NORTH CAROLINA ELECTRIC MEMBERSHIP CORPORATION/DUKE ENERGY DISTRIBUTION OPERATOR PILOT PROJECT

FINAL REPORT

DECEMBER 2020

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EXECUTIVE SUMMARY

The commercial viability of diverse technology, evolving customer preferences, and governmental and non-governmental sustainability goals all point to a future in which Distributed Energy Resources (DER) achieve greater penetration at the distribution system level and behind the customer meter. Electric utilities, individually and cooperatively, must develop the capability to integrate increasing levels of DER into their operations in a manner that enhances, or at least preserves, reliability and resiliency, and offers opportunities for suppressing and/or reducing future capital and operational costs.

For the past several years, North Carolina's Electric Cooperatives, including North Carolina Electric Membership Corporation (NCEMC), the state's generation and transmission (G&T) cooperative, and the state's network of 26 distribution cooperatives have conceptualized and operationalized the component parts of an NCEMC Distribution Operator (DO). As conceptualized, the NCEMC DO is a single entity that monitors, aggregates, and centrally dispatches DER and Demand Response (DR) resources, bringing operational benefits to the distribution system, positive system impacts on the transmission system upstream, and optimization in the market interface.

On September 29, 2020, NCEMC and Duke Energy successfully conducted a joint two-part test to demonstrate the operational capability of the NCEMC DO. Prior to this pilot, the NCEMC DO had not been fully tested with Duke Energy to ensure the viability of concerted operation. This test was performed by centrally exercising DER and DR edge-of-grid resource control, providing visibility of DER to Duke Energy – serving as the Transmission Operator (TOP), and simulating a coordinated emergency response with the TOP utilizing distribution assets for the reliability benefit of the transmission system.

Tests included a documented pre-arranged test script, real-time communication of events between NCEMC and Duke Energy, data capture and archiving, confirmation of perceived results through measurement and verification (M&V), and the utilization of established operational protocols.

The test of the NCEMC DO demonstrated coordination between a TOP and a G&T cooperative by exchanging data and operational details of activities taking place on a distribution system. With access to over 100 MW of DER and DR resources, this coordination enhances situational awareness, system reliability, load forecasting, and use of the transmission system, while enabling enhanced operational benefits on the distribution system.

The successful test is a significant proof of concept with profound implications for the future of advanced grid management for North Carolina's Electric Cooperatives. By coordinating resources throughout cooperative distribution grids, electric cooperatives in North Carolina are achieving not only a more efficient, reliable, resilient, and sustainable distribution system; but are also continuing to expand the services offered to members and meet the growing needs of our rural communities.

NCEMC PERSPECTIVE

This effort successfully demonstrated curtailment of generation and demand-response devices behind the distribution delivery point utilizing mutually agreed upon communication and data protocols to meet the needs of the TOP while maintaining the reliability coordination requirements of the distribution cooperative.

- Part I of the test curtailed approximately 40 MW of DER production through generation curtailment and battery storage charging. This portion of the test was conducted from 11:00 to 11:30am.

  Note: The nameplate capacity of the solar sites curtailed is approximately 120 MW as demonstrated. Many of the solar sites were not producing at full output due to irradiance conditions and the time of day.

- Part II of the test reduced approximately 35 MW of load from the distribution system with smart thermostat and water heater adjustments, Conservation Voltage Reduction (CVR), battery storage discharge, and activation of Customer Owned Generation (COG). Although COG is under other dispatch contracts, it was included in this pilot to demonstrate the local reliability impact of this resource.

The focus of future efforts, from a resource deployment perspective, includes the importance of automating the DER curtailment process utilizing a Distributed Energy Resource Management System (DERMS) and continued coordination and integration with third-party vendors on device and system response during event deployment. From an M&V perspective, NCEMC will continue to improve the availability of data from member distribution cooperatives, baseline modeling to more accurately account for weather anomalies, and forecasted DR capability. NCEMC expects the impact of DER and DR edge-of-grid resources will continue to grow as new technologies emerge and more devices are added at both the wholesale and retail levels.

DUKE ENERGY PERSPECTIVE

This test provided a concrete exploration and demonstration of how a DO can control various types of DER and DR on distribution systems in response to coordinated requests and directives from the TOP. This could include response to emergency operating instructions, as was tested here, or it could include actions taken by the DO in response to market pricing or local conditions on a distribution system. While Duke Energy has coordinated the operation of distributed assets for years, typically the interaction is between Duke Energy and the individual distribution cooperative or DR provider, not necessarily a G&T. In addition, it is atypical that a TOP has real-time telemetry to those types of resources, either in aggregate or the individual DER level. In this test, NCEMC shared real-time telemetry information with Duke Energy allowing Duke Energy to monitor the behavior of both individual DER (solar, battery storage) and aggregate load delivery points (showing the DR response). Duke Energy expects that NCEMC as a DO will become increasingly more sophisticated in their ability to manage DER on the distribution system, and this pilot offered an opportunity to test communication and data exchange protocols so that NCEMC and Duke Energy may think longer term about what works, what doesn't, and how to improve future coordination in these areas.

OVERALL

The NCEMC DO provides a single centralized coordinated point of contact and control for utilization of DER and DR edge-of-grid resources across multiple distribution entities for reliability coordination. This centralized coordinated action allows for resources to be utilized for reliability response prior to deployment of emergency load shed procedures. Beyond reliability curtailment, another key benefit for the TOP is improved situational awareness through increased visibility of DER and DR edge-of-grid resources and better TOP coordination with distribution companies. Development of more comprehensive coordination practices in dispatching and curtailing DERs can provide the TOP with additional information to include in planning tools for emergency conditions. This coordination also includes the ability to fine-tune load forecasts and provide operators with better situational awareness in real-time as well as in the planning environment.

As local, member-owned utilities, North Carolina's electric cooperatives will continue to research and apply innovation to build a more flexible, sustainable, and resilient distribution grid to meet the expanding needs of cooperative members and communities. Due to the success of the Duke Energy DO Pilot and the value added to both Duke Energy and NCEMC through lessons learned, both parties will continue to look for opportunities to work together on similar projects in the future.

DISTRIBUTION OPERATOR BACKGROUND

North Carolina's electric cooperatives are implementing a DO environment to enhance operational efficiencies. As illustrated by the figure below, the NCEMC DO is a single entity that monitors, aggregates, and centrally dispatches/curtails DR and DER resources. North Carolina's electric cooperatives are pursuing this structure to bring operational benefits to the distribution system and to provide support to the transmission system upstream all while optimizing the market interface.

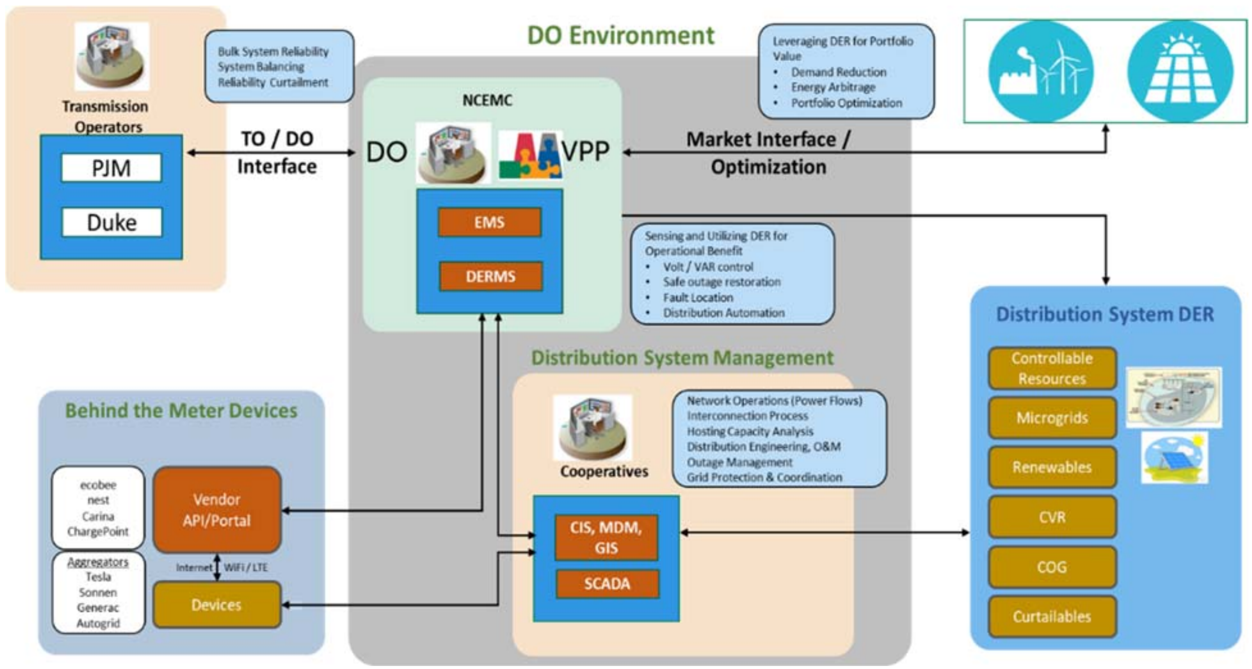

Figure 1 - DO Hierarchy

The NCEMC DO also coordinates upstream with TOPs to improve visualization of activities that are taking place on the distribution system, commonly referred to as behind-the-meter for the transmission system. For the TOP, visualization into a distribution system improves situational awareness and in turn, can help the TOP make better reliability decisions during system events. These activities include sharing real-time telemetry of load on delivery points, DR capability, DER locations, DER site specifications, and real-time production data, as well as curtailment capabilities.

