[redacted]	$/Wac
BOS	$195,000	[redacted]	$/Wp
Overhead for EPC, Developer	$260,000	[redacted]	$/Wp
Permits and project management	$66,667	[redacted]	$/Wac
Labor	$346,667	[redacted]	$/Wp
Installation overhead	$325,000	[redacted]	$/Wp
Electrical system upgrade	$850,000		
Grant	$0		
Land purchase and preparation	$17,333	[redacted]	$/Wp
Total solar pv hard cost	**$3,085,667**	[redacted]	**$/Wp**
Solar pv soft cost	$69,333	[redacted]	$/Wp
Total solar pv cost	**$3,155,000**	**2.43**	**$/Wp**

Annual OPEX

Battery			
Insurance	$5,157	[redacted]	% of hard costs
Monitoring & Maintenance	$40,000	[redacted]	$/kW
Total annual battery cost	**$45,157**		

Solar			
Insurance	$3,334	[redacted]	% of hard cost
Operating cost	$20,800	[redacted]	$/kWp
Total annual solar pv cost	$24,134		

Retail price of electricity ($/MWh) **95.00**

Other project annual cost

Cost	**Cost**	**Escalation**			**Accounting**
Aux load	$2,119		**0%**	of revenue	BESS

Degradation Management Strategy

Table 27 shows the BESS degradation and average State of Charge (SOC) over the project life. Whichever degradation mechanism (Calendar Life or Cycle Life) is most limiting is applied to calculate the BESS Capacity.

[redacted]

Figure 11 shows battery degradation over the project life. [redacted] The battery's useable capacity remains constant at 100% throughout project life. [redacted]

[redacted]

S+S – DC Coupled (LFP)

A FTM DC-coupled solar+storage, distribution-connected, 2 MW BESS in the DoS territory. The chemistry is lithium iron phosphate (LFP), the 2nd most common chemistry (e.g. BYD). The BESS performs:

- Solar Energy Savings: The Solar PV generation reduces consumption of electricity from Fortis BC, resulting in bill savings from the avoidance of purchasing energy from Fortis BC.
- Demand Charge Mitigation: The BESS charges at the flat retail rate and discharges during peak hours to reduce Wires Charges and Peak Supply Charges.

Ownership: The analysis below shows a 100% equity model, owned and operated by DoS.

Optional services can include:

- Volt / Var: The BESS can provide feeder reliability by providing real and reactive power.
- Resiliency: The BESS can provide optional resiliency by islanding a feeder segment for a specific duration of time (additional cost for islanding disconnect and reclosers).
- Distribution Deferral: The BESS can provide site-specific infrastructure investment deferral by improving operational and loading characteristics of the feeder and transformer during peak hours.

Site Overview

Table 28 shows the business model parameters.

Table 28 - Parameters

General	Batteries and Balance of Plant
Power / Energy: 2 MW / 4.5 MWh	[redacted]
Configuration: DC Coupled	90% Round-trip Efficiency
Chemistry: LFP	COD: 2019
C-Rate: 0.5C	Solar PV
POI Voltage: 8.32 kV	Inverter Sizing: 1 MW
Project Life: Solar (35 yr) Storage (20 yr)	Panel Sizing: 1.3 MWp
Taxation: 0% Fed; 0% State	DC/AC: 1.3

Results

Table 29 shows cost savings across a variety of storage durations (i.e. different C-rates). Table 30 and Table 31 show project IRR for a 2.25 hour duration battery with and without the grant, respectively. Table 32 shows the year 1 revenue for BESS and solar PV.

Table 29 – Cost Savings (Sensitivity Analysis)

2 MW DC-Coupled BESS with Different Durations (hr)								
1 hr	1.25 hr	1.5 hr	1.75 hr	2 hr	2.25 hr	2.5 hr	2.75 hr	3 hr
$123,755	$136,233	$145,221	$152,949	$164,919	$181,477	$154,598	$185,625	$98,160

Table 30 - IRR

System Size	Duration	IRR
2 MW / 4.5 MWh	2.25-hour	0.09%

Table 31 - IRR with Grant

System Size	Duration	IRR
2 MW / 4.5 MWh	2.25-hour	66.06%

Table 32 - Year 1 Savings

Service	Savings
BESS Cost Savings	$181,477
Solar Costs Savings	$80,551
Total Year 1 Cost Savings	$262,028

Optimized Dispatch

The model employs a practical logic for simulating the BESS charge and discharge cycle such that the BESS brings down the real peak to target peak for every 15 min interval.

