Lawrence B. Somers
Deputy General Counsel

Mailing Address:
NCRH 20 / P.O. Box 1551
Raleigh, NC 27602

o: 919.546.6722
f: 919.546.2694

bo.somers@duke-energy.com



February 5, 2020

**VIA ELECTRONIC FILING**

Ms. Kimberley A. Campbell, Chief Clerk
North Carolina Utilities Commission
4325 Mail Service Center
Raleigh, North Carolina 27699-4300

**Re: Duke Energy Progress, LLC's Revised Semiannual Hot Springs Microgrid Project Progress Report - Refiled Report (Public version)
Docket No. E-2, Sub 1185**

Dear Ms. Campbell:

Duke Energy Progress, LLC ("DEP") has comprehensively reviewed the confidential information filed under seal on January 15, 2020 as part of its revised semiannual progress report for the Hot Springs Microgrid Solar and Battery Storage Facility (the "Revised Report") and has removed the confidential designation in certain sections where it has deemed it appropriate. Accordingly, I enclose a corrected public version of the Revised Report for filing in connection with this matter and renew DEP's request for confidential treatment pursuant to N.C. Gen. Stat. §132-1.2. The confidential version of the filing was not affected and thus is not being refiled.

Thank you for your attention to this matter. If you have any questions, please let me know.

Sincerely,

Lawrence B. Somers

Enclosure

cc: Parties of Record

## CERTIFICATE OF SERVICE

I certify that a copy of Duke Energy Progress, LLC's Refiled Public Version of Hot Springs Microgrid Project Revised Semiannual Progress Report, in Docket No. E-2, Sub 1185, has been served by electronic mail, hand delivery or by depositing a copy in the United States mail, postage prepaid to the following parties:

David T. Drooz, Chief Counsel
Tim Dodge, Staff Attorney
Dianna Downey, Staff Attorney
Public Staff
North Carolina Utilities Commission
4326 Mail Service Center
Raleigh, NC 27699-4300
david.drooz@psncuc.nc.gov
dianna.downey@psncuc.nc.gov

Peter Ledford, General Counsel
Benjamin W. Smith, Regulatory Counsel
NC Sustainable Energy Assoc.
4800 Six Forks Road, Suite 300
Raleigh, NC 27609
peter@energync.org
ben@energync.org

This the 5th day of February, 2020.

By: ______________________________

Lawrence B. Somers
Deputy General Counsel
Duke Energy Corporation
P.O. Box 1551/NCRH 20
Raleigh, North Carolina 27602
Tel 919.546.6722
bo.somers@duke-energy.com

# Hot Springs Microgrid Solar and Battery Storage Facility
## Revised Progress Update
## NCUC Docket No. E-2, Sub 1185
## January 15, 2020

Duke Energy Progress will use the Hot Springs Microgrid Facility to establish the following operational and learning goals;

**Goals**

1) Ensure the safe and efficient operation of a distribution grid-connected Microgrid facility.
2) Use the Distributed Energy Operations & Maintenance (DEOM) team to monitor the distribution grid-connected Distributed Energy Resource (DER) and analyze data (e.g. operational, health, usage).
3) Provide reports for various stakeholders using the sample metrics provided in Table 1.
4) Develop a "transparent and comprehensive plan" to operate and monitor the Hot Springs Microgrid Facility.

Pursuant to the Commission's December 6, 2019 *Order Rejecting Progress Report and Requiring Revised Report*, the attached confidential sample report provides (1) the facility's operations profile during various months of the year; and (2) the amount of energy, capacity, and ancillary services the facility may provide to the grid during typical days during each season.

*Note: The attached sample report provides information and conclusions using simulated data. A more comprehensive report will be provided in the May 10, 2020 submittal as required by Condition 3 a-j contained on pages 14-15 of the Commission's May 10, 2019 Order Granting Certificate of Public Convenience and Necessity with Conditions ("CPCN Order").*

