NOTIFICATION OF THE BARBADOS LIGHT & POWER COMPANY LIMITED (BLPC) TO THE FAIR TRADING COMMISSION OF ITS INTENTION TO COMMISSION A 5MW ENERGY STORAGE RESOURCE AND APPLICATION FOR APPROVAL TO RECOVER THE COST OF THE STORAGE RESOURCE THROUGH THE FUEL CLAUSE ADJUSTMENT PURSUANT TO SECTION 16 OF THE UTILITIES REGULATION ACT, CAP 282 OF THE LAWS OF BARBADOS

A. APPLICATION

1. BLPC hereby notifies the Commission of its intention to install a 5 MW Energy Storage Device (ESD) as described below to enhance the grid's resilience, reliability and to lower fuel cost to customers. By virtue that the ESD will provide fuel savings benefits to customers, pursuant to Section 16 of the Utilities Regulation Act, Cap 282 (URA) and Rule 26 of the Utilities Regulation (Procedural) Rules S.I. 2003 No.104 of the Laws of Barbados, BLPC seeks the Fair Trading Commission's (Commission) approval of:
    a. Recovery of the costs of the ESD in proportion to the fuel savings benefits it delivers.
    b. The existing Fuel Clause Adjustment (FCA) as the mechanism to recover the costs of the ESD.

B. BACKGROUND

2. The FCA was originally established in 1965 for commercial and industrial customers and extended to include all customers in 1974. The Commission's forerunner, the Public Utilities Board (PUB), accepted that BLPC has to purchase fuel in order to generate electricity and permitted the recovery of all its fuel expenditure through a fuel clause adjustment mechanism.

3. The current monthly FCA is based on the sum of the previous month's cost of energy purchased and cost of fuel consumed, plus any cumulative over and under recovery divided by the kWh sales of the previous month. The cost of energy purchased currently includes energy purchased from renewable energy resources.

4. This Application seeks approval to include the relevant costs of the 5 MW ESD as an annual true-up or reconciliation in the FCA at an amount not greater than ninety-five percent (95%) of the value of the fuel savings the ESD delivers.

5. BLPC is committed to undertaking a major shift towards renewable and clean energy sources in support of the stated policy of the Government of Barbados to reduce the island's dependence on fossil fuels and facilitate greater energy price stability for customers.

6. In support of this policy objective BLPC has embraced a vision of:
   i. 100% Renewable or Clean Energy
   ii. 100% Electrification of business, industry and transportation

7. In addition to the projected fuel savings, the incorporation of cost effective, flexible and scalable energy storage is necessary to enable the sustainable achievement of clean energy objectives. Furthermore, energy storage will be required to smooth out the fluctuating supply of electricity from increasing intermittent renewable sources like solar and wind.

8. BLPC also plans to explore the installation of distributed energy storage at customers' premises. This, coupled with the proposed ESD, could further enhance reliability and customer experience.

C. CONCISE STATEMENT OF FACTS (Rule 26(1) (a) of the URP Rules)

9. BLPC is a vertically integrated electric utility company which was established on May 6, 1955 and incorporated on December 30, 1986 under the **Companies Act,** Cap 308 of the Laws of Barbados and has its registered office at Garrison Hill, St. Michael, Barbados. Pursuant to the Electric Light & Power Order, No. 3, set out in the Third Schedule of the **Electric Light and Power Act,** Cap 278 of the Laws of Barbados, BLPC was granted the right to supply energy for all public and private purposes for a period of forty-two years from August 1, 1986.

10. The Applicant is a wholly owned subsidiary of Emera Caribbean Inc. (the holding company).

11. The Applicant is required to manage the grid to ensure that the instantaneous supply of electricity meets constantly changing customers' demand. The varying need for cooling, commercial & industrial uses, lighting and other end uses drives daily and seasonal patterns.

12. To satisfy demand, BLPC operates four (4) generating plants using a mix of technologies including steam, diesel, gas turbines and solar photovoltaic to produce electricity. These technologies satisfy the requirements for both base and peaking loads.

13. The steam and diesel units operate primarily on Heavy Fuel Oil (HFO) and perform the baseload generation function of meeting the constant demand for electricity. Baseload plants have high capital costs but low variable costs, and technical constraints often restrict fast changes in their output, thus they are incentivized to run continuously and at a high capacity factor.