The operating logic sets a target peak at 95% of the load in the first 15 minutes of every month. In subsequent intervals, the BESS discharges to bring the actual load closer to this target if the actual load is greater and charges if the actual load is lower. As the load increases during the day, the BESS at some point fails to achieve the target due to its limited duration. Consequently, the operating logic then revises the target for the rest of the month to the “missed peak”, as the District will be charged for this peak even it maintains a lower peak during the rest of the month.

Therefore, the methodology allows for a rolling target peak that automatically adjusts to the actual peak for every billing period, without having knowledge of the future.

Figure 12 and Table 33 show the optimized seasonal dispatch for the business model.

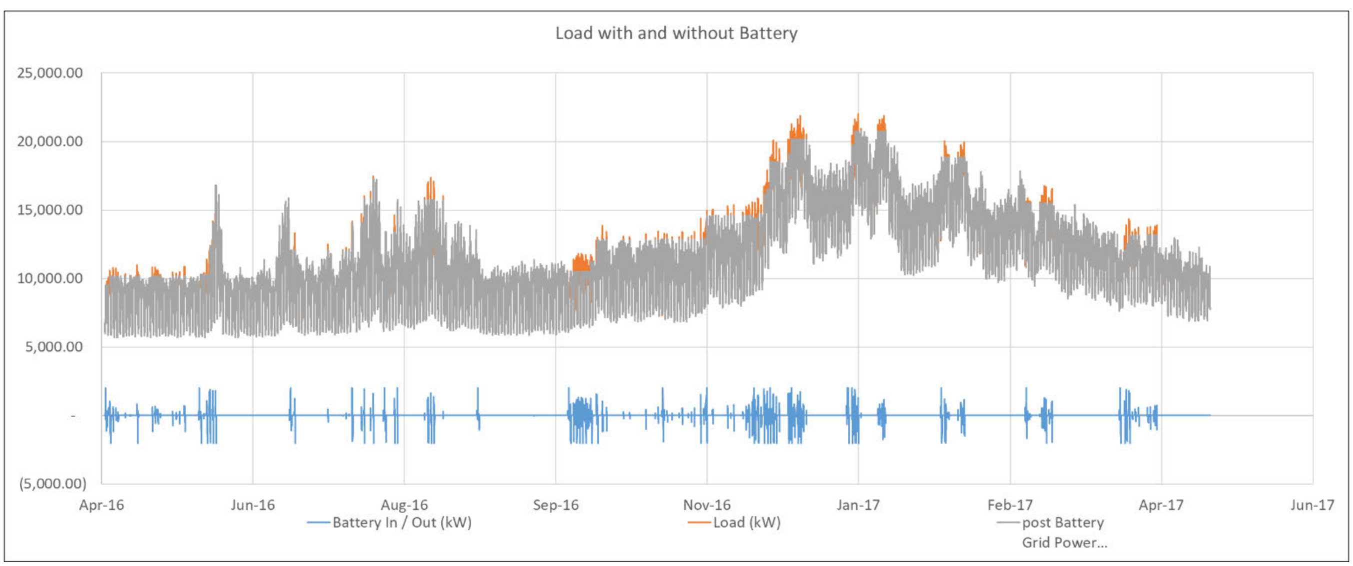

Figure 12 - Load with and without Battery

Table 33 - Seasonal Dispatch (Average Battery Power)