The capability of the NCEMC DO is enabled through a DERMS software tool. This integrated tool plays a key role in connecting the G&T cooperative and the distribution cooperative by improving communication, aggregation, and visualization of DER connected to the distribution system, facilitating operational control of DR resources, and providing a mechanism to react to optimization opportunities and upstream reliability directives from the TOP. The NCEMC DERMS tool provides a platform and a centrally located system for the operational benefit of aggregated control of DER and DR resources to aid in maintaining system stability, reliability, resiliency, and safety. In summary, the DERMS has enabled NCEMC to create operational benefits for the

NCEMC distribution cooperative members and the upstream TOP while adding a means to facilitate optimization value for the NCEMC power supply portfolio.

PARTICIPATING ENTITIES

NORTH CAROLINA'S ELECTRIC COOPERATIVES

North Carolina's electric cooperative network is comprised of 26 distinct, member-owned, not-for-profit electric cooperatives. These distribution cooperatives have approximately 106,000 miles of lines that provide electricity for close to 2.5 million North Carolinians, roughly a quarter of the state's population and covers almost 45 percent of North Carolina's land mass. Each cooperative independently owns and operates its own distribution system for serving its membership.

NCEMC is the G&T cooperative that provides services, including power supply, to most of North Carolina's electric cooperatives. The North Carolina electric cooperative service territory spans across three Transmission Providers, Duke Energy Carolinas (DEC), Duke Energy Progress (DEP), and Dominion/PJM.

Five distribution cooperatives located in the Duke Energy Carolinas and Duke Energy Progress (Duke Energy) areas participated in the DO pilot: Blue Ridge Energy (BRE), Brunswick Electric (BEMC), Energy United (EU), Randolph EMC (REMC) and Union Power Cooperative (UPC).

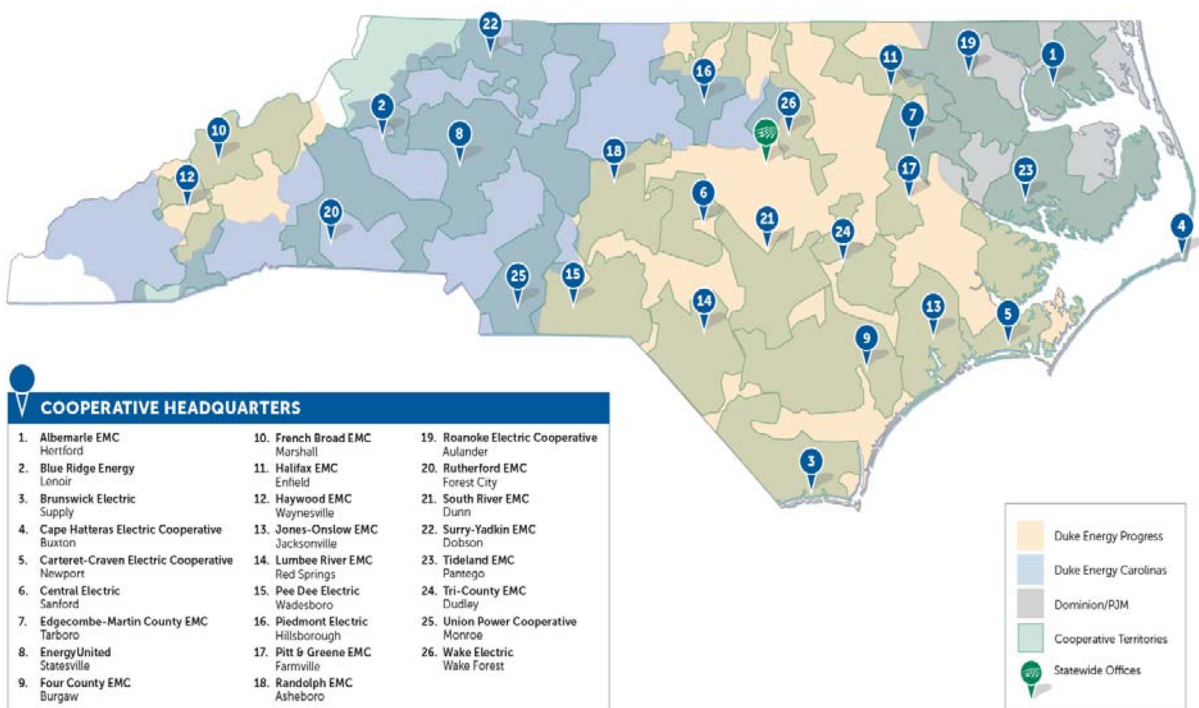

Figure 2 - NC Cooperative Service Territory

DUKE ENERGY

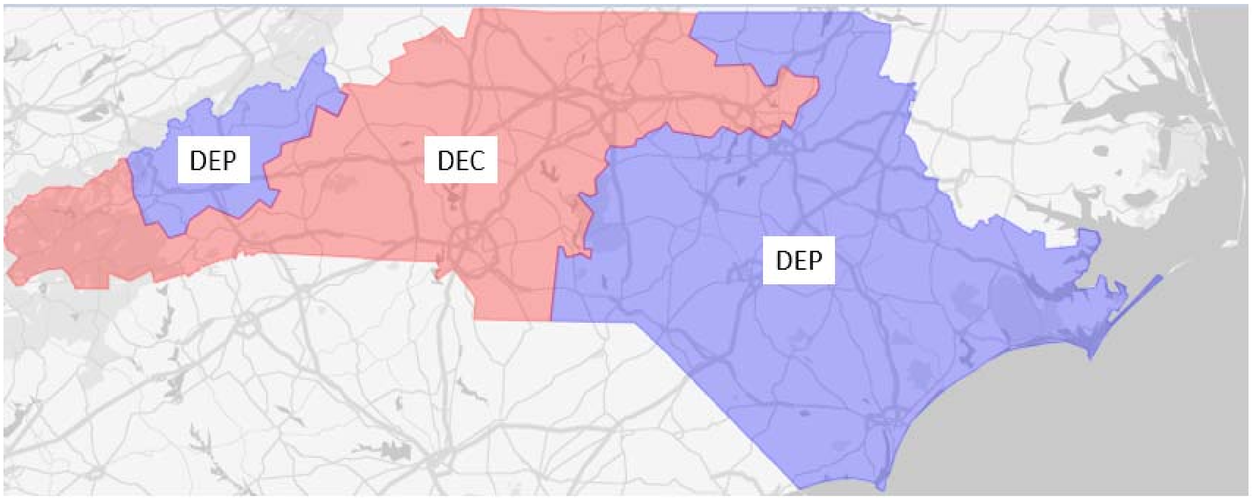

Figure 3 - Duke Energy Territory

Between DEC and DEP, Duke Energy operates and manages the planning and operation of the high-voltage electricity transmission system across a large portion of North Carolina to ensure reliability for more than 4 million customers.

In addition to operating the transmission system, Duke Energy's long-term transmission planning process provides a broad perspective that identifies the most effective and cost-efficient improvements to the grid to ensure reliability and economic benefits on a system-wide basis.

One key focus area for Duke is to realize better visibility of DER and improved coordination with distribution companies throughout North Carolina, especially those with the capability to actively manage the DER connected to their systems. More comprehensive coordination practices around how these resources will be dispatched or curtailed will assist the TOP in operating the transmission system in a safe and reliable manner. The associated operations planning and coordination includes the ability to fine-tune load forecasts and provide operators with better situational awareness for an operating day.