14. The steam and diesel units are sometimes also needed to operate at less efficient levels to serve as load following units, where they are required to increase and decrease output to match daily predictable demand fluctuations.

15. Gas turbines, operating on Av jet and diesel fuels are utilized as peaking plant to meet periods of very high demand. These turbines are less efficient than the baseload plants but are capable of quickly ramping up and down in response to the need for urgent increase or decrease in energy output.

16. Given the gas turbines' load following role and lower efficiency when compared to baseload units, the marginal fuel cost to customers increases as daily demand rises.

17. Furthermore, additional fuel costs are added to the system due to the necessity for BLPC to generally maintain operating reserves to meet unforeseen, unpredictable, and rapid fluctuations in the balancing of demand and supply for electricity.

D. GROUNDS FOR THE APPLICATION (Rule 26 (1)(b) of the Rules)

18. The utilization of an ESD can increase the efficiency of the dispatch of both the base load and peaking units. The ESD can meet some of the auxiliary services' role of frequency control and reserve capacity currently being supplied by base and peak load generation units much more reliably and efficiently, generating fuel savings.

19. Fuel savings would also be generated by the ESD providing energy shifting services. Energy shifting relates to the storage of electricity when the system generation costs are relatively lower and releasing the energy when system generation costs are higher.

20. The ESD can instantaneously adjust output or load to offset significant abrupt changes in system frequency. It can be designed to keep the frequency within specified limits in response to unexpected forced outages of generation facilities, or the loss of significant load, and to prevent frequency excursions that compromise system security which could lead to system outages.

21. Deploying the ESD for frequency control and regulation will allow the baseload generators currently utilized for load following to generate more energy, rather than providing spinning reserves. Additionally, fuel savings can be achieved through the ESD suppling a proportion of the support currently being supplied by peaking units. The instantaneous response capability of the ESD can result in greater fuel efficiency compared to the use of the current fossil fuel units.

The ESD

22. BLPC has identified the Tesla manufactured 5MW/4hour integrated lithium-ion packaged battery (Tesla PowerPack 2.0) as the ESD solution.

23. Trents generation station has been identified as the ideal location for the deployment of the ESD.

24. It is anticipated that the commissioning of the ESD will be no later than Q1, 2018 subject to regulatory approval being granted by the end of Q3, 2017. The granting of approval

outside of Q3, 2017 is likely to delay the commissioning of the ESD to the end of 2018 as BLPC would lose its current position in the manufacturer's production schedule.

25. The supply and installation of 5 MW/ 21 MWh ESD is estimated to cost a maximum of BDS$19,500,000 with a warranty life of ten (10) years.

26. The BLPC retained GE Energy Consulting in 2016 to conduct a Phase 2 Intermittent Renewable Energy Integration Study that included an examination of the potential value of 5 MW of battery storage on the grid.

27. The GE Study evaluated the fuel savings to the system that can be derived from integrating the 5 MW ESD into the grid and concluded that fuel savings in excess of BDS$2 million dollars annually can be realized through its frequency control and reserve capacity benefits.

28. BLPC conducted similar dispatch modelling analysis to that of GE Energy Consulting and has been able to confirm total net fuel savings benefits of approximately BDS$26.7 million over the useful life of the 5 MW ESD based on the fuel price assumptions in Table A2 of Appendix A.

Cost Recovery

29. BLPC is of the opinion that the FCA is an appropriate mechanism for recovery of both fuel-related and other costs incurred to deliver fuel savings to customers.

30. BLPC also views the Commission as having the flexibility to allow the recovery, through the FCA, of costs incurred to produce fuel savings from either avoiding the consumption of fossil fuels or the consumption of lower priced fuel at the plant.

31. The Applicant estimates that commissioning of the 5 MW ESD will result in direct fuel savings in the production of electricity to the amount of BDS$26.7 million over the life of the device.

32. The total cost of ownership of the ESD to be recovered over the device's useful life is estimated to be $22,947,770, consisting of the ESD cost and a return on capital. BLPC

proposes the recovery of this cost be contingent on its ability to achieve fuel savings. In this way, cost recovery is matched against the benefits that the ESD delivers.