Hour starting	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 Jan	-11	-3	-12	0	0	0	0	1	59	180	98	-31	-121	-58	-32	-3	-3	42	199	130	-30	-126	-237	-151
2 Feb	12	-1	-4	1	11	30	56	37	19	43	-27	-57	-50	-21	-63	-21	0	0	50	64	3	-57	-78	0
3 Mar	11	-4	-8	0	0	1	19	59	78	52	-15	-65	-80	-61	-17	0	0	0	41	87	41	-43	-91	-58
4 Apr	-10	-1	-7	0	0	5	39	180	187	116	1	-75	-142	-204	-171	-15	0	27	39	26	23	-14	-36	-66
5 May	-18	0	0	0	0	0	9	37	91	73	44	8	-13	-46	-62	-39	-6	117	63	-32	-41	-30	-162	-73
6 Jun	-15	-5	-1	0	0	1	36	66	30	-2	1	-3	20	24	54	107	114	116	23	-66	-145	-137	-188	-119
7 Jul	-3	-6	0	0	0	0	0	14	48	65	3	0	-2	0	-17	23	96	225	57	-106	-196	-186	-48	-62
8 Aug	7	-6	-2	0	0	0	0	18	59	52	-2	2	-3	4	49	110	151	166	96	-66	-214	-245	-245	-36
9 Sep	6	-7	0	0	0	0	18	47	67	1	0	-3	3	-9	-20	-29	-31	-18	-18	-26	-1	0	0	0
10 Oct	1	-2	-5	0	0	4	21	131	221	138	102	51	20	-71	-132	-124	-65	83	170	189	-13	-186	-422	-297
11 Nov	7	5	1	1	8	26	63	23	1	6	-2	-17	-37	-35	-7	-9	-10	47	295	28	-133	-164	-176	-11
12 Dec	-117	-6	0	0	0	0	12	55	112	142	85	-6	-133	-184	-91	-27	-2	216	629	409	13	-269	-543	-549

Component Costs

Table 34 shows the capital expenditure (CAPEX) and annual operational expenditure (OPEX) included in the IRR calculation. The CAPEX includes initial battery oversize and augmentation cost, and the OPEX includes insurance, auxiliary cost, and all operating, monitoring, and maintenance cost. Soft costs are expenses related to feasibility studies, permitting and legal. [redacted]

Table 34 - CAPEX & OPEX

Battery Capital Expenditure		
Battery power	2,000 kW	
Battery energy	4,500 kWh	
Batteries & BMS	$1,497,600	[redacted] $/kWh
Enclosure and thermal management	$360,000	[redacted] $/kWh
Inverters, bi-directional	$213,333	[redacted] $/kW
Balance of Plant	$0	[redacted] $/kW
EPC	$133,333	[redacted] $/kW
Electrical system upgrade	$850,000	
Grant	$0	
5 yr Warranty	$43,333	[redacted]
Battery hard cost	**$3,097,600**	
Battery soft cost	$53,333	[redacted] $/kW
Total battery cost	**$3,150,933**	**700.21 $/kWh**

Solar Capital Expenditure

Solar panel capacity	1,300	kWp	
Solar inverter capacity	1,000	kWac	

Capital costs			
Solar Panels	$650,000	[redacted]	$/Wp
Racking	$195,000	[redacted]	$/Wp
Inverters, with DC Disconnect, Transformers	$180,000	[redacted]	$/Wac
BOS	$195,000	[redacted]	$/Wp
Overhead for EPC, Developer	$260,000	[redacted]	$/Wp
Permits and project management	$66,667	[redacted]	$/Wac
Labor	$346,667	[redacted]	$/Wp
Installation overhead	$325,000	[redacted]	$/Wp
Electrical system upgrade	$850,000		
Grant	$0		
Land purchase and preparation	$17,333	[redacted]	$/Wp
Total solar pv hard cost	**$3,085,667**	[redacted]	**$/Wp**
Solar pv soft cost	$69,333	[redacted]	$/Wp
Total solar pv cost	**$3,155,000**	**2.43**	**$/Wp**

Annual OPEX

Battery			
Insurance	$4,409	[redacted]	% of hard costs
Monitoring & Maintenance	$40,000	[redacted]	$/kW
Total annual battery cost	**$44,409**		

Solar			
Insurance	$3,334	[redacted]	% of hard cost
Operating cost	$20,800	[redacted]	$/kWp
Total annual solar pv cost	$24,134		

Retail price of electricity ($/MWh) **95.00**

Other project annual cost

Cost	**Cost**	**Escalation**			**Accounting**
Aux load	$2,119		0%	of revenue	BESS

Degradation Management Strategy

Table 35 shows the BESS degradation and average State of Charge (SOC) over the project life. Whichever degradation mechanism (Calendar Life or Cycle Life) is most limiting is applied to calculate the BESS Capacity.

[redacted]

Figure 13 shows battery degradation over the project life. [redacted] The battery's useable capacity remains constant at 100% throughout project life. [redacted]

[redacted]

Appendix A - Application Benefits

Applications

Energy Shifting (or Solar Shifting)

The BESS charges during low prices (off-peak) and discharges during high prices (peak). It can reduce generator startups and alleviate line capacity. Alternatively, the storage can be charged using solar or wind. The BESS can be programmed to discharge at a fixed or load-dependent power level. Time shifting can be done autonomously or manually using the remote dispatch function. The user can remotely schedule or command the BESS via the human machine interface (HMI) or supervisory control and data acquisition (SCADA) interface.