GOALS

The primary goal of the pilot was to demonstrate the operational capability of the NCEMC DO to receive and respond to Emergency Operating Instructions from the TOP. The pilot test was a simulated reliability coordination event where the NCEMC DO was provided notice and given the opportunity to respond to two different simulated scenarios using DER and DR edge-of-grid resources to reduce load and generation connected to the distribution systems.

Secondary goals of the pilot test included ensuring the proper data was shared, collected, and archived for event post-analysis, as well as ensuring the proper event communication protocol was established and used.

SCOPE

The scope of the NCEMC DO pilot test with Duke Energy included a jointly-developed, documented process and protocol for testing and scheduling of DR and DER events; communication of events between NCEMC and Duke Energy as the TOP; and confirmation of results through coordinated data collection and an M&V process utilizing the NCEMC DERMS baselining methodologies. The DO pilot test was broken down into two parts to control DER and DR edge-of-grid resources in response to TOP directives; Part I of the test demonstrated the NCEMC DO's ability to curtail DER resources injecting energy into the distribution grid, while Part II demonstrated the NCEMC DO's ability to reduce load utilizing DER and DR resources.

The following resource types were utilized as part of the NCEMC DO pilot test. The values in the table below represent the total resource capacity available for the pilot test:

Technology	(Battery)	(CVR)	(Thermostat)	(Solar)	(Water Heater)	(COG)	(Load Switches)	(Virtual Peaker)
MW	6.63	15.8	2.17	110.97	0.234	18.9	10.5	0.39
Device Count	13	5 Co-ops	1,756	33	39	265	68,425	387

Figure 4 - DER Nameplate Capacity

Part I of the pilot tested the curtailment of 33 renewable solar sites and the operation of the Heron's Nest Microgrid solar and battery storage to help alleviate a simulated "Excess Energy Emergency" event. Heron's Nest is a residential microgrid located in Shallotte, NC on BEMC's system. In a non-testing environment, Duke Energy would call an "Excess Energy Emergency" event when there is, or has the potential to be, more generation on the system than load; for example, when solar farms are producing more energy than the system can consume.

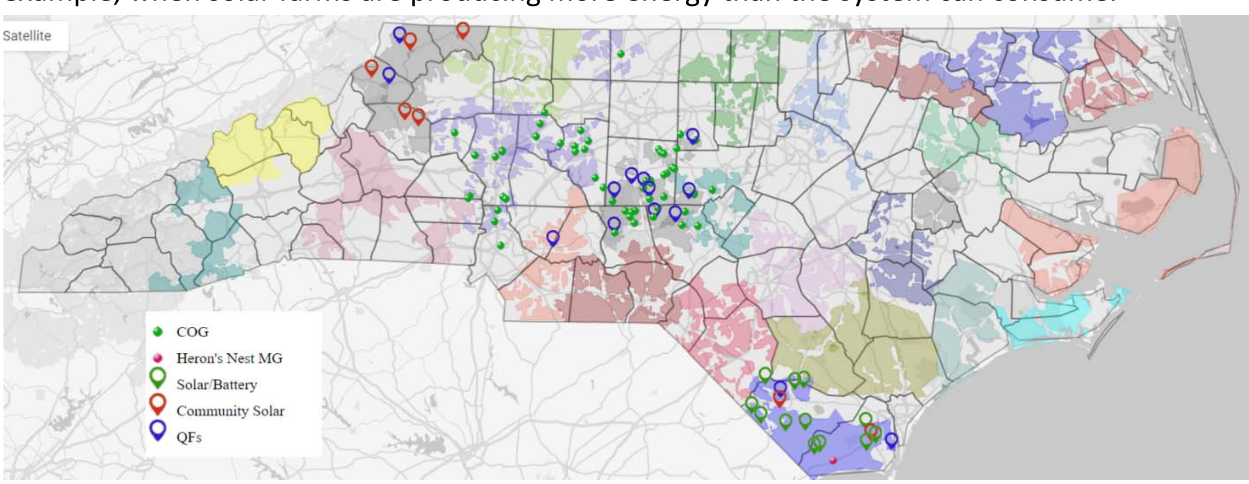

Figure 5 - DER Locations

Matching supply and demand for energy on the system is critical to avoid reliability issues. As more DERs connect to the system, it becomes increasingly difficult to monitor production and manage both supply and demand. Part I of the pilot tested the ability of the NCEMC DO to monitor and curtail supply if needed.

Prior to the test, NCEMC discharged the Heron's Nest Microgrid battery to 65 percent remaining capacity to ensure there would be ample available charging capacity for the test. Once Part I of the test was initiated, the battery was scheduled to charge at a rate of 10 kW to add load to the grid. The Heron's Nest Microgrid's battery is designed to primarily charge from the solar array only, but also has the ability to charge from the grid. Although the battery is capable of charging at a much higher rate, the battery was only being utilized as a test of the capability to charge an asset and therefore only a small rate of charge from the grid was used. After Part I of the test concluded, the battery was fully recharged in preparation for Part II of the test later that afternoon.

Part II of the test included the activation of available DR programs and the use of the Heron's Nest Microgrid battery storage to respond to a simulated "Emergency Demand Response" event. In a non-testing environment, Duke Energy would call an "Emergency Demand Response" event when the demand for energy is extremely high, i.e., during a very hot summer afternoon when air conditioners across the system are all operating simultaneously and continuously without cycling. When demand for energy is high, the cost to supply energy to meet that demand is also high, and at times, can be in short supply due to the unavailability of generation or other system constraints, such as Energy Emergency Alerts (EEA). By curtailing demand across the system, cooperatives can aid the TOP in avoiding potential reliability issues that could trigger further steps, including consumer load shedding. Part II of the pilot tested the ability of the NCEMC DO to reduce demand by implementing DR programs and battery storage.

The DR programs implemented during the pilot testing included CVR, active water heater curtailment, smart thermostat temperature control, and dispatch of COG. The Heron's Nest Microgrid battery was also discharged at a rate of 125 kW for the event. After Part II of the test was completed, the battery was returned to normal economic dispatch and recharged via solar energy.

PREPARATIONS

Part I of the test required the NCEMC DO to have the direct ability to curtail DER. To fulfill this requirement, communications for data monitoring and control was established at specific sites where the technical ability exists to participate in the curtailment exercise. NCEMC also include a DER site that is connected to a cooperative but utilizes the cooperative distribution grid to flow the output to a third-party.

DER CONTROL

UTILITY SCALE DER SOLAR SITES

NCEMC elected to curtail each utility scale DER participant site utilizing recloser and circuit breaker control to trip each site offline at the point of interconnection. This method provides an immediate relief of generation to the transmission grid during a system emergency. To meet this objective, NCEMC approached each distribution cooperative participating in the test to establish the connections necessary for the curtailment of each site. A data link utilizing DNP3 protocol was established from the NCEMC DERMS system to the cooperative Supervisory Control and Data Acquisition (SCADA) system, allowing NCEMC to send a trip command to each site individually or in aggregate. NCEMC has a separate data-only link to each utility scale DER site for telemetry to monitor site output and obtain metering data for billing purposes. To maintain safety protocols on the distribution system and protect line workers, NCEMC is only able to trip the DER sites and cannot remotely reconnect the sites. Therefore, at the conclusion of the test, a request was made to the distribution cooperatives to restore each site by closing the recloser or circuit breaker through normal operational dispatch protocols that each distribution cooperative maintains for safety and reliability.

INVERTER CONTROLLED SOLAR SITES

The NCEMC community solar sites do not have a recloser at the point of interconnection to be controlled due to their relatively small size (50-100kW). NCEMC curtailed each community solar site utilizing inverter controls to ramp the sites down to zero output. NCEMC approached BRE and BEMC as test participants for community solar curtailment of seven sites. Cellular data links were established to all but one site individually utilizing MODBUS protocol between the NCEMC SCADA system and each inverter. BRE had to manually curtail one community solar site due to the timing of the test but is actively installing the data link.

DR CONTROL

Part II of the test also utilized the NCEMC DERMS platform for scheduling, notification, execution, and post event M&V of DR devices and post-analysis activities.

NCEMC's DERMS platform is a deployment of Open Access Technology International (OATI) webMeter and webIntegrate products. Currently the DERMS has the capability to activate COG assets, adjust smart thermostats, initiate water heater controllers, provide notification requests via text and email to implement CVR, monitor and control community solar, solar plus storage, DER sites and microgrids. NCEMC continues to increase DERMS integrations with additional sites and capabilities. Some sites included in the scope of the test required manual control that was coordinated and performed locally by the cooperatives via notification requests send through the DERMS system.