33. The requirement that cost recovery be contingent on the ESD delivering actual fuel savings, eliminates the exposure of ratepayers to any price or operational risks associated with the ESD.

34. The interest of ratepayers is better served under the cost recovery mechanism proposed in this Application as more of the technology and operational risks are transferred away from the ratepayers to the BLPC's shareholders relative to the traditional cost of service recovery mechanisms.

35. The estimated net fuel savings and proposed cost recovery schedule are presented in Figure 1. The annual net fuel savings is based on the BLPC's production cost analysis and is described in Appendix A and the annual ESD cost recovery is derived from the amortization schedule in Appendix C.

Figure 1: ESD Fuel Savings & Cost Recovery

Year	Net Fuel Savings	ESD Cost Recovery	Net Cost Savings
2018	$2,698,350	$2,563,432	$134,917
2019	$2,594,937	$2,465,191	$129,747
2020	$2,628,918	$2,497,472	$131,446
2021	$2,712,489	$2,576,864	$135,624
2022	$2,629,305	$2,492,840	$136,465
2023	$2,581,070	$2,444,005	$137,065
2024	$2,648,506	$2,511,081	$137,425
2025	$2,695,646	$2,556,863	$138,782
2026	$2,736,604	$1,901,322	$835,282
2027	$2,778,184	$938,701	$1,839,483
Total	**$26,704,008**	**$22,947,770**	**$3,756,238**

36. The ESD cost recovery schedule will ensure the recovery of the cost of the ESD does not exclude customers from benefiting annually from direct fuel cost savings.

37. In the event fuel savings in any given year over the life of the ESD do not exceed 105% of the ESD cost recovery, the ESD cost recovery amount will be reduced to ensure that customers receive, at a minimum, 5% of the annual net fuel savings. The annual fuel savings would be calculated as per the methodology in Appendix B.

38. BLPC proposes that an annual reconciliation be used as the methodology to recover the ESD cost through the FCA, where the FCA is calculated for the month of February each year as:

$$FCA_{feb} = \frac{Fuel\ Cost_{n-1} + Purchase\ Power_{n-1} + ESD\ Recovery_{yt}}{Energy\ Generation_{n-1} * (1 - Aus_{n-1}) * (1 - losses)} \left[\frac{BD\$}{kWh}\right] \quad \text{(eq1)}$$

where:

$$ESD\ Recovery_{yt} = \% * Net\ Fuel\ Savings_{yt-1} \quad \text{(eq2)}$$

and where:

FCA_{feb} =Fuel Clause Adjustments for the month of February of the given year
$Energy\ Generation_{n-1}$= Energy generated in the previous month
Aus_{n-1}=Auxiliary consumption as a percentage of total generation in the previous month
$losses$= System losses as a percentage of total generation calculated based on a 12 month running average.
$Fuel\ Cost_{n-1}$=Fuel cost in previous month including cumulative under/over recovery
$Purchase\ Power_{n-1}$ = Purchase power from renewable sources in the previous month.
$ESD\ Recovery_{yt}$= Storage cost recovery for the previous year including any cost under recovery accumulated from previous year.
$Net\ Fuel\ Savings_{yt-1}$= The difference between the fuel costs with and without the ESD.

39. The annual reconciliation mechanism will be employed until the full cost of the ESD is recovered.

40. In the event the life of the ESD exceeds the period required to achieve total cost recovery, the net fuel savings benefits could be shared between BLPC and ratepayers at a level under the discretion of the Commission.

E. STATUTORY PROVISIONS UNDER WHICH THE APPLICATION IS BEING MADE (Rule 26(1) (c) of the Rules)

41. Section 16 of the URA provides that where the Commission has not fixed a period of time in accordance with section 15 (1) the Commission may on its own initiative or upon an Application by a service provider or consumer, review the rates, principles and standards of service for the supply of a utility service.

42. Section 2 of the URA defines "principles" as "the formula, methodology or framework for determining a rate for a utility service." In keeping with this definition, the FCA is deemed a formula for the purposes of the URA.