Table 36 - Benefits of BESS Time Shifting

Customer Benefits	• Reduced fuel charges and infrastructure costs • Lower energy costs and retail rate stability
DoS Benefits	• Reduced operational cost of generating power during peak periods • Deferred infrastructure investment due to flatter loads with smaller peaks • Increased system efficiency • Reduced solar PV generation mismatch and backflow • Supports integration of additional renewable energy resources

Optional Applications

Distribution CAPEX Deferral

Storage can either: a) defer or avoid the need for distribution equipment upgrade or b) to extend the life of existing distribution equipment. A small amount of storage can be used to provide enough incremental capacity to defer the need for a large 'lump' investment in equipment. The highest loads occur on just a few days, for just a few hours per year. Deferral value reflects the utility's financial carrying charge for the new equipment involved in the upgrade. Carrying charges include the costs for financing, taxes, and insurance incurred for the duration of the deferral. The carrying charge per year is estimated by multiplying the utility fixed charge rate times the total installed battery capacity.

Table 37 - Benefits of BESS CAPEX Deferral

Customer Benefits	• Reduced infrastructure costs • Lower energy costs and retail rate stability
DoS Benefits	• Improved asset utilization • Freed capital for use on other projects • Reduced financial risk associated with lump investments • Reduced planning risk with load growth scenarios • Flexible and dispatchable peak load reduction strategy

Volt / Var Support

Voltage support offsets reactive effects to maintain grid voltage. Unlike system frequency, which is consistent across the network, voltage across the grid is different. To manage reactance at the grid level, system operators need voltage support resources to offset reactive effects to maintain and operate the transmission system and restore when unacceptable voltage excursions occur. Energy storage can support voltage by supplying reactive power and injecting real power.

Table 38 - Benefits of BESS Volt/Var Support

Customer Benefits	• Improved power quality and reliability
DoS Benefits	• Increased reliability and power quality resulting in improved customer satisfaction • Reduced power outages due to mitigated voltage fluctuates from renewable energy, air conditioning, compressors and motors • Distribution-connected storage can be more effective in providing reactive power thereby reducing related power outages • Reduced voltage excursions can avoid under-voltage load shedding (UVLS) • Increased system efficiency • Mitigates power quality challenges due to renewable energy resources

Resiliency

The BESS can provide resiliency by islanding a customer or feeder segment for a specific duration of time. Note: The BESS must be designed with proper components, breaker and protection schemes to island and grid-form. The BESS is sized to meet the customer(s) emergency requirements (load and duration). The BESS can provide stable and reliable power to: a) serve critical safety-related loads such as emergency lighting and medical equipment, b) reduce or avoid production loss, and c) reduce or avoid damage (e.g. electronics).

Table 39 - Benefits of Resiliency

Customer Benefits	• Increased reliability • Reduce fossil fuel generator usage • Business integrity and revenue protection
DoS Benefits	• Protection against unforeseen weather and grid events • Increased serviceability and satisfaction of critical customers • Supports sustainability initiatives and social responsibility • Economic development driver

Appendix B – Load Analysis

Figure 14 - Figure 17 show different views of DoS loads and costs. The different figures show various views of the DoS load profile and associated costs.