NCEMC works with its member cooperatives to create, deploy, and maintain various DR programs. To achieve load reduction, NCEMC and the cooperatives utilize various methods of device deployment including previously established DR programs, Bring Your Our Thermostat (BYOT) programs, and an NCEMC coordinated large-scale direct sales program called Connect to Save. Control of the deployed assets depends on the specific program; for example, behind-the-meter devices are typically scheduled and controlled by the DERMS via a third-party vendor’s Application Programming Interface (API) while CVR and curtailable resources are controlled directly by the cooperatives or consumers and the DERMS provides only an event request notification and M&V functions.

COMMUNICATION PROTOCOL

DATA COMMUNICATION

Real-time data was exchanged by NCEMC to Duke Energy via a SCADA to SCADA Inter-Control Center Protocol (ICCP) connection. NCEMC shares real-time output data of all utility scale DER and all NCEMC member cooperative load by delivery point with Duke Energy.

All necessary data for post-analysis was archived by NCEMC utilizing the General Electric E-Terra historian product. Data was captured and archived with one-minute granularity.

Data for post-analysis was archived by Duke Energy utilizing a software tool called OSI Soft Plant Information (PI) historian that is designed specifically for large quantities of data archiving and retrieval.

Duke Energy's SCADA system imports data from the NCEMC ICCP link every 10 seconds and archives it in the PI historian. In the PI historian, the analog data is stored using a compression resolution similar to that which is implemented in SCADA by default with a compression setting that allows efficient and meaningful storage usage for MW/MVAR level data while saving enough granularity for analysis. For data points that need a more granular view, this compression setting is manually changed to allow higher resolution for the data that is being stored. As will be discussed later, this data management system has implications on the granularity of DER data.

VOICE COMMUNICATION

NCEMC and Duke Energy coordinated to simulate emergency conditions on the Duke Energy system necessitating actions by NCEMC to assist in relieving emergency operating conditions.

Since the simulated emergencies were only intended for NCEMC and not all parties connected to the Duke transmission grid, Duke Energy agreed to use voice communications directly to NCEMC rather than utilizing the normal electronic communication through Duke Energy's robo-call telephone notification system.

For Part I of the test, Duke Energy contacted NCEMC with a pre-arranged "drill" message simulating an "Excess Energy Emergency" event that requested NCEMC take steps to aid in relieving an excess generation issue on the system.

For Part II of the test, Duke Energy contacted NCEMC with a pre-arranged "drill" message simulating an "Emergency Demand Response" event requesting that NCEMC activate its DR programs to aid in relieving the emergency by reducing load.

All phone calls were placed according to the testing protocol timing laid out ahead of time and both parties utilized three-part communication to confirm receipt and understanding of the message content.

TESTING PROTOCOL

NCEMC and Duke Energy collaboratively created the testing protocol for both Part I and Part II of the test. Both Part I and Part II were conducted on the same day and on a date selected by NCEMC. Part I of the test was initiated at 11:00 EPT with a planned duration of 30 minutes. Part II of the test was conducted in the afternoon beginning at 16:00 EPT with a planned duration of one hour.

The following steps were taken to perform each part of the test. All times, issues and follow-up questions were recorded as the steps were completed.

PART I

1) At 11:00, Duke Energy placed a phone call to NCEMC declaring a mock "Excess Energy Emergency" beginning at 11:00 and asking NCEMC to take steps to aid in relieving an excess generation issue on the system.
2) In response, NCEMC took the following actions in the DEC and DEP service territories via the NCEMC DERMS and SCADA systems:
    a. Curtailed seven Community Solar sites at BEMC, BRE and REMC via inverter control by changing the inverter output setpoints from 100 percent to zero percent via the DERMS system. All inverters ramped down to zero within seven minutes of issuing the commands.
    b. Curtailed 11 utility scale DER solar sites, 1 in BEMC (Goins), 9 in REMC (Bear Creek, Copperfield, Debestani, Flint Hill, Hopewell, Morning View, Snow Camp, Strider

and Zelda) and 1 in UPC (McBride) via recloser or breaker control by sending a "trip" command from the NCEMC DERMS system through the cooperative SCADA system to the field device.

   c. Placed a phone call to the Cypress Creek control center and issued an operating instruction to curtail all 12 solar sites immediately.
   d. Curtailed the solar array at the Heron's Nest Microgrid site via inverter control by changing the inverter output setpoint from 100 percent to zero percent
   e. Sent a "charge" command to the Heron's Nest Microgrid controller to begin charging the battery at a charge rate of 10 kW to add load.

3) NCEMC and Duke Energy were both monitoring and archiving real-time telemetry from all impacted sites as well as cooperative member load by delivery point for post-event analysis.
4) At 11:30am, Duke Energy placed another phone call to NCEMC terminating the mock "Excess Energy Emergency" event.
5) In response, NCEMC took the following actions to restore solar production:
   a. Restored the curtailed Community Solar sites at BEMC, BRE and REMC via inverter control by changing the output setpoints from zero percent to 100 percent. Each site was restored to full available output within seven minutes of issuing the commands.
   b. Restored the Heron's Nest Microgrid solar array to full available production via inverter control by changing the output setpoint from zero percent to 100 percent. The site was restored to full available output within seven minutes of issuing the command.
   c. Discontinued the Heron's Nest battery charge and returned the microgrid to normal operation
   d. BEMC, REMC and UPC restored all DER sites to normal operation by remotely closing the reclosers and breakers, restoring power to each site and allowing all DER solar generation to resume production.
   e. Called Cypress Creek and requested to restore all 12 solar sites to normal operation.
6) NCEMC and Duke Energy verified, via real-time telemetry, that all solar generation production was restored.
7) Part I of the test was concluded.

PART II

1) At 16:00, the afternoon of the same day, Duke Energy placed a phone call to NCEMC declaring a mock "Emergency Demand Response" event beginning at 16:00 and asking NCEMC to take steps to aid in relieving an anticipated generation shortage issue on the system.
2) In response, NCEMC took the following actions in the DEC and DEP service territories via the DERMS system:
    a. Scheduled a thermostat event in the DERMS system adjusting ecobee thermostats up three degrees from their current setpoints for a three-hour event beginning at 16:00.
    b. Scheduled a water heater control event in the DERMS system that essentially turned off one of two water tank heating elements and allowed the tank temperature to drift beginning at 16:00.
    c. Scheduled an immediate CVR event in the DERMS system sending out notifications requesting each cooperative participating in the test to initiate an immediate CVR event.
    d. Scheduled a COG event in the DERMS system requesting generators to run from 16:00 – 16:35.
    e. Scheduled a discharge of the Heron's Nest microgrid battery to inject stored energy onto the grid.
    f. Sent notification via the DERMS to EU to initiate their Virtual Peaker and COG programs manually.
    g. Verified all DR events were properly scheduled and initiated via device indications, DERMS notifications, and viewing event schedules in vendor web portals.
    h. NCEMC and Duke Energy were both monitoring and archiving real-time telemetry from all cooperative member load delivery point for post event analysis.
    i. At 17:00, Duke Energy placed another mock phone call to NCEMC terminating the "Emergency Demand Response" event.
    j. Part II of the test was concluded.

DATA COLLECTION AND ANALYSIS

Both NCEMC and Duke Energy were tasked with collecting and archiving real-time telemetry data from each of the NCEMC cooperative loads as well as each of the DER sites within the scope of the test. This was important to allow each entity to independently verify the results of the test through post analysis.

NCEMC

NCEMC archives data on a 1-minute basis using the E-Terra database platform linked to the SCADA system.

During each part of the test, NCEMC verified the output of the generators being curtailed and the delivery point loads were being archived in the E-Terra database. Step changes in DER output and in delivery point loads at the end of each event were clearly identifiable and correlated to the actions taken during the test.

DUKE ENERGY

Duke Energy monitored the data during the test as an observer. The system operators were not monitoring the tests in real-time because the MW impact was not significant to system operations.

The PI historian that Duke Energy uses captures and archives measured data when the value being archived exceeds a pre-determined delta threshold.

RESULTS AND OBSERVATIONS

The test was a success as both NCEMC and Duke Energy met both the primary and secondary goals of proving the concept that NCEMC can effectively add value and aid the TOP during reliability and transmission system emergencies.

WEATHER

Weather conditions for the test date were moderate with temperatures across the state ranging from lows in the lower 70s to highs in the lower 80s.