43. Section 2 of the URA further sets out that the term "rates" includes every rate, fare, toll, charge, rental or other compensation of a service provider; a rule, practice, measurement, classification or contract of a service provider relating to a rate; and a schedule of tariff respecting a rate.

44. Additionally, the BLPC has structured its Application and the order being sought in accordance with Rule 26 of the Rules.

45. The BLPC's Application will result in the alteration of the FCA formula and therefore this Application, made pursuant to Section 16 of the URA and Rule 26 of the Rules, forms the statutory basis on which the Commission may act in relation to granting our request.

F. NATURE OF ORDER BEING SOUGHT

46. BLPC requests that the Commission approve the recovery of the costs associated with the commissioning of a 5 MW ESD in proportion to the fuel savings benefits it delivers.

47. BLPC also requests that the existing FCA mechanism be used to annually recover the cost of the ESD and be amended based on the formula proposed below where the FCA is calculated for the month of February each year as:

$$FCA_{feb} = \frac{Fuel\ Cost_{n-1} + Purchase\ Power_{n-1} + ESD\ Recovery_{yt}}{Energy\ Generation_{n-1} * (1 - Aus_{n-1}) * (1 - losses)} \left[\frac{BD\$}{kWh}\right] \qquad (eq3)$$

where:

$$ESD\ Recovery_{yt} = \% * Net\ Fuel\ Savings_{yt-1} \qquad (eq4)$$

and where:

FCA_{feb} =Fuel Clause Adjustments for the month of February of the given year
$Energy\ Generation_{n-1}$= Energy generated in the previous month
Aus_{n-1}=Auxiliary consumption as a percentage of total generation in the previous month
$losses$= System losses as a percentage of total generation calculated based on a 12 month running average.
$Fuel\ Cost_{n-1}$=Fuel cost in previous month including cumulative under/over recovery
$Purchase\ Power_{n-1}$ = Purchase power from renewable sources in the previous month.
$ESD\ Recovery_{yt}$= Storage cost recovery for the previous year including any cost under recovery accumulated from previous year.
$Net\ Fuel\ Savings_{yt-1}$= The difference between the fuel costs with and without the ESD.

DATED THIS 4th DAY OF AUGUST, 2017

SIGNED BY: ....

ADRIAN CARTER

THE APPLICANT'S REPRESENTATIVE AND DULY AUTHORIZED OFFICER

APPLICANT'S ADDRESS: THE BARBADOS LIGHT & POWER COMPANY LIMITED

GARRISON HILL

ST. MICHAEL

BARBADOS

TELEPHONE NUMBER: (246) 626-9000

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Appendix A: Production Cost Analysis

A1. Battery Modelling

The production cost modelling analysis sought to quantify the benefit of a 5MW battery (proposed to be located at Trents in 2018) when implemented on the capacity build out as per BLPC's understanding of future renewable generation developments in Table A1.

Status		Projected Installed Renewable Generation							EXISTING FLEET
Primary Energy Source		Distributed Biomass J.V.	Utility Solar PV			Wind Turbines		Solar PV	Solar PV
Technology/ Unit/Location		Gasifier	Solar Farm 1	Solar Farm 2	Solar Farm 3	Wind Farm 1	Wind Farm 2	Distributed RE Rider	Trents
2017	MW							14.6	10
2018	MW				6			15.9	10
2019	MW	1	8	4	6		10	17.2	10
2020	MW	1	8	4	6	5	10	18.7	10
2021	MW	1	8	4	6	10	10	20.4	10
2022	MW	1	8	4	6	10	10	22.2	10
2023	MW	1	8	4	6	10	10	24.2	10
2024	MW	1	8	4	6	10	10	26.3	10
2025	MW	1	8	4	6	10	20	28.8	10
2026	MW	1	8	4	6	10	20	31.4	10
2027	MW	1	8	4	6	10	20	34.3	10

Table A1: Proposed Future Renewable Development 2017 – 2027

GE Energy Consulting conducted a Phase 2 Intermittent Renewable Energy Integration Study that included an examination of the potential value of 5 MW battery storage on the grid. The objective of the study was to co-optimise the battery operation. GE took the approach to separate the impacts of the batteries on a generation system and thus examined the battery in the two modes of energy shifting and reserve provision utilizing the Energy Exemplar PLEXOS modelling software. BLPC applied a similar dispatch modelling approach in examining the energy shifting and reserve provision benefits of battery storage.

