BESS Technical Viability – Wagner and Brandon Shores Retirements

PJM Transmission and Operations Planning

May 3, 2024

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Contents

Executive Summary

On April 6, 2023, Talen Energy (parent company of Brandon Shores LLC) announced that the Brandon Shores two-unit, 1,280 MW coal-fired generation facility in Anne Arundel County, Maryland, would seek deactivation on June 1, 2025.

Subsequently, PJM initiated its standard generator deactivation process to determine whether the facility's retirement would have effects on the transmission system, requiring immediate transmission reliability solutions. Results of PJM's analysis showed that transmission solutions are immediately required, as early as 2025 to address reliability issues brought on by the deactivation. These transmission solutions include in-service estimates in the 2027–2028 time frame. As a result, PJM requested that Brandon Shores units remain in operation until all transmission system upgrades are in-service.

On Oct. 16, 2023, Talen also announced that the three oil-fired steam units and one gas combustion turbine (CT) (Units 1, 3, 4 and CT) at its H.A. Wagner Generating Station in Anne Arundel County, Maryland, with a combined capacity of 844 MW, would seek deactivation on June 1, 2025. PJM's reliability analysis reaffirmed the need for immediate transmission reinforcements as early as 2025 and further determined that two of Wagner's units would be needed to run through 2028 as the necessary upgrades are completed.

On April 18, 2024, Talen filed Reliability Must-Run (RMR) arrangements with the Federal Energy Regulatory Commission for both Brandon Shores and H.A. Wagner Units 3 and 4.

This report summarizes the technical analysis conducted by PJM to evaluate the performance of the BGE system and surrounding areas with two potential battery energy storage system (BESS) proposals brought forward by the Sierra Club in response to the planned retirements of Brandon Shores and, subsequently, Wagner generation facilities. Sierra Club and its consultant, Telos, acknowledged the need for the PJM transmission solution and the H.A. Wagner RMR to address the significant reliability issues, while proposing an interim solution that, they stated, would avoid the need for the Brandon Shores RMR arrangement.

The transmission reliability solution to the Brandon Shores and Wagner retirements should be robust and compatible with the evolving (at a minimum near-term) needs of the system, particularly to BGE, given the relatively limited import capability into the BGE system. The internal BGE load of about 6.5 GW, with only one primary 500 kV in/out configuration feed into Brighton (Conastone to Brighton and Doubs to Brighton), currently tests the existing transmission infrastructure, and that is with Brandon Shores and Wagner generation facilities fully operational.

The analysis summarized in this report covers the following assessments:

- Deactivation Analysis for Brandon Shores
- Deactivation Analysis for Wagner (including Brandon Shores)
- Operational performance of the system (as of today with the Brandon Shores and Wagner units)
- BESS proposed solution submitted by Telos (on behalf of Sierra Club) to address the reliability needs in BGE following Brandon Shores and Wagner retirements
- Technical Validity Evaluation of the proposed BESS using 2025 and 2027/2028 models

PJM evaluated the performance of the proposed battery solution using the originally submitted size of 600 MW x 4 hours and the updated size of 800 MW x 4 hours. The reliability analyses indicate that, even with more than 2,000 MVAR of additional reactive power reinforcement, both proposed battery sizes do not address (on their own) the reliability needs of the BGE system under the 2025 and 2027/2028 system conditions, which represent a more realistic, earliest in-service date for the proposed battery.

The analysis finds that the proposed battery solution cannot replace the need to maintain the existing generation capacity in BGE through Reliability Must-Run (RMR) arrangements with the Brandon Shores and Wagner generation units until the planned transmission reinforcements needed to support the BGE and greater PJM system are energized.

Today, the BGE system predominantly relies on the availability of the internal generation in BGE that is currently operational, offering more than 2,000 MW of capacity and locally supplying a considerable portion of BGE's system load. The Operational and Transmission Planning analysis confirms the need for the existing Brandon Shores and Wagner generating facilities to maintain reliable operation in the BGE and surrounding system. Operational planning analysis highlights the need for the units to maintain reliable system operation with the current load level and existing transmission infrastructure. Planning analysis further confirms this need to support reliable operation as the load increases and until the planned transmission facilities are energized. These findings align with the analysis shared by the Sierra Club's own consultant for the year 2025.

PJM extended its analysis to the 2027/2028 time frame to represent system conditions expected to be present prior to when the battery could be theoretically energized. The reliability violations are pervasive and severe in nature, which could lead to a potential voltage collapse in the entire BGE system as well as multiple overloads throughout the BGE system and the larger PJM network. The analysis concludes that both Brandon Shores and Wagner are required to be available for operation in order to maintain reliability prior to complete energization of the planned transmission reinforcements in the area.

From a constructability perspective, the Telos/GridLab concept does not have a viable integration plan to the PJM system. It is unclear who will sponsor, procure, own and operate the proposed battery. The concept also assumes the utilization of the existing Brandon Shores site for the installation of the battery and the utilization of the generator step-up transformers. PJM did not receive a confirmation or any commitment from the plant owner (Talen) that it would accept such an arrangement, nor is there an estimated cost of such an arrangement to evaluate the overall cost and feasibility of this battery concept.