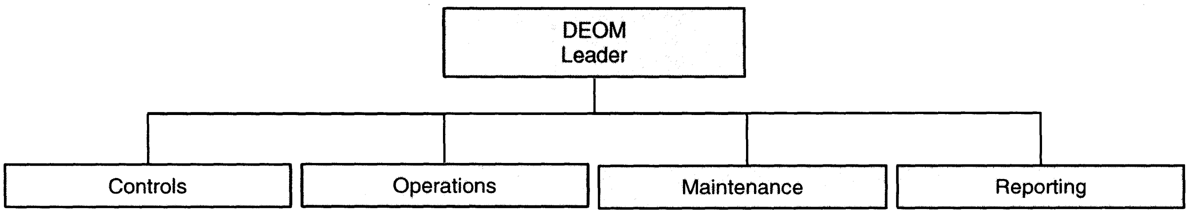
In response to the Commission's request that the revised report include (3) DEP's plan for maintaining a state of charge that will allow the microgrid to serve the Hot Springs community during a night-time power outage, DEP provides the following:

The battery capacity is sized to meet 100% of the Town of Hot Springs peak load and the duration (hours) of backup power will be dependent on several factors, such as solar availability, battery state of charge, and customer load. The battery will be operated and the state of charge managed based on the optimal use case for the grid and customers and will not be specific to the time-of-day. However, if inclement weather which could lead to a power outage is expected in the Hot Springs area, the operational plan would be to charge the battery to maximize the amount of backup power it could provide.

## Business Plan

The Distributed Energy Operations & Maintenance (DEOM) team is part of the Distributed Energy, Enablement & Storage (DEE&S) Program within Duke Energy's Customer Delivery department. DEOM will assist Duke Energy Progress with safe operation and maintenance of regulated distributed energy assets including the Hot Springs Microgrid Facility beginning Day 1 of operations. The DEOM team consists of 4 major focus areas depicted below;

**Distributed Energy Operations & Maintenance (DEOM)**




## Controls

The control system implemented at Hot Springs will allow DEOM to monitor, analyze, and report operational data, plus provide the ability to trouble shoot potential issues or alarms for the site. The Greensmith Energy Management System (GEMS) will sit within the Duke Energy Control Zone and allow remote operations and monitoring of the microgrid utilizing a single control platform. Ongoing development and deployment of the control system will dovetail with the library of business use cases and operational procedures created.

## Operations

DEOM has begun and will continue to build a library of operational documents and is responsible for monitoring the operation of all regulated distribution grid-connected DERs. Emergency Response Plans (ERP), Comprehensive Test & Commissioning Plans, Transition to Operations Checklists, and other Day 1 Operational protocols are in place for the first grid-connected DERs going operational in early 2020.

## Maintenance

DEOM will maintain DER's (battery, solar, and microgrid) through contracted service agreements with third party vendors for the foreseeable future. Third party vendor agreements focus on preventative and corrective maintenance activities which will be performed monthly, quarterly, semi-annually, or annually as appropriate. DEOM will project manage these third party vendors' maintenance execution.

## Reporting

DEOM will be responsible for collecting and communicating data and reports to a variety of stakeholders. Reports will include, at a minimum: weather adjusted predicted energy production, actual energy production, energy yield, inverter availability, capacity factor, and more. Additional performance metrics can be tracked and reported when requested. The metrics that will be monitored and tracked in GEMS or PI Historian for the Hot Springs Microgrid facility are listed in Table 1.