A2. Reserve Provision

The system reserve provision is one of the areas that batteries can assist with the variability impacts of renewable resources. Here, the variability in the shorter term, i.e. in timescales of ten (10) minutes or less, must be accounted for by online generation or by battery support if available.

These reserves are made up of two components, the load following reserves (available from online units, currently a static 5MW at BLPC) and the operating reserve (which is available from online units or other resources to account for the variability of renewable resources and varies according to the renewable resource output).

For reserve impacts, the spinning reserve to be maintained by the system for appropriate stability was derived based on the level of RE penetration for each scenario without batteries. GE developed the required levels of the operating reserve component using the following methodology:

- Creating an aggregated 10-min power output profile of the total solar and wind output for each scenario.
- Comparing each aggregate power output in the current 10-min period back to the previous 10- min period to capture the 10-min delta change in power output. Repeating for all periods in the year.
- Associating all 10-min negative deltas with their corresponding level of total wind and solar output, at which they were observed.
- Identifying the 99.9 percentile 10-min event for each level of wind and solar generation.

The level of operating reserve required is thus taken as the level needed to cover for the 99.9 percentile 10-min variable loss event, based on the wind and solar capacity contribution at that moment. A relationship between reserve requirement vs solar and wind generation was derived to illustrate.

For the various annual scenarios now identified in the strategic plan, first the model was run to determine the RE contribution to the system. The relationship was then applied to this output to determine the reserve requirement for each interval. This was used to generate an hourly reserve data file on a 10-minute interval for the production cost modelling. A generation dispatch was then determined as a base case for the generation capacity available. BLPC's battery modelling approach uses interpolations between scenarios available in the GE studies to approximate the renewable resource penetrations now required.

The reserve data file was then modified to account for the impacts of batteries by adjusting (down) the required reserve margins by the capacity of the battery. Here the battery capacity is 5MW, resulting in effectively removing the static portion of the reserve provision and maintaining an operating reserve only. This new reserve file was applied to the system model and a new generation dispatch derived.

In high renewable resource penetration scenarios, a baseload plant may be sub-optimally loaded with respect to its heat rate, resulting in an increased fuel usage, due to the higher reserves carried by the unit. When the battery adjusted reserve file is applied, the loading of baseload plant is at a more optimal point on its heat rate curve, resulting in a more optimal production cost. The cost savings were evaluated on a production costs basis mainly due to changes in the loading of baseload units for the two scenarios.

The difference between the two scenarios on a fuel basis is the benefit to be derived.

A3. Energy Shifting

For energy shifting impacts, the battery object which is available in the PLEXOS software is used. Known parameters are used to represent the battery behaviour, e.g. capacity, efficiency, etc. The software dispatches the cycles of charge and discharge on the battery based on the production cost of generation for each interval of analysis. The general trend observed is that the batteries charge when the cost of generation is comparatively lower and to discharge to the system when the costs are comparatively higher. Again, the benefit is evaluated as the production cost difference between a system without a battery object and one containing a battery object, on a fuel cost basis. In this instance there is a battery object in the model to be interrogated.

A4. Co-optimization

The current version of PLEXOS, 7.4, has the ability to co-optimise the dispatch of the battery for both reserve provision and energy shifting.

To implement the battery and to co-optimize both energy and reserve services, a constraint was applied to co-ordinate the amount of energy in the battery with the amount of reserve provision the battery can provide, defined as a time duration. This ensures that should the battery fully discharged, then it would not be able to provide any reserve.

A5. Assumptions

- Three-year averages for Forced Outage Rate (FOR), Maintenance rate, Mean Time to Repair (MTTR), Fixed Operations & Maintenance (FO&M) and Variable Operations & Maintenance (VO&M) were utilised.
- Fuel prices are escalated according to a World Bank Oil Price Forecast.