In conclusion, while a large battery could potentially reduce the severity of the reliability concerns in the BGE and larger PJM system following the retirement of the Brandon Shores and Wagner generation units, they do not replace the need to maintain the operation of Brandon Shores units 1 and 2 and Wagner units 3 and 4 until transmission upgrades are completed nor do they address the reliability needs for the system in the near term and longer term. PJM's study ultimately concludes that the Brandon Shores units 1 and 2 and Wagner units 3 and 4 cannot reliably be retired until the needed transmission reinforcements are in place. While the proposed battery concept would help offer some local supply within the BGE system, it will not eliminate the need for the proposed major transmission reinforcements required to maintain system reliability.

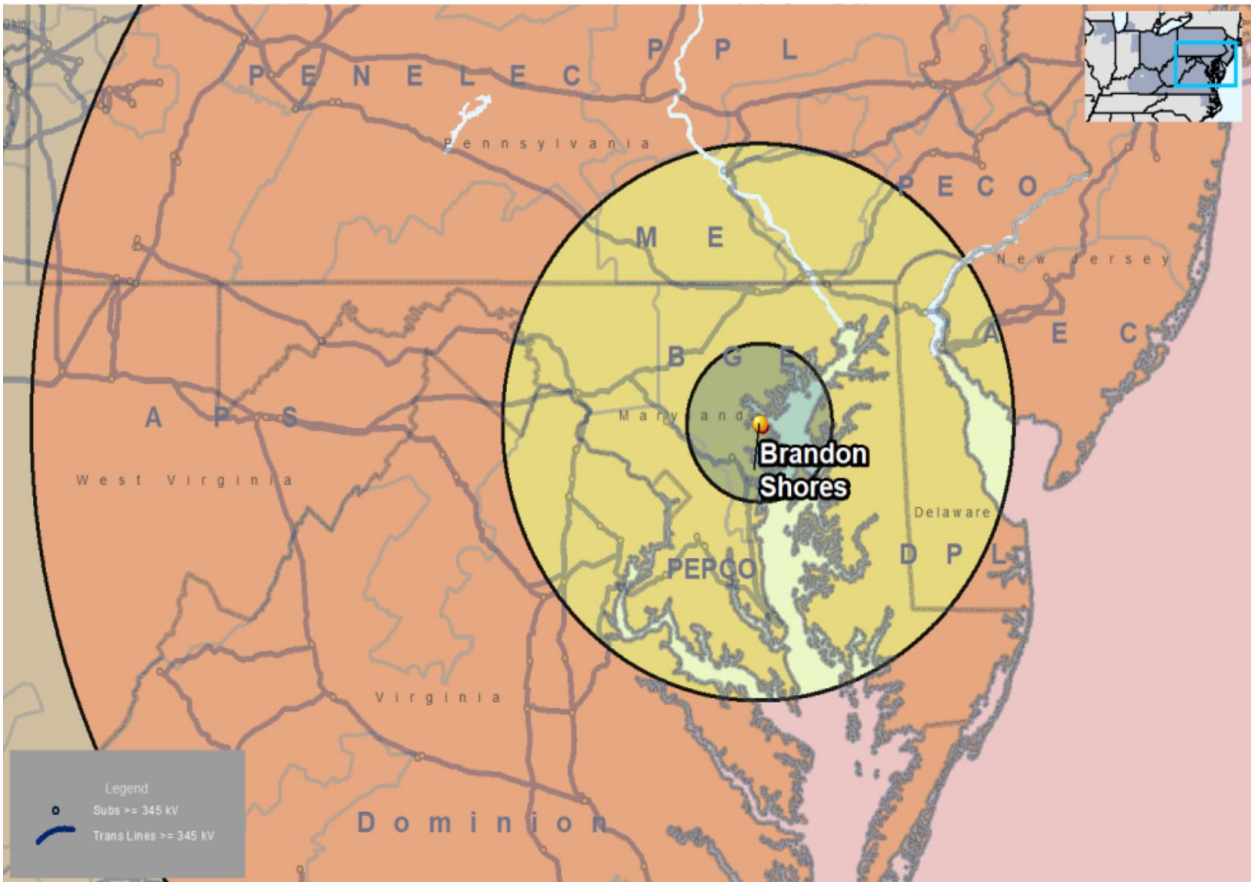
PJM Deactivation Analysis – Brandon Shores

The purpose of the PJM deactivation analysis is to assess the immediate reliability impacts coincident with the time the retirements are requested. The purpose is not to capture all reliability needs for near, mid and longer term for the system. Hence, the efficacy of any proposed solution needs to not only meet those immediate needs but also be compatible and efficient to meeting the evolving reliability needs of the system.

In 2023, PJM completed its established review process for Brandon Shores Units 1 and 2 generator retirement requests and their potential impact on the transmission system. As part of the deactivation process, PJM conducts a full analysis to determine if there would be any effects on the grid that require transmission upgrades, considering reasonably anticipated system additions.

PJM's analysis (PDF) showed that transmission solutions will be required to address reliability issues brought on by this deactivation. The analysis showed the potential for voltage collapse and thermal overloads on the transmission system as a result of the deactivation.

Figure 1. Brandon Shores Location and Area of Its Deactivation Reliability Impacts



Brandon Shores is in the BGE transmission zone. BGE peak load is approximately 6,500 MW; total existing generation in the zone is about 2,500 MW (including both Brandon Shores and Wagner facilities). Once the Brandon Shores units retire, total generation in the BGE zone will be about 1,200 MW. The reliability concerns in the BGE system and surrounding areas will be further exacerbated by the announced retirement of the nearby Wagner units.