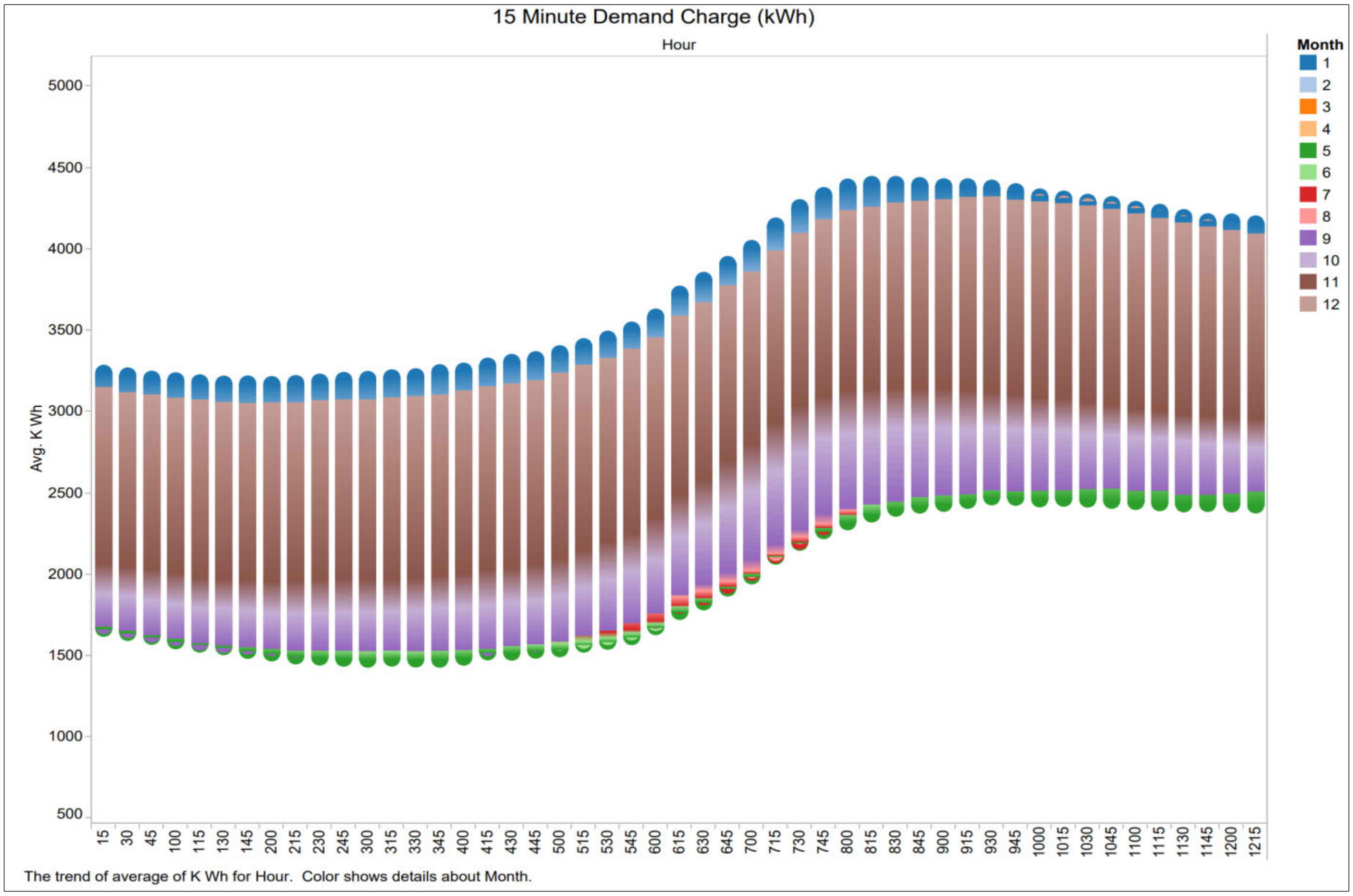

Figure 14 - Peak Loads by Month

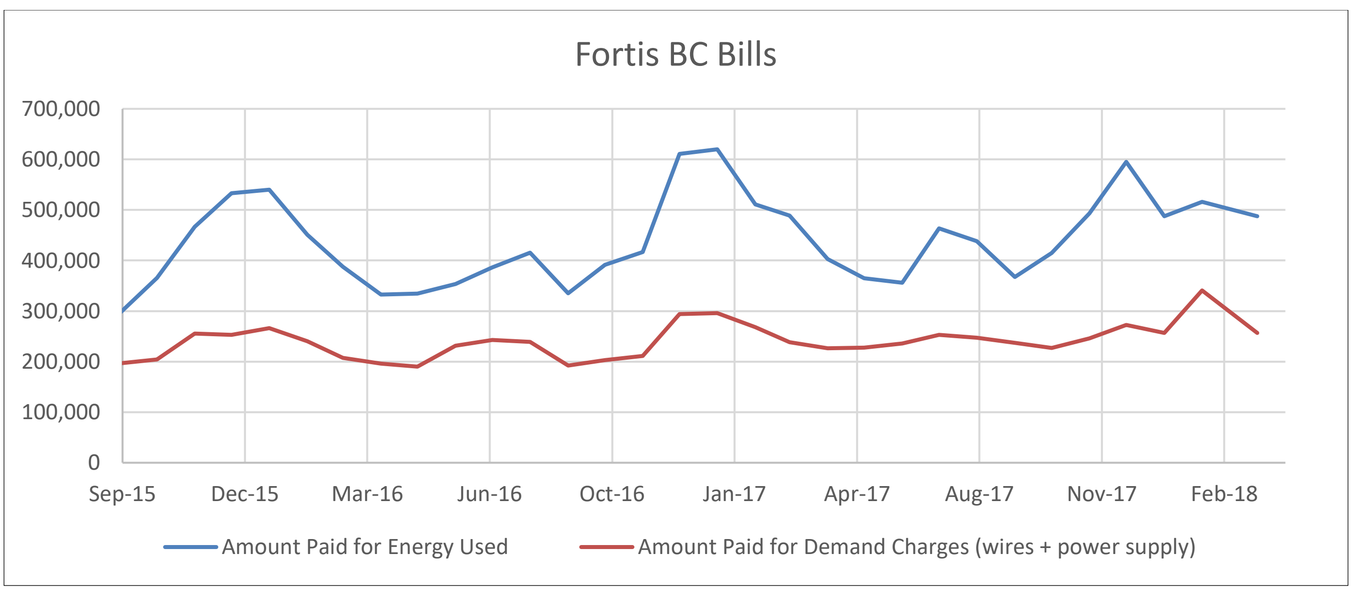

Figure 15 – Fortis BC Bills Summary

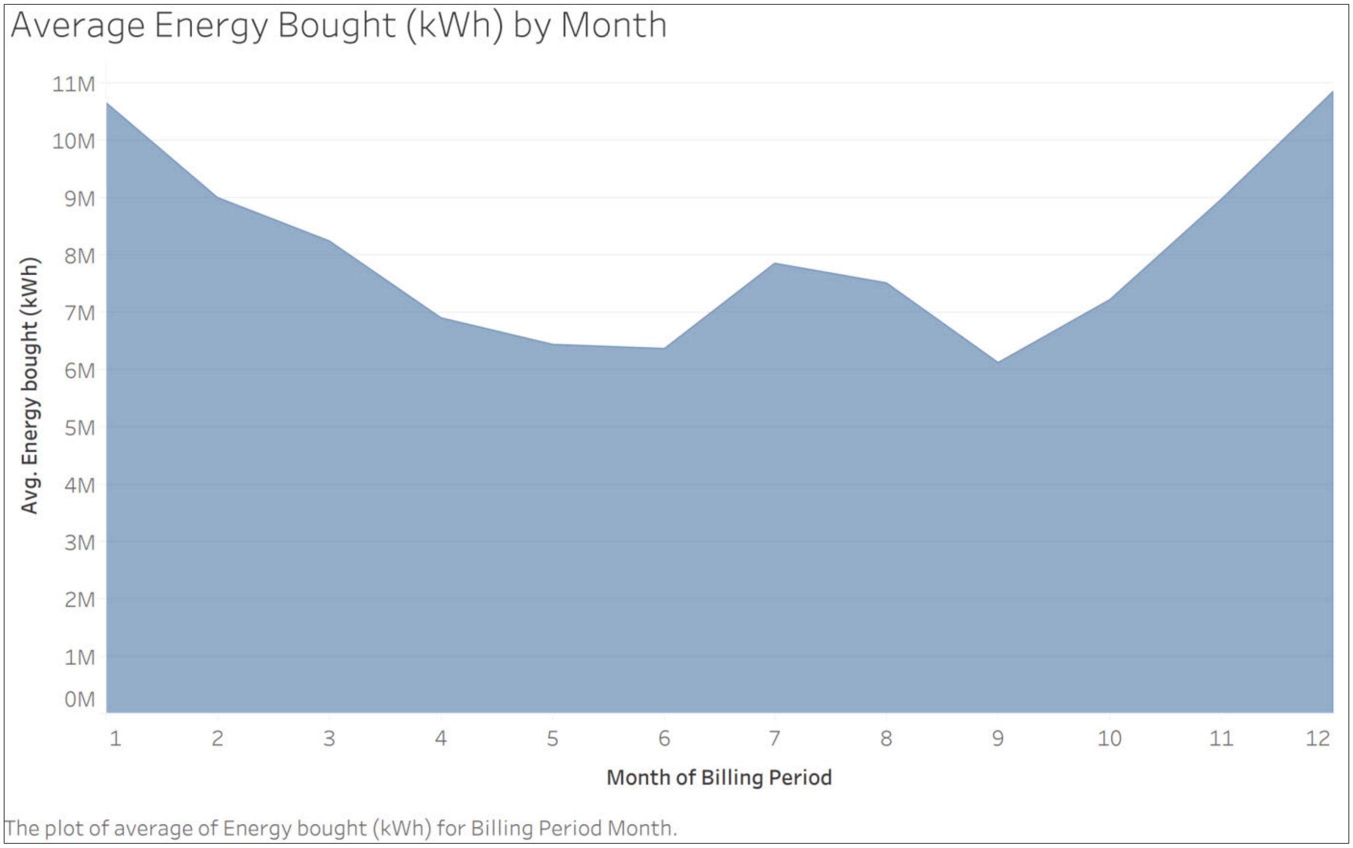

Figure 16 - Average Energy Purchased by Month

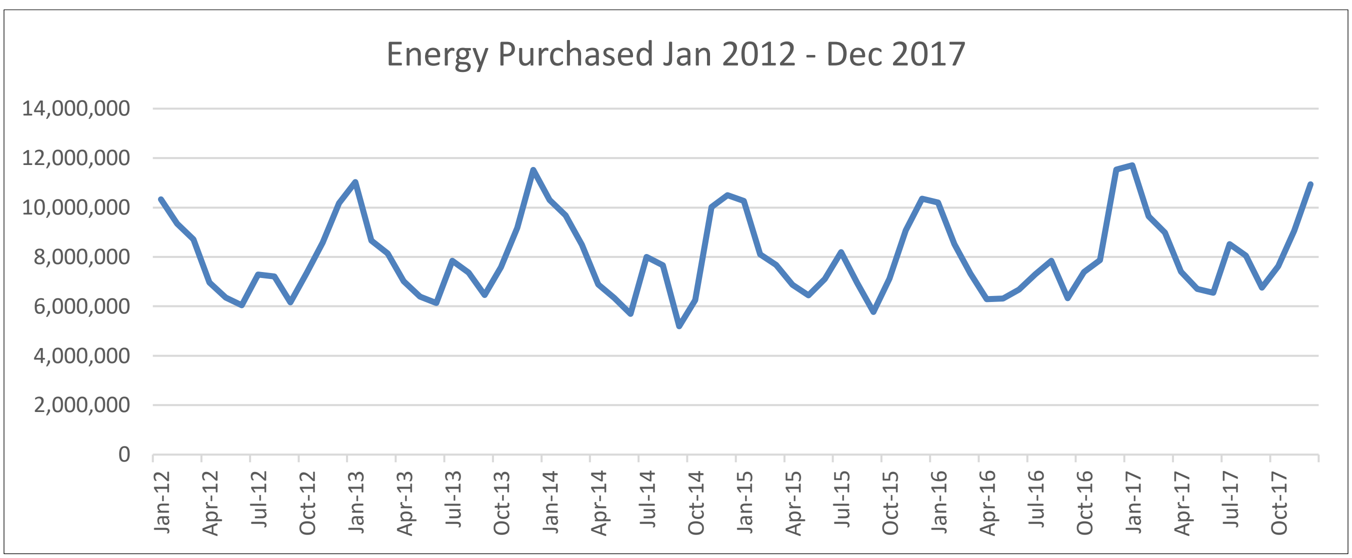

Figure 17 - Energy Purchased Jan. 2012 – Dec. 2017

Acronyms

Acronym	Definition
AC	Alternating Current
BESS	Battery Energy Storage System
BOL	Beginning of Life
BOP	Balance of Plant
DC	Direct Current
CAPEX	Capital Expenditure
COD	Commercial Operation Date
C Rate	Charge Rate
ESS	Energy Storage System
FTM	Front-of-the-Meter
HMI	Human Machine Interface
IA	Interconnection Agreement
ILR	Inverter Load Ratio
IRR	Internal Rate of Return
LSE	Load Serving Entity
NMC	Lithium Nickel Manganese Cobalt Oxide
O&M	Operation and Maintenance
OPEX	Operational Expenditure
POI	Point of Interconnection
PV	Photovoltaic
RPS	Renewable Portfolio Standard
SCADA	Supervisory Control and Data Acquisition
SOC	State of Charge
UVLS	Under Voltage Load Shedding
Volt / Var	Voltage and Reactive Power
YTD	Year to Date