Year	HFO	Jet A1	Diesel
	$/mmbtu	$/mmbtu	$/mmbtu
2017	18.31	27.05	36.34
2018	19.20	28.25	37.68
2019	21.23	30.99	40.76
2020	21.69	31.6	41.45
2021	22.20	32.3	42.23
2022	22.69	32.95	42.96
2023	23.21	33.65	43.75
2024	23.76	34.39	44.58
2025	24.31	35.13	45.41
2026	25.92	37.3	47.86
2027	27.54	39.04	49.81

Table A2: Fuel Price Assumptions

- The steam station was retained as the first unit in the dispatch merit order, by placing a “commit” on it in the model.

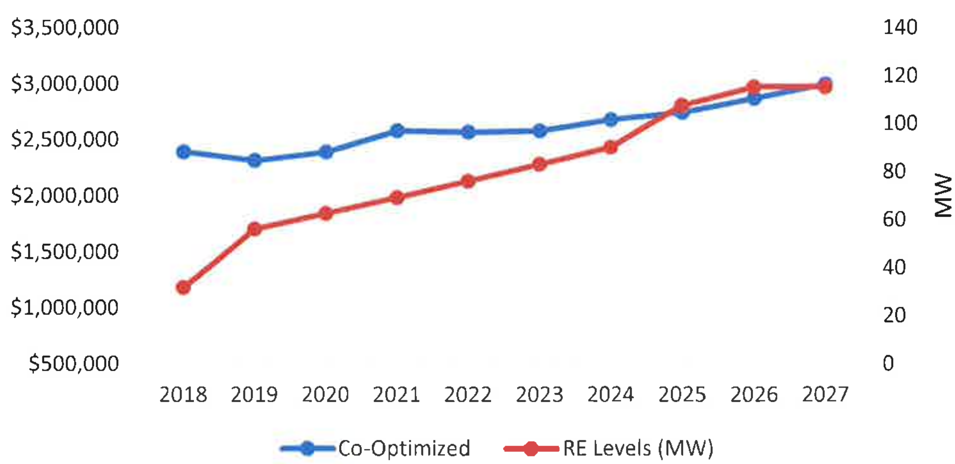
A6. Results

The results of the co-optimization of the battery for both reserve provision and energy shifting are displayed in Table A3 and Figure A1 below.

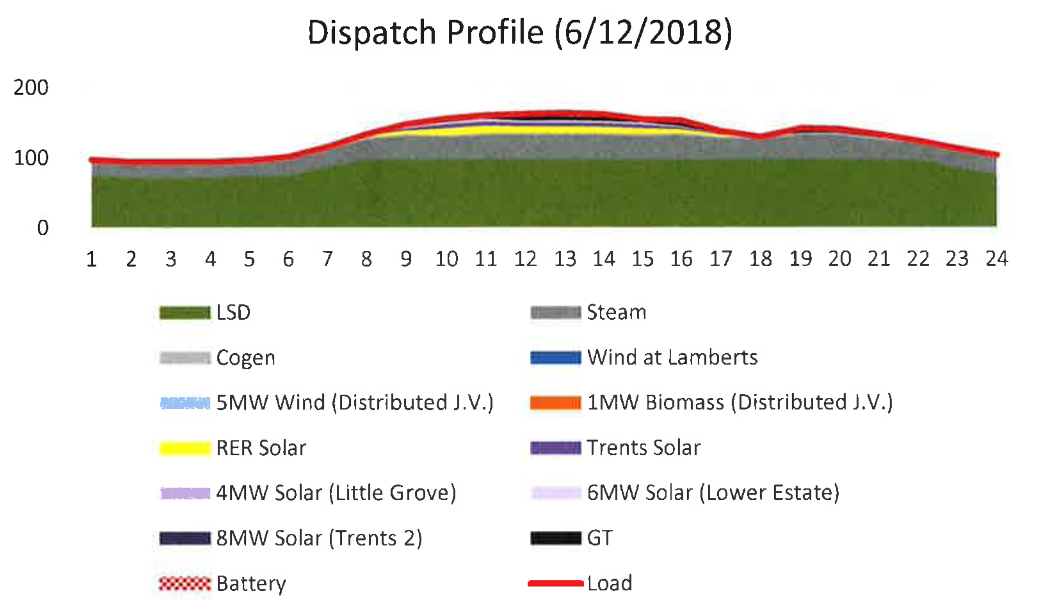
Year	Co-Optimized
2018	$2,698,350
2019	$2,594,937
2020	$2,628,918
2021	$2,712,489
2022	$2,629,305
2023	$2,581,070
2024	$2,648,506
2025	$2,695,646
2026	$2,736,604
2027	$2,778,184
Total	**$26,704,008**