This means only 20% of the BGE peak load could be served by generation in the zone, and 80% of the load will have to be served by importing power. Significant transmission reinforcements are required to import such a large amount of power into the BGE zone.

Solutions

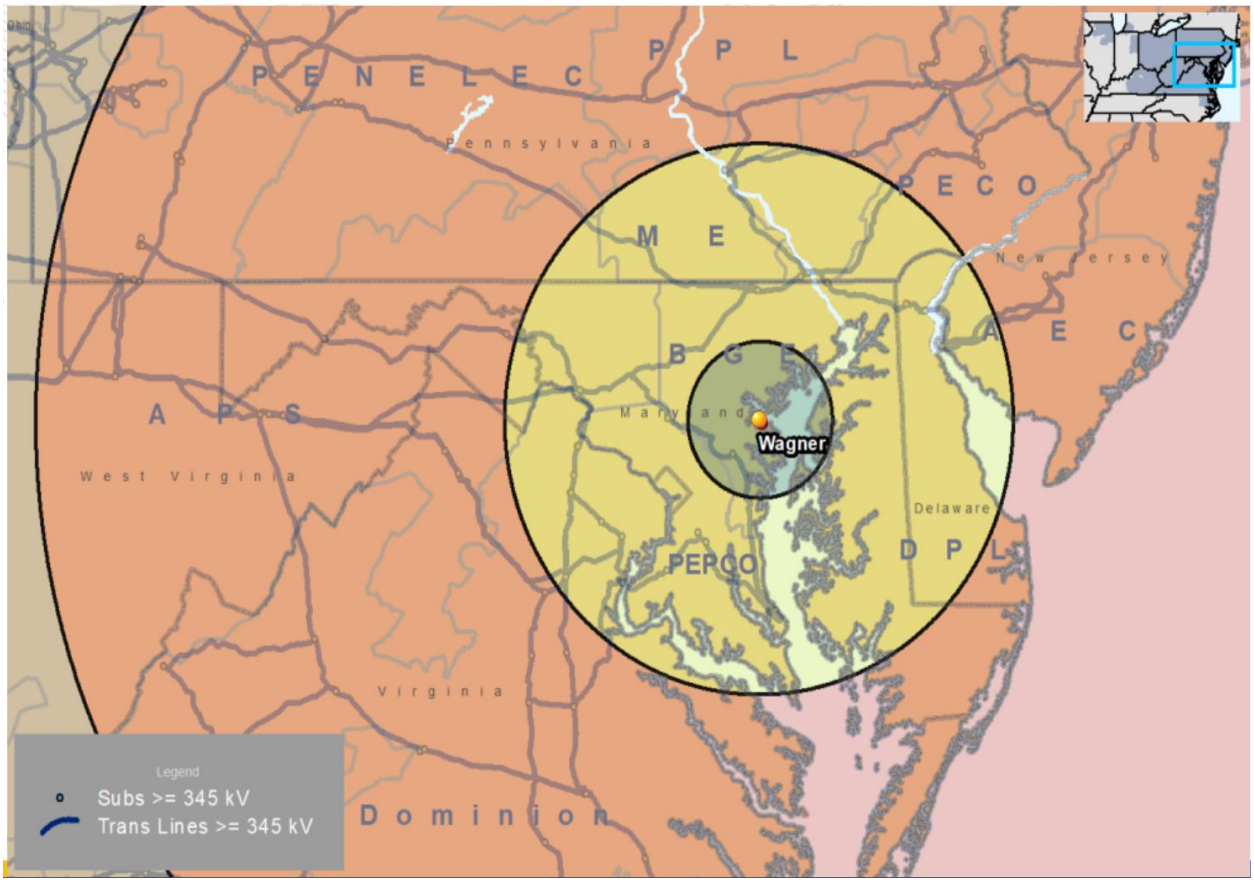
- Transmission upgrade costs are approximately $800 million and include a new 500 kV feed, two new 230 kV lines to deliver power into the area, and other upgrades to support voltage control.
- These required upgrades, however, hold an estimated in-service date that falls after the requested Brandon shores deactivation date of June 1, 2025. This includes preliminary transmission upgrade in-service estimates in the 2028 time frame, approximately three years after the noted deactivation date.
- As a result, PJM requested that the unit owner, Talen Energy, retain the generating units in operation to support system reliability until required transmission upgrades are in place.
  - While PJM cannot compel a unit to remain in-service, in unique circumstances such as this, PJM can request the unit owner to retain the unit in operation to support reliability. This process, detailed in Part V of the PJM Open Access Transmission Tariff, provides a deactivating unit the opportunity to remain in-service and recover its operating costs until all necessary transmission upgrades are in place.

PJM Deactivation Analysis – H.A. Wagner

Toward the end of 2023, PJM also completed its established review process for the Wagner retirement requests and their potential impact on the transmission system.

PJM's analysis (PDF) showed that significant and exacerbated reliability violations would exist if the Wagner units were retired without further reinforcements in the BGE system. Similar to the analysis carried out for the retirement of Brandon Shores, this analysis showed the potential for voltage collapse and thermal overloads on the transmission system as a result of the deactivation. With the deactivation of both Wagner and the Brandon Shores units, the total remaining generation in the BGE system will drop to about 350 MW (from the existing 2,500 MW currently operational). This means that the BGE system will need to supply nearly 95% of its peak load through imports from the rest of the greater PJM system.

