Duke Energy Carolinas

2015 Smart Grid Technology Plan Update

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Overview

As required by the North Carolina Utilities Commission (NCUC) Rule R8-60.1(b), Duke Energy Carolinas (DEC or Company) submits its 2015 Smart Grid Technology Plan update (Plan Update). The 2015 Plan Update represents the significant amendments or revisions to the 2014 Plan, and is the best projection of how the Company is making smart grid investments in the near term and leveraging leading edge technologies for the future.

Duke Energy has many grid modernization projects currently underway, and many more technologies that are being evaluated for the future. Some of these ideas and technologies may or may not meet the requirements of each gate in the project lifecycle to become a full-scale project. Similar to the 2014 Plan, the projects included in the 2015 Plan Update have progressed within the project lifecycle and installation is scheduled to begin in the next five years.

1. Technology Description

Reference	Requirement
NC R8-60.1 (c) 1	A description of the technology for which installation is scheduled to begin in the next five years, including the goal and objective of that technology, options for ensuring interoperability of that technology with different technologies and the legacy system, and the life of the technology.

<u>Advanced Metering Infrastructure (AMI) Projects</u>

Large Commercial & Industrial (C&I) and Special Meter AMI Conversion

A small subset of customers within the DEC service territory have meters which are read via cellular communications or manual "walk-by" readings. These include some large C&I customers, customers participating in solar PV net metering, as well as those with load research meters. Managing these separate meters and systems are costly due to the manual nature of the processes involved, as well as the meter hardware and reading costs. The AMI system, already in place through the initial DEC AMI deployment, is able to meet the billing requirements for the majority of these customers, and will reduce the complexity of supporting these customers.

In the DEC service territory, there are a total of approximately 4,700 meters that will be exchanged with an AMI meter within the scope of this project. Approximately 3,100 meters are for customers in North Carolina, and the remaining approximately 1,600 meters are for South Carolina customers. These new meters are directly interoperable with the existing AMI meter systems and have a planned life of approximately 15-20 years. As of August 1, the deployment planning process was underway; however, no meters have yet been exchanged. Completion is currently planned for the second quarter of 2016.

Walk-by Meter Reduction

Approximately 26,500 customers with walk-by meters were bypassed in the initial phases of the AMI project due to their location in rural areas, outside of the communications mesh created as part of the initial AMI rollout. A 4G cellular direct connect meter is now available for deployment to these customers. These direct connect cellular meters will communicate across the cellular network, back to the collection system, and into the Meter Data Management system which feeds the customer billing system. Approximately 20,000 meters are for customers in North Carolina, and the remaining approximately 6,500 meters are for South Carolina customers.

These meters are directly interoperable with the existing AMI meter systems and have a planned life of approximately 15-20 years. The majority of the customers in scope are small to mid-sized commercial and industrial customers on a demand or time-of-use rate schedule. As of August 1, the deployment planning process was underway; however, no meters have yet been exchanged. Completion is currently planned for the second quarter of 2016.

AMI Expansion

DEC began a limited-scope AMI project to install approximately 181,300 advanced meters to residential customers in the Charlotte Metro area. Approximately 176,700 meters are for customers in North Carolina, and the remaining approximately 4,600 meters are for South Carolina customers.

Deployment of the new AMI meters is targeted to replace older, electro-mechanical meters that have reached end of life, areas that experience higher customer turnover (e.g. apartment buildings), and areas within the existing AMI mesh communications network. These meters are directly interoperable with the existing AMI meter systems and have a planned life of approximately 15-20 years. As of August 1, approximately 19,000 advanced meters have been installed. Completion is currently planned for the first quarter of 2016.

2. SGMM Roadmap

Reference	Requirement
NC R8-60.1 (c) 2	A smart grid maturity model "roadmap," if applicable, or roadmap from a comparable industry accepted resource suitable for the developments of smart grid technology.

No significant amendments or revisions were made to the 2014 Smart Grid Technology Plan for this section.

3. Capital Expenditures

Reference	Requirement
NC R8-60.1 (c) 3	Approximate timing and amount of capital expenditures.

Large C&I and Special Customer AMI Conversion

Total capital costs are planned to be approximately $1.6 million through the second quarter of 2016.

Walk-by Meter Reduction

Total capital costs are planned to be approximately $11.9 million, with $2.0 million planned through the end of 2015 and $9.9 million planned for 2016.

AMI Expansion

Total capital costs are planned to be approximately $32.0 million, with $27.1 million planned through the end of 2015 and $4.8 million planned for 2016.

4. Cost-Benefit Analyses

Reference	Requirement
NC R8-60.1 (c) 4	Cost-benefit analyses for installations that are planned to begin within the next five years, including an explanation of the methodology and inputs used to perform the cost-benefit analyses.

Large C&I and Special Customer AMI Conversion [BEGIN CONFIDENTIAL]

Project Costs	
Meter Material	[redacted]
Meter Installation Labor	[redacted]
Project Team, Support & Contingency	[redacted]
Licensing Fees	N/A – The meter quantities are within current licenses.
Project Total	**$1,633,000**
On-Going Costs	
Cellular & Communications	[redacted]/annually
Benefits	
Meter reading cost savings	**$6,510,000** over 15 years
Meter hardware cost savings	**$8,003,000** over 15 years

** All calculations are simplified and do not include an escalation factor over the 15-year period.*

Meter Reading Cost Savings

Meter Type	Approx. Total #	Current Reading Costs / Meter per Month	Current Annual Costs	New Reading Costs per Month	New Annual Costs
Load Research	1,100	[redacted]	[redacted]	[redacted]	[redacted]
Net Metering & Other	3,580	[redacted]	[redacted]	[redacted]	[redacted]
		Total	[redacted]	**Total**	[redacted]
				Annual Savings	$434,028
				15 year Total	**$6,510,420**