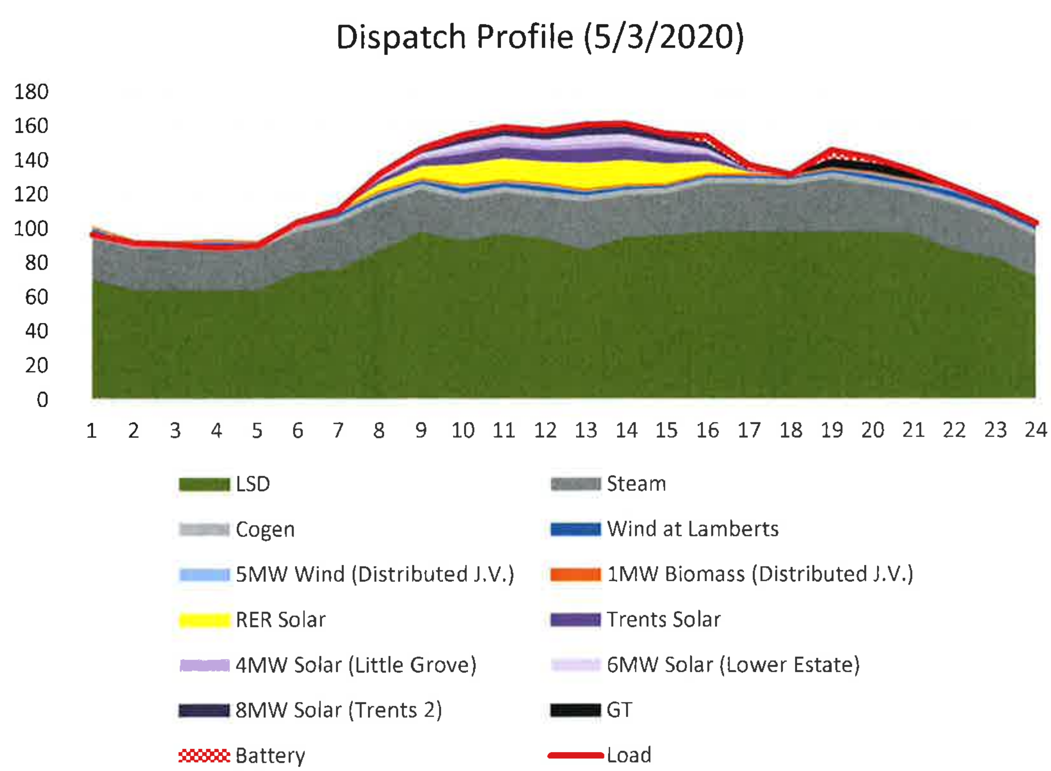
Table A3: Co-Optimized Fuel benefits

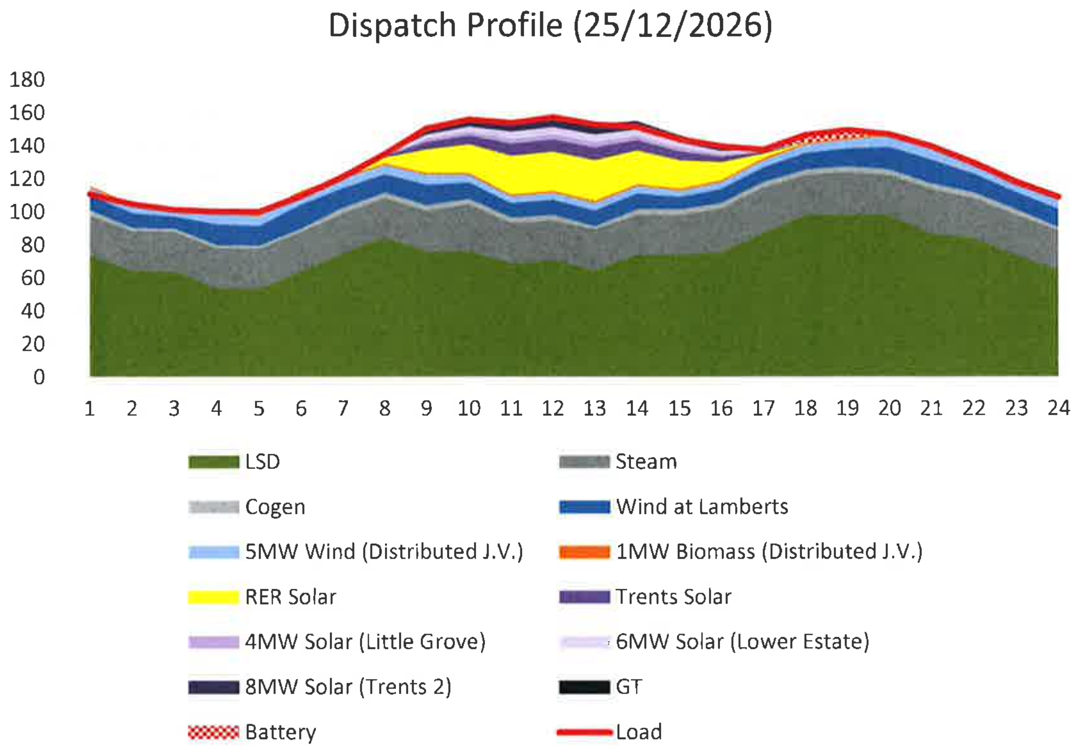
Figure A1: Projected Annual Fuel Saviing
5 MW Battery Storage



The impact of energy shifting is illustrated below. Sample days are illustrated in 2018, 2020 and 2026.






Dispatch Profile (25/12/2026)
180
160
140
120
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
LSD
Steam
Cogen
Wind at Lamberts
5MW Wind (Distributed J.V.)
1MW Biomass (Distributed J.V.)
RER Solar
Trents Solar
4MW Solar (Little Grove)
6MW Solar (Lower Estate)
8MW Solar (Trents 2)
GT
Battery
Load

Appendix B: Annual Fuel Savings Calculation

The calculation of fuel savings annually will follow a modeling approach similar to that outlined in Appendix A. In that, production cost analysis using the Plexos software will be employed to model the fuel savings had the system not obtained ESD benefits. The net fuel savings is derived as the difference between the fuel costs with and without the ESD. It is anticipated the calculation of the net fuel savings will be audited annually by the Commission or an agent appointed by the Commission.

Thus:

$$ESD\ Recovery_{yt} = \% * Net\ Fuel\ Savings_{yt-1}$$

where:

$$Net\ Fuel\ Savings_{yt-1} = Fuel\ Cost\ with\ ESD_{yt-1} - Fuel\ Cost\ without\ ESD_{yt-1}$$

and where:

$$Fuel\ Cost\ with\ ESD_{yt-1} = Actual\ Generation\ Fuel\ Cost_{\ yt-1}$$

$$Fuel\ Cost\ without\ ESD_{yt-1} = \min(Generation\ Fuel\ Cost_{\ yt-1}), \quad subject\ to: Generation\ Constraints_{yt-1}$$

Appendix C: Battery Cost Amortization & ESD Recovery

Figure B1: Amortization & Recovery Schedule

Year	+Project Cost	Net Fuel Savings	ESD Cost Recovery	Net Cost Savings
2018	$3,186,371	$2,698,350	$2,563,432	$134,917
2019	$3,062,920	$2,594,937	$2,465,191	$129,747
2020	$2,866,985	$2,628,918	$2,497,472	$131,446
2021	$2,674,828	$2,712,489	$2,576,864	$135,624
2022	$2,461,848	$2,629,305	$2,492,840	$136,465
2023	$2,287,321	$2,581,070	$2,444,005	$137,065
2024	$2,077,574	$2,648,506	$2,511,081	$137,425
2025	$1,893,679	$2,695,646	$2,556,863	$138,782
2026	$1,321,572	$2,736,604	$1,901,322	$835,282
2027	$1,114,673	$2,778,184	$938,701	$1,839,483
Total	**$22,947,770**	**$26,704,008**	**$22,947,770**	**$3,756,238**

+Project cost is equal to the annualized cost outlay plus a return on capital