Figure 2. H.A. Wagner Location and Area of Its Deactivation Reliability Impacts



Solutions

The Wagner Deactivation Analysis further assessed the reliability impacts with the 2022 RTEP Window 3 transmission development planned to be in service in the 2028–2030 time frame. The study concluded that with these planned longer-term developments, no additional transmission upgrades are required. Wagner Units 3 and 4 and Brandon Shores Units 1 and 2 would need to be retained to meet the reliability needs of the system until these planned transmission developments are in place.

Operational Assessment (Using Historical Operational Conditions – Today's Load State)

The independent PJM operational planning analysis, Appendix 1, revealed the following;

1. Several thermal and voltage exceedance violations are controllable by reducing northeastern generation (potentially at the expense of Area Control Error (ACE) control due to impacts on interchange).
2. However, on the loss of certain facilities, PJM would be forced to go directly into pre-contingency load shed to prevent adverse cascading events.

The operational study assessment clearly indicates a strong need for reinforcement today. PJM Operations will be relying on major out-of-merit re-dispatch of generation and curtailment of interregional energy transfers. Under sustained outage of certain facilities (500 kV lines into BGE: Conastone-Brighton and Doubs-Brighton), PJM would be forced to initiate pre-contingency load shed to prevent cascading and voltage collapse concerns.

Accordingly, the retirement of the Brandon Shores and Wagner facilities introduces reliability concerns that are present even at today's load levels, let alone in 2025 or even 2028 when the system overall load is expected to grow by an additional 7,500 MW within the greater area of concern surrounding and including the BGE system.

PJM Operations also assessed the potential for load shed if both Brandon Shores and Wagner retire. With today's load level and with out-of-merit dispatch, there is no pre-contingency load shed (assuming no major outages). However, based on severe N-1 thermal overloads, should the first contingency occur, PJM would need to issue a Manual Load Dump Action[1] for a significant amount of load shed in the BGE/PEPCO areas. This analysis indicated that should the first contingency occur, the next contingency would result in an unbounded cascade (i.e., system collapse). We observe this risk based on peak load levels for the following number of hours:

1. Summer 324 hours of N-1 load shed risk
2. Winter 48 hours of N-1 load shed risk (Chalk Point 3 & 4 assumed offline)

In addition to the N-1-1 concern under normal system configurations, there is a significant amount of system upgrade work and associated transmission outages needed to implement the recently approved transmission upgrades. PJM will need Brandon Shores and Wagner for control at various times during spring and fall as well, particularly whenever the path from the north is restricted. In particular, the rebuild of 5012 Conastone-Peach Bottom and the 5011 Conastone-Brighton upgrade work.

[1] Manual Load Dump Action is defined as: The request to disconnect firm customer load (rotating blackouts). This is issued when additional load relief is needed and all other possible procedures have been exhausted.

Reliability Assessments

The PJM reliability assessment recommended addressing these reliability needs in 2025 (through the deactivation process) and further affirmed the need through the 2022 RTEP Window 3 assessments for 2027/2028. These studies confirmed the need for the facilities listed below to maintain reliability in the BGE system following the retirement of Brandon Shores and Wagner. The facilities are listed in the sequence they will be built:

1. Brandon Shores Deactivation analysis (2025):
    a. Development of 2x230 kV between the Graceton area extending farther south to the vicinity of the Brandon Shores site (Graceton to Batavia development)
    b. Development of a Graceton 500 kV yard, 500 kV Peach Bottom-Graceton circuit and the new Batavia substation
    c. Multiple voltage support devices
    d. Since the developments above could not be brought into service before the deactivation of Brandon Shores, PJM recommended the continued operation of Brandon Shores units 1 and 2 until the planned deactivation reinforcements are energized.
    e. A single Brandon Shores unit (together with the Wagner facility, which did not submit its deactivation request at the time) was found to be insufficient by PJM to maintain reliability, as the system needs to be prepared to lose either unit on a forced outage. Hence, a single replacement unit (or a battery) would not meet this reliability requirement even at the same size as one of the Brandon Shores units.
2. 2022 RTEP Window 3 – 2027/2028: 7,500 MW of load growth + Block Dispatch + Brandon Shores deactivation:
    a. Confirmed the need and efficacy of the deactivation solutions (as they were designed in tandem with the 2022 RTEP Window 3 solutions offered by Exelon)
    b. Confirmed the need for two key additional developments to meet the load growth by 2027/2028:
        i) 1x500 kV line between North Delta and High Ridge (at the heart of the BGE system)
        ii) 1x500 kV line between Otter Creek and Doubs
3. 2023/24 Wagner Deactivation analysis:
    a. Confirmed the efficacy of the planned 2022W3 and Brandon Shores deactivation reinforcements to handle both Brandon Shores and Wagner, once energized

Sierra Club (Telos/GridLab) BESS Proposed Solution

PJM reviewed and evaluated the alternative solution that was proposed by the Sierra Club to meet the reliability needs of the BGE system in response to the Brandon Shores and Wagner facilities retirements. PJM found that a four-hour battery storage concept developed by Telos Energy and GridLab is not a viable or realistic option at present. Our analysis reviewed several factors, including the length of time it would take to construct a battery storage project of this size, as well as its estimated cost. However, most importantly, our analysis revealed that this battery storage concept is not technically viable, on its own, at this time.