The weather in the morning, at the time of Part I of the testing, was transitioning from mostly cloudy to mostly sunny with light winds and no precipitation across the state.

During Part II of the testing, weather was near normal for this time of year with temperatures reaching the low 80's. The graphs below illustrate the daily weather from Wilmington, NC and Charlotte NC, two of the official weather stations located closest to the member cooperatives that participated in the pilot testing.

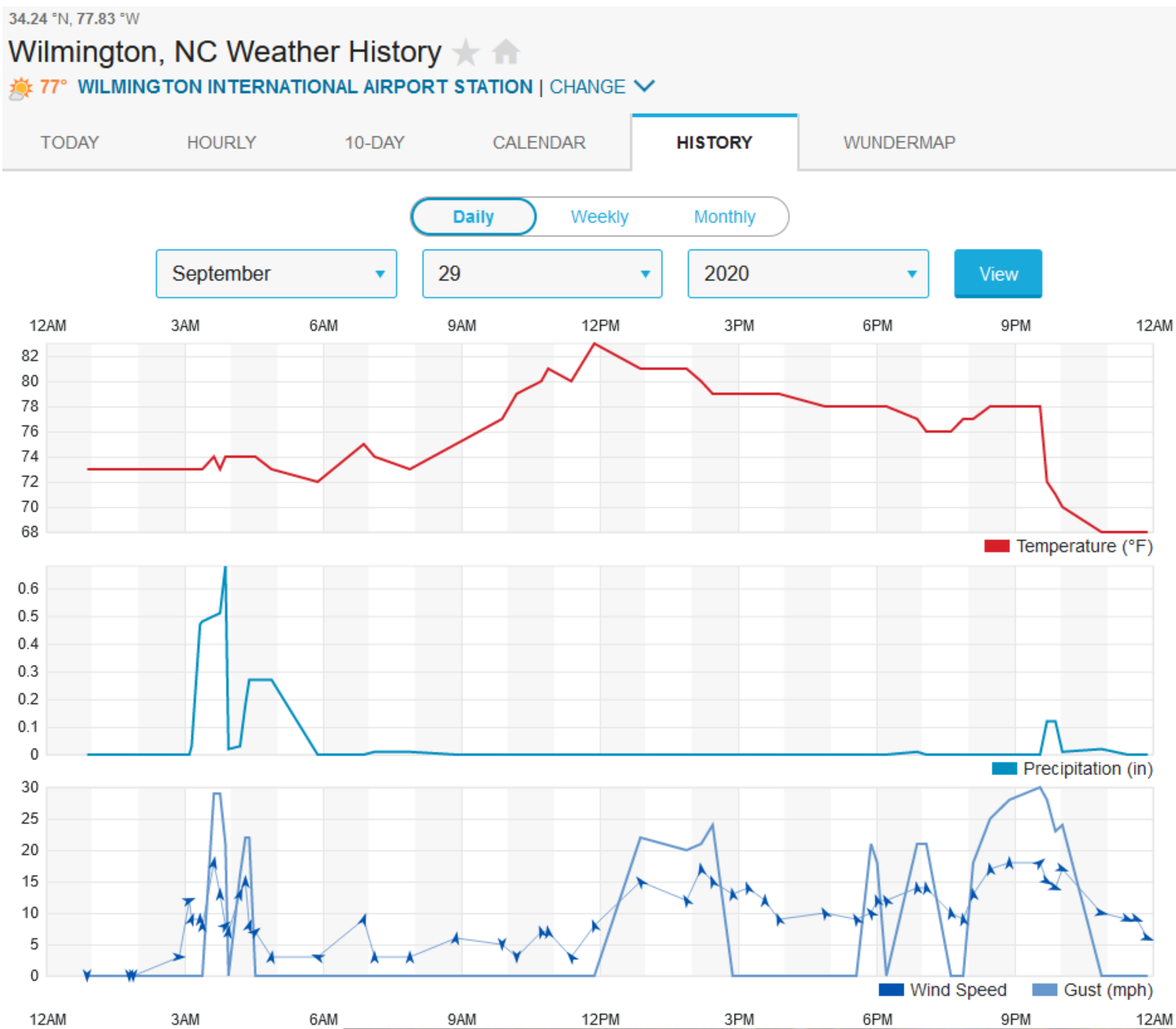

Figure 6 - Wilmington NC Weather Profile from Weather Underground

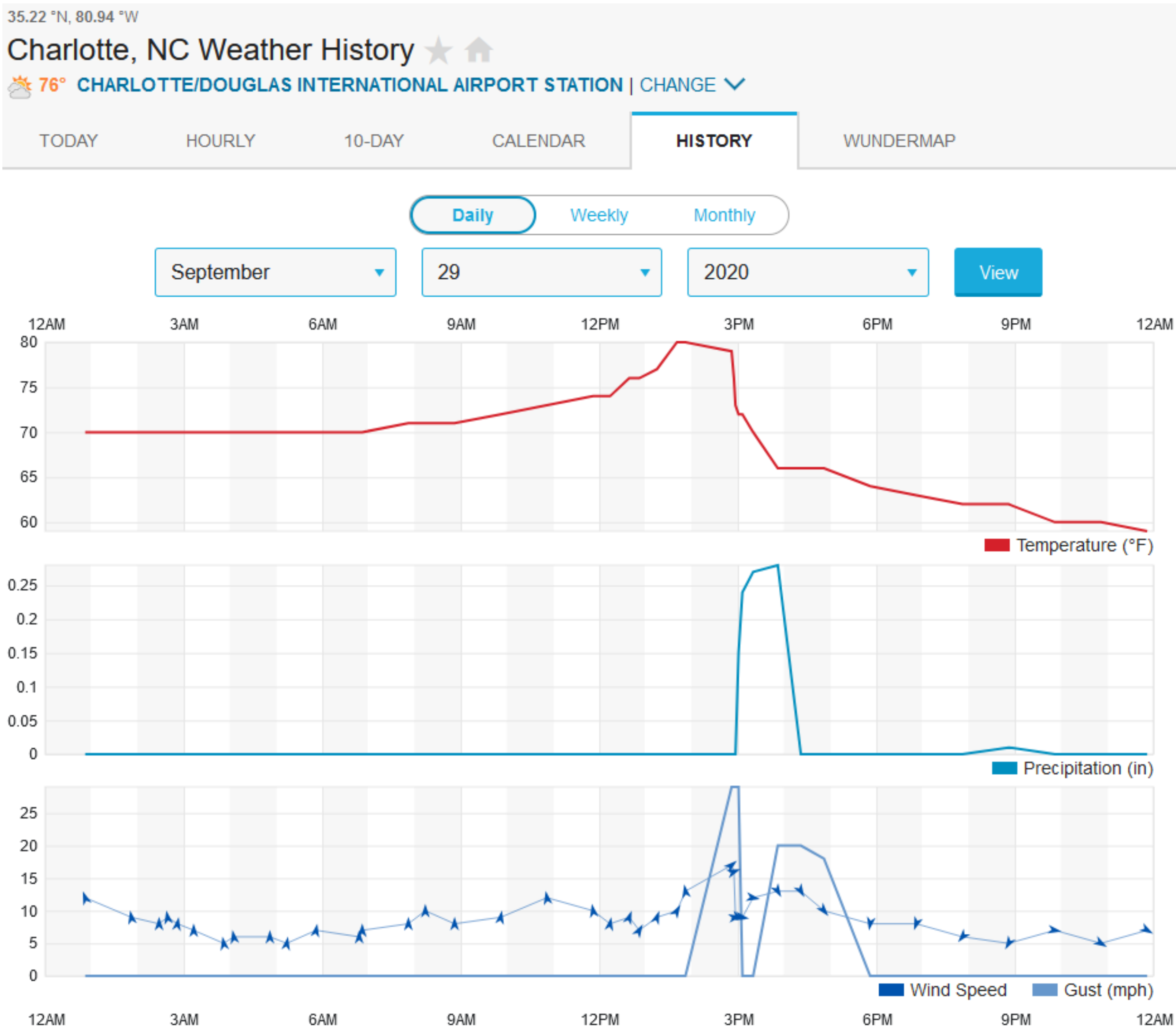

Figure 7 – Charlotte NC Weather Profile from Weather Underground

MEASUREMENT & VERIFICATION

ASSET/DEVICE SUMMARY & EFFECTIVE DEMAND REDUCTION

NCEMC utilizes the DERMS to perform post-event M&V. The DERMS M&V capability relies on metered data collected from the distribution cooperatives and a baseline function. NCEMC utilizes a seven-day methodology to calculate demand reduction baselines. Delivery point and behind-the-meter program participant metering for participating distribution cooperatives is being collected within the DERMS and can be analyzed for event periods. Figure 8 below represents the various DR devices utilized for the load reduction event broken down by program and distribution cooperative. In addition, the two columns on the right side of the table show the average and peak DR. These values were measured at each delivery point and aggregated by the DERMS. It is notable that the DR during the pilot was significantly less than the total DR capacity of the assets in Figure 4. This difference is due to the several factors including weather, time of day, time of year, and number of assets responding to the event. A sample plot of the DR results is provided in Figure 9.