## Table 1: Hot Springs Microgrid Metrics

| Level | BESS System Tags | Unit | Precision | Sample Rate |
|---|---|---|---|---|
| Battery Rack Array/System (Each Rack Array/System) | System Fault Status | bit | 1 | 1sec |
| | System Alarm Status | bit | 1 | 1sec |
| | System Current | A | 0.1 | 1min |
| | System Voltage | V | 0.1 | 1min |
| | System SoC | % | 0.1 | 1min |
| | System Mode | bit | 1 | 1min |
| | Max Cell Temp of System | Deg C | 0.001 | 1min |
| | Min Cell Temp of System | Deg C | 0.001 | 1min |
| EACH Rack | Rack Voltage | V | 0.1 | 1min |
| | Rack Current | A | 0.1 | 1min |
| | Rack SOC | % | 0.1 | 1min |
| | Rack SOH | % | 0.1 | 1min |
| | Rack Fault Status | bit | 1 | 1sec |
| | Rack Alarm Status | bit | 1 | 1sec |
| | Maximum Cell Voltage Value | V | 0.1 | 1min |
| | Maximum Cell Voltage Position | dec | 1 | 1min |
| | Minimum Cell Voltage Value | V | 0.1 | 1min |
| | Minimum Cell Voltage Position | dec | 1 | 1min |
| | Maximum Cell Temperature Value | Deg C | 0.001 | 1min |
| | Maximum Cell Temperature Position | dec | 1 | 1min |
| | Minimum Cell Temperature Value | Deg C | 0.001 | 1min |
| | Minimum Cell Temperature Position | dec | 1 | 1min |
| | Rack DC Switch Status | bit | 1 | 1min |
| | Rack DC Switch Position | bit | 1 | 1min |
| Container | Ambient Tempreture (measured from at least 3 points external to each container) | Deg C | 0.001 | 1min |
| Inverter | Active Power Setpoint | kW | 0.1 | 1min |
| | Reactive Power Setpoint | kVAR | 0.1 | 1min |
| | Measured Active Power Per Phase (Pa,Pb,Pc) | kW | 0.1 | 1min |
| | Measured Reactive Power Per Phase (Qa,Qb,Qc) | kVAR | 0.1 | 1min |
| | Measured Apparent Power Per Phase (Sa,Sb,Sc) | kVA | 0.1 | 1min |
| | AC Phase to line voltage (Van,Vbn,Vcn) | V | 0.1 | 1min |
| | AC Phase Current (Ian,Ibn,Icn) | A | 0.1 | 1min |
| | DC Voltage | V | 0.1 | 1min |
| | DC Current | A | 0.1 | 1min |
| | Alarms | bit | 1 | 1sec |
| | Mode of Operation | dec | 1 | 1min |
| Switchgear | Breaker position for all ways of swgr | bit | 1 | 1sec |
| | Swgr relay voltage, current and power points | V,A,kW,kVAR, kVA | 0.1 | 1min |

| **Original Cost Estimate** | | **Current Cost Estimate** |
|---|---|---|
| | **[BEGIN CONFIDENTIAL]** | |
| [redacted] | | [redacted] |
| | **[END CONFIDENTIAL]** | |

*Cost estimates include generation and transmission facilities costs.

| **Task** | **Original CPCN Filing Estimate** | **Current Status/Estimate** |
|---|---|---|
| Limited Notice To Proceed | March 2019 | July 2019 |
| Interconnection Agreement | August 2019 | March 2020 |
| Begin Construction | September 2019 | March 2020 |
| Commercial Operation | January 2020 | *September 2020 |

**The delay of the Hot Springs Microgrid project can be attributed to the following reasons:*

- *The project team received the CPCN Order from the Commission approximately 2 months later than originally anticipated. This impacted the limited notice to proceed date with the vendor.*
- *DEP has delayed the original estimated date to execute the Interconnection Agreement ("IA"). The Hot Springs Microgrid project is treated the same as other interconnection customers in the queue and the project team has not received the executed IA from DEP.*
- *Construction is still on track to begin soon after the approved IA is received.*
- *The original construction duration period was an estimate developed without a binding EPC contract. The current construction duration incorporates the actual project schedule submitted by DEP's selected EPC provider and executed in DEP's EPC contract.*

DUKE ENERGY®

Energy Storage Engineering & Project Execution
Distributed Energy Technologies
Duke Energy

# Hot Springs
# Frequency Control Battery Profile
# Last Modified February 5, 2020

## 1. Definitions

**Balancing Authority (BA)**: The responsible entity that integrates resource plans ahead of time, maintains load interchange-generation balance within a Balancing Authority Area, and supports Interconnection frequency in real time. Hot Springs Storage site will be part of a Duke Balancing Authority.

**Area Control Error (ACE)**: The instantaneous difference between a Balancing Authority's net actual and scheduled interchange, taking into account the effects of Frequency Bias, correction for meter error, and Automatic Time Error Correction (ATEC), if operating in the ATEC mode. In simple terms, the Area Control Error refers to the difference between scheduled and actual electricity generation within a control area on the [power grid. For example, a –5 MW value of ACE would indicate that a Balancing Authority should be generating 5 MW more to meet its obligation to the Interconnection. A positive value of ACE indicates that the Balancing Authority needs to decrease its generation to meet its interconnection Obligation.

**Balancing Authority ACE Limit (BAAL)**: The Balancing Authority ACE Limits are unique for each Balancing Authority and provide dynamic limits for its Area Control Error value limit as a function of its interconnection frequency. As per NERC STANDARD BAL-001-2 requirement R2, Balancing Authority shall operate such that its clock-minute average of reporting ACE does not exceed its clock-minute BAAL for more than 30 consecutive clock-minutes. This means that the BA needs to closely regulate its ACE value to be close to zero and ensure that it does not exceeds the BAAL. Generation and load needs to be balanced continuously to regulate the ACE value. Please refer to NERC STANDARD BAL-001-2 for more details.