The following sections summarize the evaluation summary presented to PJM by Telos and PJM's response to it, as well as additional analysis conducted by PJM to evaluate the BESS proposal efficacy to meet the PJM transmission needs, particularly by 2027/2028 when any effective solution could be practically placed in service.

Telos' BESS Solution Proposal

The Telos assessment (on behalf of Sierra Club and included in summary as Appendix 2) confirmed the reliability concerns with the Brandon Shores and Wagner facilities retirements. It accordingly proposed alternate "conceptual solutions" that hinge on utilizing grid-enhancing technologies (GETs) like BESS, dynamic line ratings and automatic power-flow controllers (APFCs), Appendix 2. Telos and Sierra Club have indicated that the PJM transmission solution is necessary to address the significant reliability issues. Telos' solution was proposed as an interim solution to avoid the need for Brandon Shores RMRs, yet it recommended retaining Wagner as RMR instead.

It is important to mention that, in PJM, Transmission Owners can and have proposed GETs or non-wire solutions to address planning needs. PJM has considered and studied these solutions and, in 2023, enabled a GETs solution to accommodate an interconnection request as well as enabled utilization of dynamic line ratings within its footprint when deemed appropriate and efficient. PJM welcome GETs planning solutions when they are reliable, feasible and cost-efficient.

Based on a detailed review by PJM, the Telos assessment is flawed in a number of aspects, as summarized below, and addressed in detail in specific sections:

1. Assumption on BESS replacements (BESS merits, location and size):
    a. BESS placed at the existing Brandon Shores facility location
        i) Telos did not model a real proposed BESS system. Rather they kept "one Brandon Shores unit" online as a proxy for analysis.

    This is generally acceptable at a conceptual stage, but more details on the battery, its capability, number of tie-in transformers and duration must be specified, as they impact the reliability assessment and cost evaluation metrics of the option when compared to a transmission solution. These factors appear to have been all afterthoughts, and following PJM flagging these deficiencies, Telos and Sierra Club attempted to address them via multiple assumptions.

        ii) Availability of space at the Brandon Shores site is a key assumption, which is a concern since BGE confirmed the space at the Brandon Shores substation to be insufficient (perhaps at least not until total demolition of the plant site and procurement of land by a potential developer).

iii) Telos did not specify nor evaluate their proposed BESS duration. They assumed it to offer similar reliability services that a single Brandon Shores unit can offer.

(1) This is a major flaw in assumption as the BESS being assumed infinitely available (or at the same rate as a thermal unit) is erroneous.

(2) A feasible BESS solution will need to demonstrate that it could be charged and made available to provide reliability services for the longest possible duration that the replacement thermal unit can provide. This demonstration was not conducted by Telos. In December 2023, PJM requested that Telos provide this analysis to confirm the size (megawatts) and duration (megawatt-hours) of the battery necessary to meet the reliability needs, and enable PJM to evaluate the capital and operating costs.

2. Telos' BESS solution not sufficient on its own:

a. Telos (See Telos assessment summary, Appendix 2) confirmed the existence of several overloads (using only the 2025, flat dispatch case) – see slides 24 and 25 of the Telos presentation.

This deficiency needs to be addressed through either rebuilds or new lines or a combination of transmission and non-wires solutions. All of which needs to be evaluated by the proposing entity, which then allows the cost of the overall, reliable solution concept to be considered by PJM.

i) Telos did not consider/specify the number of BESS banks that will be required to account for an outage of one interconnecting transformer or BESS controller.

This will affect cost and reliability performance as the system must be able to operate reliably if one BESS component fails while operating to next contingency.

ii) Telos' assessment still assumed Wagner to be in-service/retained.

This continues reliance on Wagner as an RMR indefinitely or at least until the full bulk transmission solution is in-service. PJM planning analysis, which is offered later in this report, showed that the need to retain Wagner as RMR beside the BESS would also be driven by the need to charge the BESS where the existing BGE transmission system cannot provide sufficient capacity to charge the battery even under light-load conditions. This will lead to potential periods where the BESS is charged through the Wagner oil-fired units.

3. Telos' assessment did not consider operating throughout the 8,760 hours of the year.

a. Telos assumes that since the PJM transmission assessment did not consider the shoulder season, the BESS did not require analysis during the shoulder season.

b. This is a flawed assumption since with a thermal asset, the units could be dispatched at any time as long as they are available and the fuel is secure. For the BESS, assuming that the system will have sufficient reliability margins to charge during shoulder and light-load periods is deficient since a large number of thermal units (throughout the system) may not be available to provide the needed charging level for the needed duration.

PJM has confirmed that the system during winter peak (or winter in general) could have a much different dispatch profile than it will during summer, which makes the winter analysis more stressful than that of summer.

   a. A full 8,760 analysis needs to be performed by Telos to prove feasibility of the BESS solution.

   b. To simplify the analysis and focus on the feasibility of replacing the 2,100 MW of capacity currently offered by Wagner and Brandon Shores supporting the reliability needs of the BGE system, PJM conducted its analysis (that is summarized later in this report) assuming 100% availability of the full 600 MW and 800 MW battery sizes proposed by Telos.

4. Telos' analysis indicates that there will be reliability violations even during favorable charging periods.

   a. Slide 24 of the Telos presentation indicates overload of the Graceton-BGE line.

   b. Multiple N-1-1 violations are still captured with the Telos BESS solution – Slide 24.

   c. More lines are likely going to show reliability violations with higher load levels between 2025 and 2028 when the planned reinforcements are in place.

   d. PJM's analysis showed that the system couldn't support the charging of the BESS even at light-load conditions at the proposed capacity size. This indicates tight operational conditions to charge the battery (will take more than four hours at a reduced, below capacity charging rate).