Demand Reduction (DR) Device and Results Summary							
	Device Counts by Program and Cooperative					Demand Reduction	
Cooperative	Conservation Voltage Reduction (CVR)	Thermostats	Water Heater Controllers	Load Switches	Customer Owned Generation (COG)	Event Average (MW)	Event Peak (MW)
BREMC	YES	170	0	20,000	0	0.83	1.68
BEMC	YES	1,096	17	0	0	5.29	7.74
EU	YES	387	0	48,425	28	11.04	13.70
REMC	YES	101	22	0	237	2.90	5.55
UPE	YES	2	0	0	0	14.72	24.70
	Totals	**1,756**	**39**	**68,425**	**265**	**34.78**	**53.37**

Figure 8 - Demand Reduction Device and Results Summary

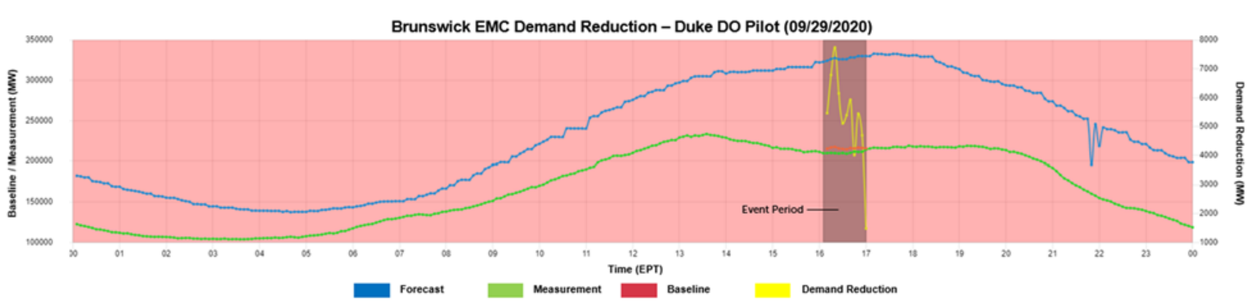

Figure 9 - Brunswick EMC Deliver Point Meter Data for 09/29/2020 DR Event & 7 Day Baseline

In Figure 9 above, a DERMS generated M&V graph, the blue Forecast line is based on weather normalized historical data, the green Measurement line represents the customer meter data, the red Baseline represents the adjusted forecast for the specific day during the DR event - assuming the event had not been called, and the yellow Demand Reduction line represents the delivered DR during the event. The gray area from 16:00 to 17:00 represents the DR event period.

As shown in Figure 7, a weather event traveling west to east occurred prior to the initiation of the DR event significantly dropping the temperature and bringing rain to BRE, EU, and UPC and lowering the temperature at REMC and BEMC. This reduced load is shown by the Measurement line decreasing from approximately 13:30 to the beginning of the event period.

Although some positive DR is indicated, due to the weather event and the time of year of the pilot test, the amount of DR achieved is less than the peak amount of DR the cooperatives can provide. However, given the unplanned nature of a potential reliability load reduction call from Duke Energy, this is an accurate representation of the potential DR benefit. In Figure 8, BEMC's peak DR during the event was captured at 7.74 MW and the average DR provided by BEMC was 5.29 MW. Despite the weather event, this aligns closely with the expected DR for BEMC at 5.5 MW.

NCEMC ONE-MINUTE TELEMETRY DATA

PART I

With the exception of the UPC McBride solar, BEMC Cypress Creek solar and BRE community solar #5, all DER solar sites were curtailed via recloser and breaker trip at 11:00 immediately reducing the output of the sites to 0 kW as shown in Figure 10. The McBride solar site started ramping down at 10:41 prior to the test beginning so the site would experience a controlled shutdown as opposed to a site trip. The breaker at the site was still tripped via the DERMS at 11:00 so if the site had been online, the production would have immediately been curtailed.

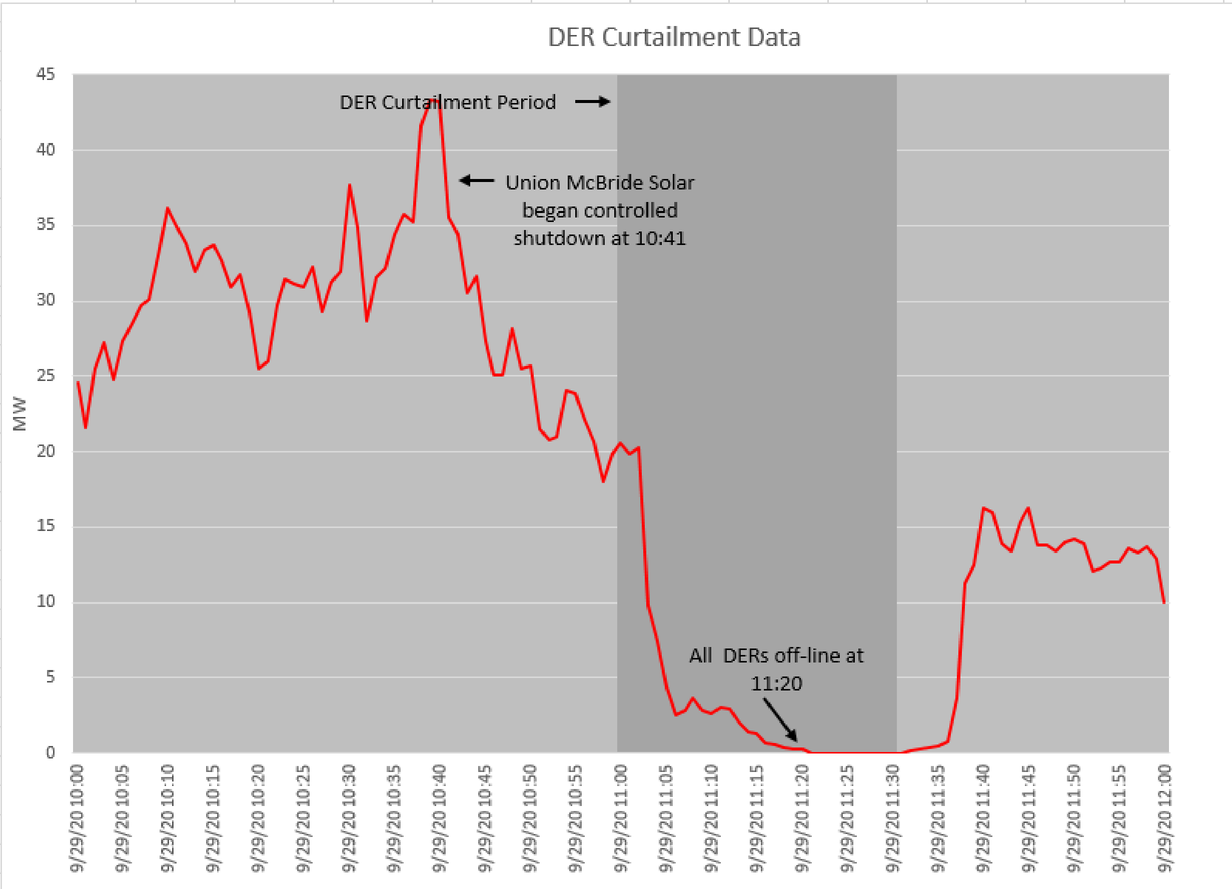

Figure 10 - DER 1-Minute Telemetry Data

Based on one-minute telemetry data, the estimated impact of DER solar curtailment was approximately 43.3MW.

All community solar sites, as well as the Heron's Nest microgrid solar array were curtailed via inverter control starting at 11:00. After the command was issued, the site outputs ramped down at a rate of seven to 10 percent per minute until the output reached zero. Figure 11 below illustrates the ramping that took several minutes to reach zero output. The Cypress Creek DER's were manual curtailments and took longer to execute.