**Control Performance Score 1 (CPS1)**: CPS1 is a measure of a Balancing Authority's control performance as it relates to its generation, load management, and interconnection frequency when measured in one-minute averages over a rolling one-year period. A Balancing Authority reports its CPS1 value to its regional entity each month. The value needs to be greater than or equal to 100 percent for the applicable interconnection in which it operates for each 12-month period. Please refer to NERC STANDARD BAL-001-2 for more details.

**Battery Energy Storage System (BESS)**: All components and subsystems needed for charging and discharging of storage, including but not limited to 1) the connection to the energy source, 2) energy storage enclosures, 3) power conditioning (for electricity storage), 4) overall controls (including charge and discharge, rate of discharge, response to initiating signals, others), 5) monitoring, 6) diagnostics, and 7) communication.

## 2. Frequency Control Algorithm Overview

Duke Energy intends to use the Hot Springs Battery Energy Storage System (BESS) to provide ancillary services to the bulk power system. The battery can provide frequency response as well as regulation services. One of the important tasks of Balancing Authority is to maintain the generation and load balance. The chart in Figure 1 is called Balancing Authority ACE Limit (BAAL) chart which has frequency on the x axis and Area Control Error (ACE) on the y axis. Each Balancing Authority (BA) balances load and generation to ensure it CPS1 score remains within BAAL limits (see Figure 1). If the BAAL limits are exceeded and the ACE is positive, then the balancing authority needs to decrease generation or increase load. And, If the BAAL limits are exceeded and the ACE is negative, then the balancing authority needs to increase generation or decrease load. BESSs have the ability to respond faster according to the changes in the system, and it is used here to provide fast response to ACE, frequency and CPS1 score changes so as to defer the need of other rotating machine generators from providing this same service (which would be done at a higher cost). Also, BESSs can provide primary frequency response whenever frequency goes beyond the specified deadband. If the frequency exceeds the upper limit, the battery charges, and when it goes below the lower limit, the battery discharges. The section below shows the results of the simulation cases run using historical data for four days from four different seasons. These showcase how the battery can help the balancing authority in meeting BAAL limits and provide primary frequency response

**[BEGIN CONFIDENTIAL]**

**[END CONFIDENTIAL]**

3. **Simulation Notes:**

- The results show the battery dispatch from the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** control algorithm and do not consider the operational limits of the circuit hosting the energy storage.
- The actual battery dispatch might be different and will be limited by the plant controller to ensure that the BESS operation does not violate any circuit local feeder operational limits (voltage & ramp-rate).
- Also, system operators can set tunable parameters according to the system needs which in turn can control the battery response. The parameter values used during operation might be different than used in the simulation results shown below.

Negative sign in battery dispatch indicates charging and positive sign indicates discharging.

## 4. Simulation Results

### 4.1. Winter Season:

Figure 2 below shows a time series 24-hour system information of a historical winter day from the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** and the simulated battery information. Figures 2a, 2b and 2c show the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**. Figures 2d and 2e show the battery simulated active power dispatch and corresponding state of charge respectively. Figure 2 shows the overall battery dispatch for a 24-hour period as the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**. To explain the relationship between battery dispatch and system parameters **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**, three events are highlighted in Figure 2 and elaborated below,

Event 1: During this event the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** exceeds its limit, and the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** is positive. A positive **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** value means that the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** has excess generation and needs to increase load or decrease generation. So, the battery starts charging (negative sign indicates charging in the simulation) which helps to increase the system load. Also, **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** exceeds the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**, and the battery provides primary **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** based on its droop settings.

Event 2: Event 2 shows a large drop in the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**, system **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** and **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** (Figure 2a, 2b and 2c). This indicates a loss of large generating unit within the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** and exceedance of **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** limit. As soon as the loss of generation happens, the battery starts to discharge (Figure 2d, (positive sign indicates discharging in the simulation)) to help arrest the drop of **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** and **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**. As the battery discharges, Figure 2e shows that the state of charge of the battery decreases.

Event 3: Event 3 highlighted in Figure 2 shows the battery operation whenever the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** goes beyond the specified **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**. It shows the battery dispatches according to its droop setting whenever the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** excursion occurs. If the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** exceeds the upper limit, the battery charges, and when it goes below the lower limit, the battery discharges.