5. Telos' analysis captured the need for "additional VARs" on top of and beyond the BESS, thermal upgrades and RMR of Wagner.

   a. No analysis was done to identify the needed upgrades nor their cost.

   b. Telos needs to address these identified reliability needs in order to provide a solution that could be evaluated on reliability, operational and cost merits.

   c. PJM also assessed the BESS solution by assuming that more than 2,000 MVAR of reactive power resources would be added to support the reliability needs of the system on top of the BESS proposed solution. Analysis showed that the system would still experience voltage collapse and severe under-voltage conditions under several contingencies, indicating the need for import capability/transfer-in reinforcement into the BGE system, even with the proposed BESS assumed at 100% full output.

6. Telos' analysis is confined at 2025 system conditions.

   a. For the proposed solution to be deemed feasible, it should be proven useful (or at least assessed for efficacy) in the longer term (2028) given the forecasted load growth.

   b. The BGE system reliability, especially post retirement of its thermal assets, relies on the strength of the upstream PJM system (MAAC and Dominion/APS) to provide the needed support. With load growing in APS/Dominion, the system reliability margin will require reinforcements that will deem the reliability margin relied on by Telos in 2025 insufficient for the longer term.

7. Telos' analysis did not consider load deliverability and assumed Capacity Emergency Transfer Limit[2] (CETL) will remain the same.
   a. Telos did not conduct the load deliverability analysis and test its solution performance to ensure load deliverability; Telos made the assumption that CETL will remain the same as it is today (both Brandon Shores resources remain operational).
   b. PJM analysis indicated load deliverability issues, and therefore PJM tested its recommended transmission solution to ensure it adheres to load deliverability criteria.
   c. Assuming CETL will remain the same is flawed. For the analysis to be accurate, CETL should be recalculated, and the solution should be tested to ensure load deliverability is met.
8. There is no project proponent/sponsor for Telos' proposed conceptual solution.
   a. Neither the incumbent TO nor non-incumbents proposed GETs to resolve the reliability concerns identified through either the deactivation analysis or the 2022W3 RTEP solicitation.
   b. Note that under a competitive solicitation process, potential transmission developers are incented to provide the more efficient or cost-effective solution to address the identified reliability needs.
   c. PJM does not dictate a specific solution to resolve an identified reliability concern. The solution needs to be proposed by a project proponent through the appropriate and approved FERC process for developing transmission within the PJM footprint.
   d. PJM estimated the 2024 cost to build a 600 MW four-hour and six-hour duration battery; the capital cost alone is ~$1 billion and ~$1.4 billion respectively in 2022 dollars, based on the overnight capital cost from NREL's Annual Technology Baseline.[3]
   e. Before recommending the GETs solution, Telos needs to calculate the cost and the timeline to implement its proposed interim solution to evaluate its reasonableness and overall efficiency in meeting the reliability needs of the BGE system.

Summary

As demonstrated above, Telos switched off one Brandon Shores unit to run its analysis (simulating a 600 MW battery at 100% discharge capacity) using the 2025 deactivation cases provided by PJM. This analysis was already done by PJM as part of its deactivation assessment work. The RMR analysis conducted by PJM confirmed the need for both Brandon Shores units plus Wagner Units 3 and 4 to maintain reliability. A single Brandon Shores unit (even with its increased dispatchability/flexibility compared to BESS) was found insufficient to maintain reliability.

[2] Capacity Emergency Transfer Limit (CETL) is the capability of the transmission system to support deliveries of electric energy to a given area experiencing a localized capacity emergency as determined in accordance with the PJM Manuals

[3] NREL – Cost Projections for Utility Scale Battery Storage: 2023 Update. https://www.nrel.gov/docs/fy23osti/85332.pdf

The Telos proposed alternative does not offer a full and complete solution that demonstrates reliable performance. In order for the proposed alternative to be deemed feasible for alternative evaluation, it needs to be technically viable on its own. Evaluation of alternatives to select a more efficient or cost-effective solution would require considerations (for a BESS to serve as a reliability solution/transmission asset) of associated capital and operating costs as well as replacement cost of the BESS as it will not last beyond 10–20 years depending on use.

With the proposed size and application of the BESS solution, it would be relied on daily to meet reliability needs. It is accordingly expected that the BESS solution will be subject to excessive cycling, which will negatively impact the lifespan of the BESS. This will increase its operating and maintenance costs and will expose the system to periodic risks where the battery capacity is reduced. The overall efficacy and cost-effectiveness of the proposed solution requires evaluation of needed additional transmission solutions (as indicated by Telos in their presentation) including any of their proposed additional GETs (specify needed ratings/DLRs or APFCs) and provide cost for those.

It is to be noted that both the PJM and Telos analyses indicate that the system experiences pervasive and severe voltage collapse conditions because of lack of transmission import capability without further reinforcements. Using DLR and APFC GETs to manage thermal loadings on the system will not help in this regard since the need is for net import capacity to avoid severe voltage collapse conditions and is not predominantly thermal overload related.