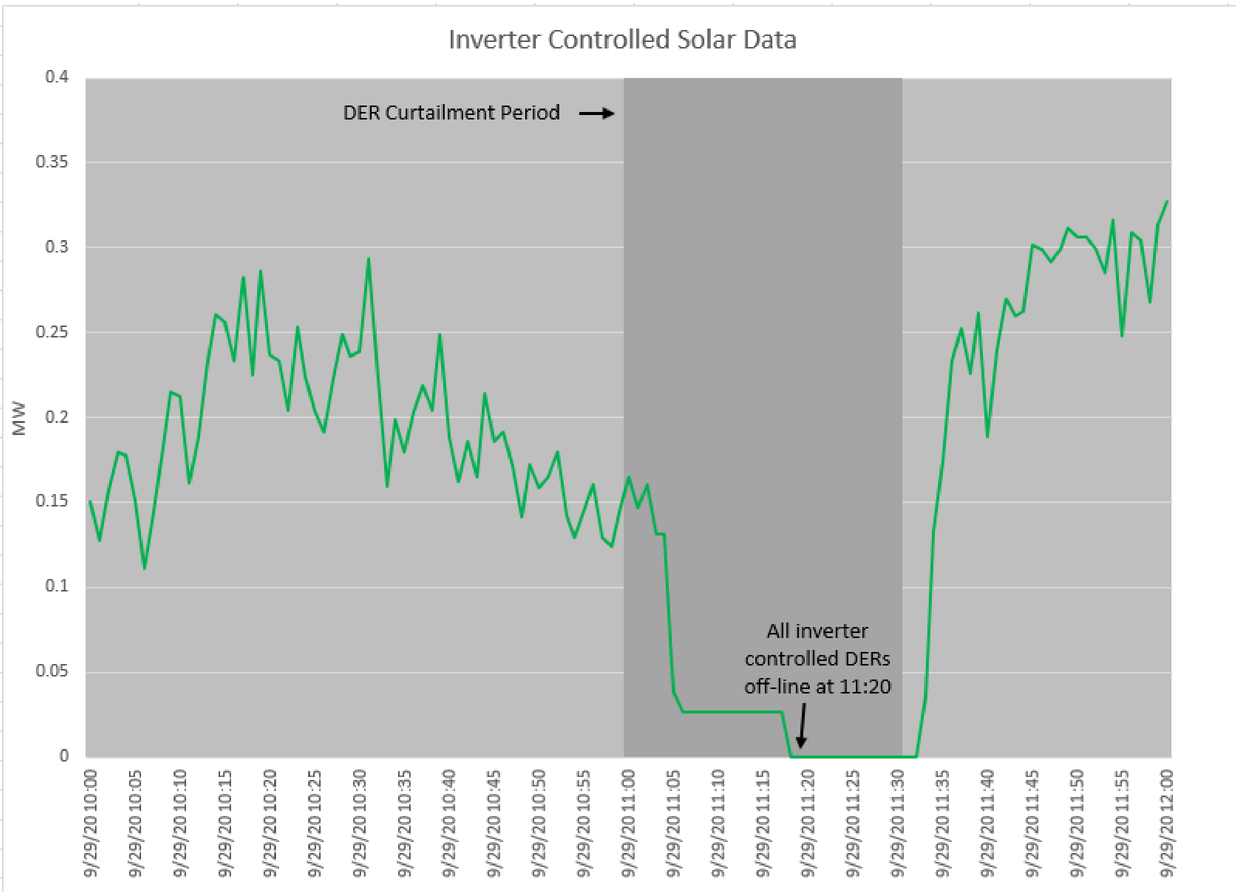

Figure 11 - Inverter Controlled Solar 1-Minute Telemetry Data

Based on the one-minute telemetry data, the estimated impact of Inverter Controlled DER curtailment was approximately .164MW.

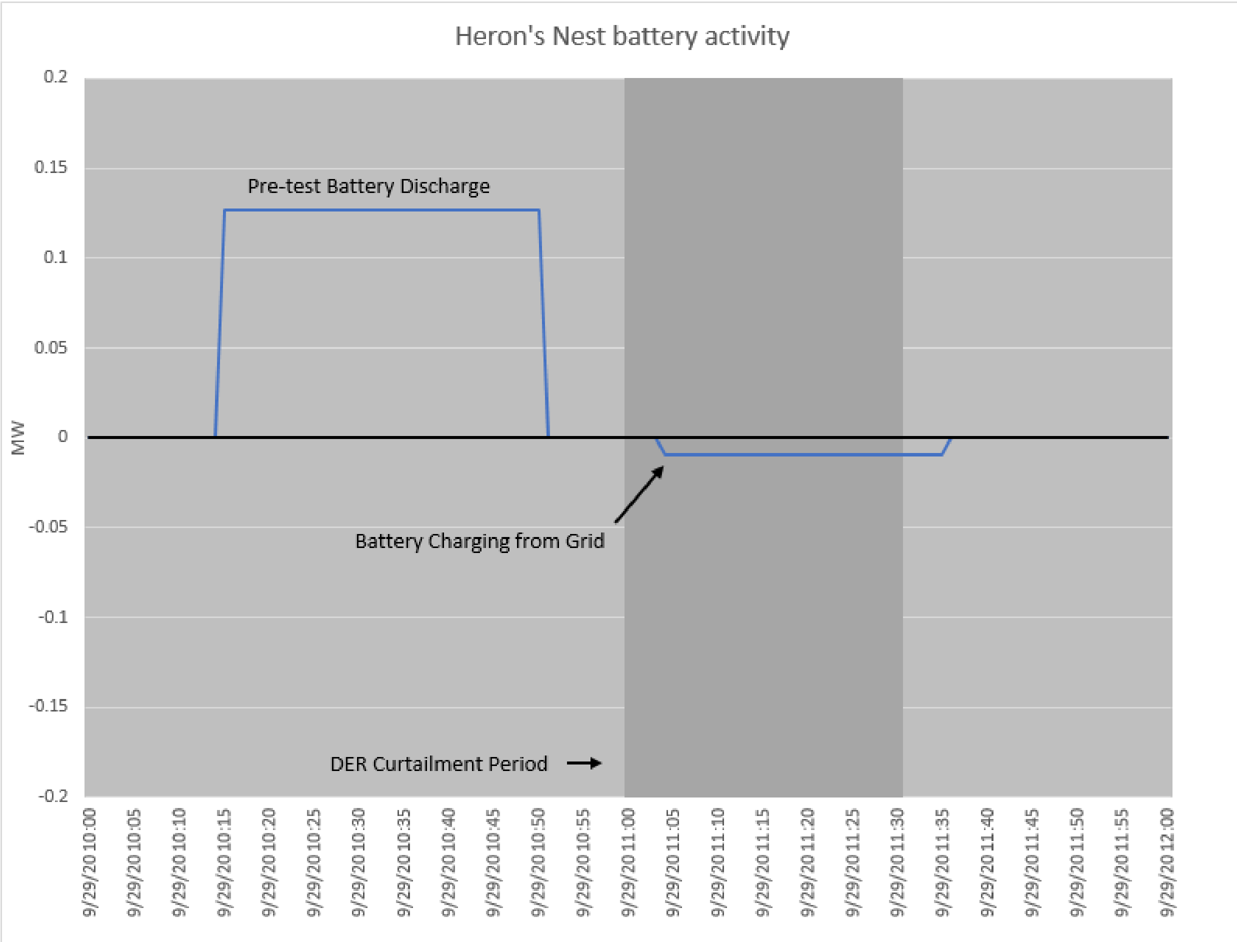

Figure 12 - Heron's Nest Microgrid Battery Activity 1-Minute telemetry data

The Heron's Nest microgrid battery is designed to primarily charge from the solar array but also has the capability to charge from the grid. During Part I of the test, the Heron's Nest battery was charged at a rate of 10kW from the grid as shown in Figure 12 and indicated by the negative telemetry value. Positive values indicate battery discharge that occurred pre-test to ensure there was adequate room for charging.

Although the Heron's Nest battery is capable of charging at a much higher rate, the test plan was set up to only charge the battery at a small rate from the grid to prove the concept and avoid excessive demand charges.

Based on one-minute telemetry data, the total estimated impact of Part I of the test from DER curtailment was approximately 43MW.