**[BEGIN CONFIDENTIAL]**

**[END CONFIDENTIAL]**

### 4.2. Spring Season:

Similar to winter season, battery dispatch is simulated using the system information (**[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**) from a historical day in spring and the results are shown in Figure 3. Battery is dispatched to support the grid depending on the system conditions. As described in the previous case, although the battery is providing support continuously for the 24-hour period simulated, only 3 events are selected here to explain the functionality.

Event 1: Event 1 highlighted in Figure 3 shows the battery operation whenever the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** goes beyond the specified **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**. It shows the battery dispatches according to its droop setting whenever the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** excursion occurs. If the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** exceeds the upper limit, the battery charges, and when it goes below the lower limit, the battery discharges.

Event 2: During this event the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** exceeds its limit and the system **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** is positive. A positive **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** value means that the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** has excess generation and needs to increase load or decrease generation. So, the battery starts charging (negative sign indicates charging in the simulation) which helps to increase the system load. Figure 3e shows that the battery state of charge increases because of the charge. Also, **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** exceeds the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**, and the battery provides primary **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** based on its droop settings.

Event 3: Event 3 shows a large drop in the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**, system **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** and **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** (Figure 3a, 3b and 3c). This indicates a loss of large generating unit within the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** and exceedance of **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** limit. As soon as the loss of generation happens, the battery starts to discharge (Figure 3d, (positive sign indicates discharging in the simulation)) to help arrest the drop of **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** and **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**. As the battery discharges, Figure 3e shows that state of charge of the battery decreases.

**[BEGIN CONFIDENTIAL]**

**[END CONFIDENTIAL]**

**Summer Season:**

In this case, a day is simulated using the historical data from a day in summer season and results are shown in Figure 4. Battery responds similar to the previous seasons. Like previous seasons, 3 events are selected here to explain the functionality.

Event 1: During this event the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** exceeds its limit, and the system **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** is positive. A positive **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** value means that the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** has excess generation and needs to increase load or decrease generation. So, the battery starts charging (negative sign indicates charging in the simulation) which helps to increase the system load. Also, **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** exceeds the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**, and the battery provides primary **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** based on its droop settings.

Event 2: Event 2 shows a large drop in the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**, system **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** and **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** (Figure 4a, 4b and 4c). This indicates a loss of large generating unit within the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** and exceedance of **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** limit. As soon as the loss of generation happens, the battery starts to discharge (Figure 4d, (positive sign indicates discharging in the simulation)) to help arrest the drop of **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** and **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**. As the battery discharges, Figure 4e shows that state of charge of the battery decreases.

Event 3: Event 3 highlighted in Figure 4 shows the battery operation whenever the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** goes beyond the specified **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**. It shows the battery dispatches according to its droop setting whenever the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** excursion occurs. If the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** exceeds the upper limit, the battery charges, and when it goes below the lower limit, the battery discharges.

**[BEGIN CONFIDENTIAL]**

**[END CONFIDENTIAL]**

**Fall Season:**

In this case, a day is simulated using the historical data from a day in fall season, and results are shown in Figure 4. Battery acts similar to the previous seasons. Like previous seasons, 3 events are selected here to explain the functionality.

Event 1: During this event the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** exceeds its limit, and the system **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** is positive. A positive **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** value means that the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** has excess generation and needs to increase load or decrease generation. So, the battery starts charging (negative sign indicates charging in the simulation) which helps to increase the system load. Also, **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** exceeds the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL],** and the battery provides primary **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** based on its droop settings.

Event 2: Event 2 highlighted in Figure 5 shows the battery operation whenever the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** goes beyond the specified **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**. It shows the battery dispatches according to its droop setting whenever the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** excursion occurs. If the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** exceeds the upper limit, the battery charges, and when it goes below the lower limit, the battery discharges.

Event 3: Event 3 shows a large drop in the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**, system **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** and **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** (Figure 5a, 5b and 5c). This indicates a loss of large generating unit within the **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** and exceedance of **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** limit. As soon as the loss of generation happens, the battery starts to discharge (Figure 5d, (positive sign indicates discharging in the simulation)) to help arrest the drop of **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** and **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**. As the battery discharges, Figure 5e shows that state of charge of the battery decreases.

**Remarks:**

Several days have been simulated using the historical data from several seasons. The results show that over the 24-hour period, the battery provides a significant amount of **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** as well as **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**.

**[BEGIN CONFIDENTIAL]**

**[END CONFIDENTIAL]**