PJM 2027/2028 Assessment of the Telos Proposal

PJM further evaluated the efficacy of the Telos proposed 800 MW x 4 hours upgraded (from the original 600 MW) BESS solution. Since the BESS solution will need to be proven effective to meet the reliability needs of the system immediately when it could be practically energized and at the same time be proven effective in meeting the evolving system needs, PJM conducted its analysis as well on the 2027/2028 system model.

The 2028 PJM analysis focused on evaluating the adequacy of the planned reinforcements as well as the adequacy of maintaining a number of thermal units in BGE (as BESS proxies) to maintain reliability. The analysis considered the following:

- Evaluate the need/impact of all relevant planned transmission reinforcements to BGE
  - Graceton 500 kV substation and Peach Bottom-Graceton 500 kV line
  - Graceton-Batavia 2x230 kV development
  - Graceton-High Ridge 500 kV line

2028 Year Scenario 1 (800 MW BESS, Brandon Shores and Wagner Retired)

Base Case and RTEP Upgrades Modeled

PJM used the 2028 RTEP case with 2022 Window 3 upgrades included as starting case

Model Assumptions for the Battery Study:

Generation Assumptions:

- Wagner Units 3 and 4 offline
- Brandon Shores Units 1 and 2 both offline
- 800 MW, 300 MVAR battery at Brandon Shores – modeled as two units, 400 MW each full output, using the Brandon Shores GSUs

Topology Assumptions:

- Remove all Brandon Shores deactivation-related upgrades and 2022 RTEP Window 3 BGE system upgrades (proposal ID 344 and 660), **except the reactive model.**
- Removed Elements:
  - Graceton 500 kV substation and two 500/230 kV transformers
  - High Ridge 500 kV substation and two 500/230 kV transformers
  - Batavia 230 switching station
  - Peach Bottom-Graceton 500 kV line
  - North Delta-High Ridge 500 kV
  - Graceton-Batavia double circuit 230 kV line

Reactive Devices Assumptions:

The Brandon Shores deactivation proposed reactive solutions are modeled/included in the case. See **Table 1**.

Table 1. Modeled Reactive Power Solutions in the 2028 Assessment

Upgrade ID	Description
b3780.5	Build Solley Road substation + Statcom. New STATCOM rating: 350 MVAR Add 4x 230 kV breakers bays.
b3780.6	Build Granite substation + Statcom. New STATCOM rating: 350 MVAR Add 4x 230 kV breaker bays.
b3780.10	Install new Conastone capacitor. New capacitor rating: 350 MVAR
b3780.11	Brighton Statcom and capacitor New STATCOM rating: 350 MVAR New capacitor rating: 350 MVAR
b3780.12	Burches Hill capacitor New capacitor rating: 250 MVAR

Studied Scenario Assumptions:

All three season base cases were considered

- Summer peak case → Battery generating (discharging) at full
- Winter peak case → Battery generating (discharging) at full
- Light load peak case → Battery charging at full

Analysis Type:

- Generation deliverability – Thermal (summer, winter and light load)
- N-1 (base case) – Thermal and voltage (summer, winter and light load)
- N-1-1 – Voltage (summer, winter)

2028 Reliability Evaluation Results

The reliability analysis revealed that the proposed 800 MW BESS battery is unable to meet the reliability needs of the BGE and surrounding area needs in 2027/2028 when the BESS could be practically assumed in service. This is even when assuming the BESS full capacity being available for reliability service and the additional 2,100 MVAR of reactive reinforcement. The results are summarized in **Table 2** below, which indicate a very large number of reliability violations under voltage collapse and thermal overload violations. There are a total of eight 500 kV, seven 230 kV and six lower voltage "unique" facilities overloaded facilities. The study also reveals that there are an extensively large number of contingencies leading to these overloads as indicated by the results summarized in the second row of **Table 2**. These results indicate that Telos' proposed GETs and APFCs to manage overloads on the 115 kV facilities are quite deficient and not suitable for this type/scale of need in the BGE system. Moreover, the table also summarizes the number of unique, single contingency violations observed in the 2027/2028 time frame, which are still quite extensive.

The results summarized in the last two rows of **Table 2** indicate that voltage collapse conditions are observed under a large number of contingencies, not only part of N-1 analysis but also under first contingency single outages. Flow balancing, dynamic line rating GET solutions would not help alleviate these conditions even with a large reactive power compensation additions (per the deactivation and 2022 RTEP Window 3 proposed reinforcements) in the area of more than 2,100 MVAR.

2028 Analysis – Light Load/Charging Conditions

PJM also assessed the system performance under light load conditions where the battery will be in full charging mode (800 MW charging). **Table 3** and **Table 4** below summarize the overall performance of the 2027/2028 analysis including light load condition. It is clear from the results shown in **Table 4** that the BESS charging yields a large number of reliability violations even during most favorable light load conditions.

Table 2. 2028 Analysis – 800 MW BESS + 2,100 MVAR Reactive Solutions Reliability Evaluation Summary

Summer and Winter
Summary of the Violations With the 800 MW Battery

	500 kV	230 kV	<200 kV
Generation Deliverability (Thermal). Number of Facilities	8	7	6
Generation Deliverability (Thermal). Number of Flowgates	131	86	16
N-1 Thermal. Number of Facilities	6	6	3
N-1 Thermal. Number of Flowgates	31	19	9
N-1 Voltage	Widespread voltage collapse and voltage violation concerns under several contingencies		
N-1-1 Voltage	Widespread voltage collapse and voltage violation concerns under several contingencies		

See appendix for detailed results.