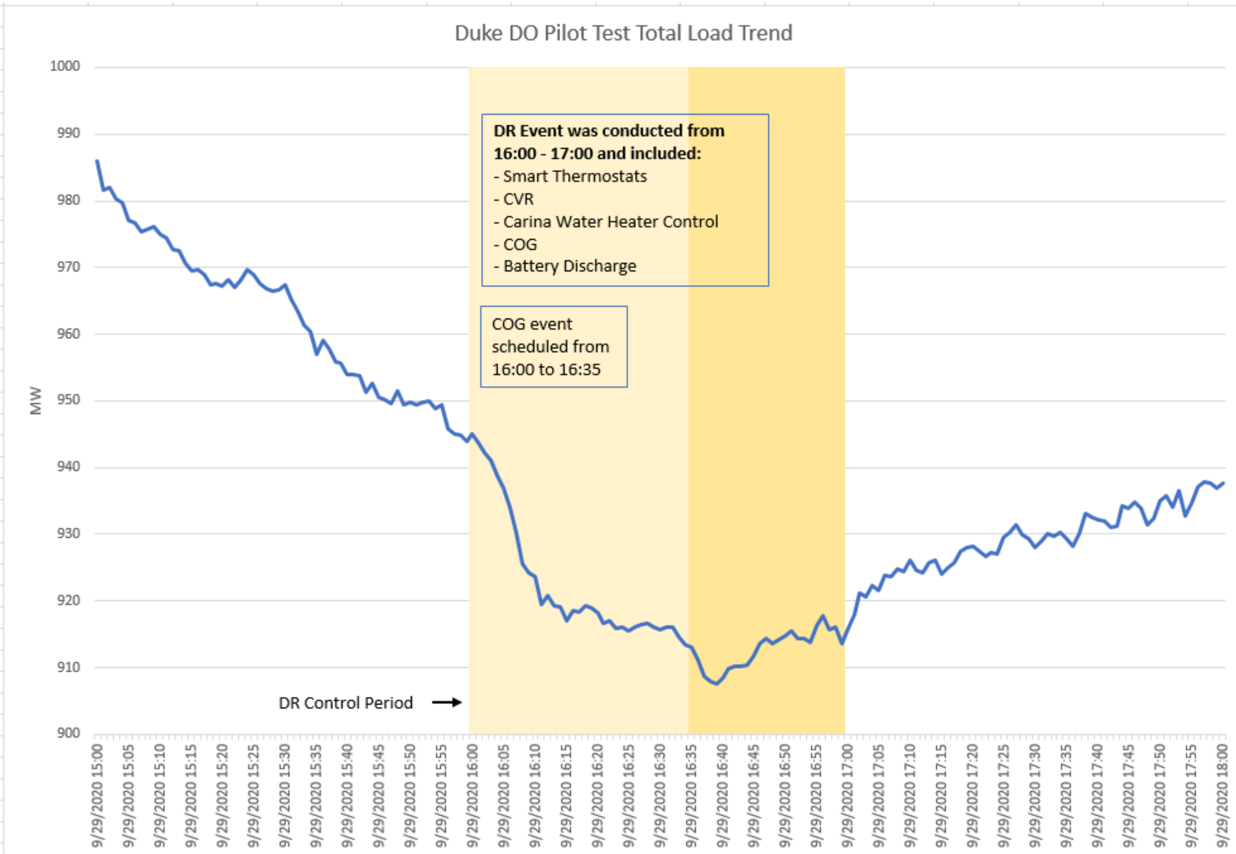

Figure 13 - Load sum of all Cooperatives that participated in the testing

The load was already in a downward trend and in the process of turning to an upward trend during the testing period. As indicated in Figure 133, activation of DR programs produced a noticeable decrease in load as the programs ramped in. There is also a slightly noticeable step-change and a load rebound when the DR events were ended.

Based on one-minute telemetry data, the total estimated impact of Part II of the test from DR programs was approximately 35MW, with 25 MW realized in the first 10 minutes and an additional 10 MW drop over the following 25 minutes.

OBSERVATIONS & LESSONS LEARNED

NCEMC PERSPECTIVE

During the test, NCEMC observed that the processes and systems that it uses performed as expected with a couple of minor exceptions that fell into one of the following categories:

- Lack of device integration into the DERMS requiring labor intensive manual intervention to initiate some actions
- Communication challenges affecting some field devices
- Unexpected technological challenges with third-party equipment

NCEMC is actively working to integrate additional field devices into the DERMS to expand functionality and increase response capabilities.

REMC experienced some SCADA communication issues to a couple of sites while attempting to trip reclosers. These issues were intermittent and the reclosers were still able to be opened remotely. Additionally, all DER sites curtailed by opening a recloser to de-energize the site also de-energized the communications equipment at the site, resulting in telemetry failure alarms and frozen data. NCEMC is investigating the use of alternative energy sources for telecommunications equipment to maintain data integrity.

Technology challenges and issues with third-party systems are a known risk and will occur in the future. NCEMC and OATI will continue to work collaboratively with third-party vendors to identify, manage, and respond to issues with the goal of ensuring their systems are reliable and perform when called upon.

When scheduling the ecobee smart thermostats, NCEMC used a “scheduling template” that had been set up ahead of time and tested within the DERMS to schedule thermostats across multiple cooperatives simultaneously. During the test, this template was used but was only able to successfully schedule the thermostat event in one out of three cooperatives. The scheduling commands were successfully sent by the DERMS, but the third-party vendor experienced technical issues and only processed a small portion of the commands. Once discovered, NCEMC was able to schedule the event using the third-party vendor web portal rather than the API via the DERMS system. This method allowed the events to be scheduled but was more labor intensive and caused delays.

DUKE ENERGY PERSPECTIVE

The morning of the test was mostly cloudy with irradiance not reaching the output that would be expected on a blue-sky day. Using the DEP distribution-connected solar data as a proxy, the total MWs from the NCEMC solar available for curtailment could have been in the 30 MW range. Though the reduction on the test day was good, the curtailment amount on a day we would expect to experience an “Excess Energy Emergency” event could be larger. A similar issue occurred for the load data as the temperatures and radiant light effect on system load were not at their peak conditions. This means load magnitudes during the test were already low and any HVAC controls would not fully realize the load reduction like they would on a day we would expect to experience an “Emergency Demand Response” event. Overall, both tests appear to have been successful, even in less than ideal weather conditions for such a test. A future test during winter load conditions would be warranted to assess the full scale of impact that could be obtained from such curtailments.

Regarding data management, Duke Energy’s PI historian is efficient for storing large amounts of data, but special considerations need to be made when the data’s range is small in terms of megawatts, such as is the case with individual DER sites and loads. By way of example, if a 1,000 MW generator sends consecutive data points at 1,000.12 MW and 1,000.21 MW, PI would only store the first value since the second value does not change by more than 0.1 MW, and greater granularity isn’t needed. In the case of individual DER monitored for this pilot, greater granularity was important because the magnitude of the data is very small, meaning even little changes that are meaningful in terms of their individual performance were not directly captured. Moving forward, Duke Energy will explore a “DER scaling” factor to better account for the granularity needed to assess the performance of DER resources.

Additionally, some of the larger DER sites were curtailed by opening an isolation device which additionally de-energized the communications equipment at the respective sites, resulting in telemetry failure and frozen data. It is recommended that the sites utilize alternative energy sources for telecommunications equipment to maintain data integrity.

CONCLUSION

In conclusion, the test was successful and met the proof-of-concept goals that were set forth ahead of time. This pilot project demonstrated NCEMC's ability to receive an Operating Instruction or reliability directive from the TOP and translate that into meaningful value-added actions.

Coordination between Duke Energy and NCEMC took place at several stages ranging from goal setting several months before the test to testing protocol review to event post analysis. Communication during the test was good and without issue. Three-part communication was used for all voice communication during the test. There was heavy coordination before the test to ensure Duke Energy was receiving all necessary telemetry data via the ICCP link to be able to monitor NCEMC's actions through movements in the data. Between both companies, there was enough data collected and archived to perform a post-event analysis and M&V process.

The pilot testing also proved that having a DERMS system for central and simultaneous dispatch and control of DR and DER edge-of-grid resources is key to the success of a DO and will continue to increase in scope, value, and importance as new devices and resources are added. Manual actions and processes will not suffice in a scaled-up environment.

NCEMC and Duke Energy are discussing and considering additional testing on both peak load days and minimum load days to demonstrate and realize maximum effects of NCEMC's programs. The NCEMC DO capabilities will continue to grow as additional resources are integrated into the DERMS and the processes become more automated.

This pilot also served as a relationship bridge between NCEMC and Duke Energy, narrowing the gap between transmission and distribution operations by adding value through greater situational awareness and operational coordination leading to increased stability, reliability, and resilience.

Cooperatives are committed to innovation and are taking steps now preparing to manage the evolving grid and better serve our members, now and into the future.