Table 3. 2028 Analysis – 800 MW BESS + 2,100 MVAR Reactive Solutions Reliability Evaluation Summary

Summer, Winter and LL
Summary of the Violations With the 800 MW Battery

	500 kV	230 kV	<200 kV
Generation Deliverability (Thermal). Number of Facilities	8	7	11
Generation Deliverability (Thermal). Number of flowgates	158	115	35
N-1 Thermal. Number of Facilities	6	6	12
N-1 Thermal. Number of Flowgates	40	37	27
N-1 Voltage	Widespread voltage collapse and voltage violation concerns under several contingencies		
N-1-1 Voltage	Widespread voltage collapse and voltage violation concerns under several contingencies		

See appendix for detailed results.

Table 4. 2028 Analysis – 800 MW BESS + 2,100 MVAR Reactive Solutions Reliability Evaluation Summary

Light Load
Summary of the Violations With the 800 MW Battery

	500 kV	230 kV	<200 kV
Generation Deliverability (Thermal). Number of Facilities	5	5	11
Generation Deliverability (Thermal). Number of Flowgates	27	29	19
N-1 Thermal. Number of Facilities	2	4	11
N-1 Thermal. Number of Flowgates	9	18	18
N-1 Voltage	Widespread voltage drop violation for tower line outage		

2028 Year Scenario 2 (800 MW BESS, Brandon Shores Retired, Wagner RMR)

PJM further extended its analysis to evaluate the efficacy of the BESS proposal assuming that the Wagner units will be retained as RMR (fully dispatched) together with the 800 MW BESS and the additional 2,100 MVAR of proposed reactive reinforcements in the BGE system by 2027/2028.

The results as summarized in **Table 5** below indicate that, even with the 705 MW by Wagner and the 800 MW offered by the BESS, the system experiences a large number of thermal and voltage violations. As the system still experienced a large number of violations under the generation delivery test and the N-1, N-1-1 voltage tests, PJM did not assess individual N-1 thermal violations further under this test as it already indicated extreme reliability performance concerns.

The analysis of this scenario did not extend to evaluate the charging of the BESS under light load conditions since there were violations already observed when the battery is charged without the Wagner units under RMR (see **Table 3**). Running the Wagner units during the charging period of the BESS to alleviate the identified violations is counter intuitive to the purpose of considering the BESS itself as it will rely on an oil-fired unit to charge a BESS that was essentially proposed by Telos to offset and avoid emissions.

Table 5. 2028 Analysis – 800 MW BESS + Wagner RMR + 2,100 MVAR Reactive Solutions Reliability Evaluation Summary

Summary of the Violations With the 800 MW Battery and Wagner 3 & 4 Online

	500 kV	230 kV	<200 kV
Generation Deliverability (Thermal) Number of Facilities	8	4	4
Generation Deliverability (Thermal) Number of Flowgates	129	75	8
N-1 Voltage	Widespread voltage collapse and voltage violation concerns under few contingencies		
N-1-1 Voltage	Widespread voltage collapse and voltage violation concerns under few contingencies		

Conclusion

PJM evaluated the performance of the proposed battery solution using the originally submitted size of 600 MW x 4 hours and the updated size of 800 MW x 4 hours. The reliability analysis indicate that, even with more than 2,000 MVAR of additional reactive power reinforcement, both proposed battery sizes do not address (on their own) the reliability needs of the BGE system under the 2025 and 2027/2028 system conditions, which represent a more realistic, earliest in-service date for the proposed battery. The proposed battery cannot replace the need (RMR) of the existing generation capacity in BGE (Brandon Shores and Wagner generation units) until the planned transmission reinforcements needed to support the BGE and greater PJM system are energized.

Today, the BGE system predominately relies on the availability of the internal generation on BGE that is currently operational offering more than 2,000 MW of capacity and locally supplying a considerable portion of BGE's system load. These findings align with the analysis shared by the Sierra Club's own consultant for year 2025. PJM extended its analysis to the 2027/2028 time frame to represent system conditions expected to be present prior to when the battery could be theoretically energized. The reliability violations are pervasive and severe in nature, which could lead to a potential voltage collapse in the entire BGE system as well as multiple overloads throughout the BGE system and the larger PJM network. The analysis also indicates that without a transmission solution, both Brandon Shores and Wagner will be required to maintain reliability prior to complete energization of the planned transmission reinforcements in the area.

From constructability perspective, the Telos/GridLab concept does not have a viable integration plan to the PJM system. It is unclear who will sponsor, procure, own and operate the battery. The concept also assumes utilizing the existing Brandon Shores site for the installation of the battery and the utilization of the generator step-up transformers. PJM did not receive a confirmation or any commitment from the plant owner (Talen) that it would accept such an arrangement nor is there an estimated cost of such an arrangement to evaluate the overall cost and feasibility of this battery concept.

In conclusion, while a large battery could reduce the severity of the reliability concerns in the BGE and larger PJM system following the retirement of the Brandon Shores and Wagner generation units, it does not replace the need for a Brandon Shores RMR nor address the reliability needs for the system in the near and longer term. PJM's study ultimately concludes that the Brandon Shores units cannot be retired to maintain system reliability until the needed transmission reinforcements are in place. While the proposed battery concept would help offer some local supply within the BGE system, it will not eliminate the need for the proposed major transmission reinforcements required to maintain system reliability.

The appendices have been redacted.