Meter Hardware Cost Savings

Meter Type	Annual Installations	Annual Failures	Meter Hardware Cost Difference	Annual Savings
Single-phase	500	70	[redacted]	[redacted]
Poly-phase	50	112	[redacted]	[redacted]
			Annual Savings	$533,520
			15 Year Total	**$8,002,800**

Walk-by Meter Reduction [CONFIDENTIAL CONTINUED]

Project Costs	
Meter Material	[redacted]
Meter Installation Labor	[redacted]
Project Team, Support & Contingency	[redacted]
Licensing Fees	N/A – The meter quantities are within current licenses.
Project Total	**$11,944,000**
On-Going Costs	
Cellular/Communications	[redacted]/annually
Benefits	
Meter reading cost savings	**$8,347,000** over 15 years

* *All calculations are simplified and do not include an escalation factor over the 15-year period.*

Meter Reading Cost Savings

Meter Type	Approx. Total #	Current Reading Costs / Meter per Month	Current Annual Costs	New Reading Costs / Meter per Month	New Annual Costs
Walk-by Meters	26,500	[redacted]	[redacted]	[redacted]	[redacted]
				Annual Savings	$556,500
				15 year Total	**$8,347,500**

AMI Expansion [CONFIDENTIAL CONTINUED]

Project Costs	
Meter Hardware	[redacted]
Meter Installation Labor	[redacted]
Project Team, Support & Contingency	[redacted]
Licensing Fees	[redacted]
Project Total	**$32,211,000**
On-Going Costs	
Cellular/Communications	[redacted]/annually
Benefits	
Meter reading cost savings	$1,955,000 over 15 years
Remote Order Fulfillment	$11,295,000 over 15 years
Avoided AMR purchases	$4,460,000 over 4 years
Meter Integrity	Unquantified – Some benefits are expected; however, have not been quantified due to the limited-scale deployment.

** All calculations are simplified and do not include an escalation factor over the 15-year period.*

Meter Reading Cost Savings

Meter Type	Approx. Total #	Current Reading Costs / Meter per Month	Current Annual Costs	New Reading Cost Reduction Factor	New Annual Costs
Residential AMR	181,000	[redacted]	[redacted]	[redacted]	[redacted]
				Annual Savings	$130,320
				15 year Total	**$1,955,000**

** Cost reduction based on conservative estimate of adjustments to AMR meter reading routes vs. elimination of routes.*

Remote Order Fulfillment Savings

Approx. Total # AMI	Reduction in Costs / Meter
181,000	$4.16
Annual Savings	$753,000
15 Year Total	**$11,295,000**

** Cost reductions estimated per meter based on current operating expenses for manual connects and disconnects.*

AMR Inventory Cost Savings

Total #	Approx. % of Meters Available for Restocking	Approx. Meters Returned to Inventory	Annual Purchases Avoided	Approx. Average Cost / AMR Meter
181,000	[redacted]	[redacted]	[redacted]	[redacted]
		[END CONFIDENTIAL]	Annual Savings	$1,115,100
			4 year Total	**$4,460,400**

5. Existing Equipment Book/Salvage Value

Reference	Requirement
NC R8-60.1 (c) 5	A description of existing equipment, if any, to be rendered obsolete by the new technology, its anticipated book value at time of retirement, alternative uses of the existing equipment, and the expected salvage value of the existing equipment.

Large C&I and Special Customer AMI Conversion

Some meters are being returned to inventory, based on condition and age of meter, and refurbished for reuse. Others are scrapped and will reduce the number of meter vendors used, thereby reducing the need to support multiple meter types and vendors.

Walk-by Meter Reduction

Some meters are being returned to inventory, based on condition and age of meter, and refurbished for reuse. Others are scrapped and will reduce the number of meter vendors used, thereby reducing the need to support multiple meter types and vendors.

AMI Expansion

Approximately half of replaced meters will be returned to inventory for reuse and enable the company to avoid AMR meter purchases for new customers and defective meter replacement. The remaining are considered to have reached the end of useful life.

6. Project and Pilot Status Update

Reference	Requirement
NC R8-60.1 (c) 6	Status of pilot projects and projects, including a description of whether and to what extent these projects are or will be funded by government grants.

The information provided below includes new pilot projects that have begun since the 2014 Plan.

IVVC Pre-scale Deployment

This project is a small-scale installation of Integrated Voltage/Volt-Ampere Reactive Control (IVVC) technology within the DEC service territory. IVVC is one of the first advanced distribution management system (DMS) functionalities to be installed in the DEC territory and will reduce overall system demand by optimizing voltage and reactive power (VARs) across the distribution network under all load conditions.

The deployment project is using real-time field conditions on a small scale (approximately seven substations) to demonstrate the use of IVVC technology and gain experience and understanding around IVVC's operational impacts for a future full-scale deployment. The project's other objectives include:

- Installing, configuring and testing new field devices and security standards with the Distribution Supervisory Control and Data Acquisition (DSCADA) and DMS systems
- Validating IVVC technology, costs and benefits within the DEC circuit network topology
- Determining key technical assumptions and designs
- Verifying and evaluating new substation communication and control architecture
- Documenting and refining project work flows as needed

As of August 2015, the project team has completed the majority of the substation distribution work and is beginning the process of commissioning IVVC in the DMS. The project is estimated to be completed by the first quarter of 2016. This project will not be funded by government grants.

Emerging Technology Trends

The Emerging Technology Office's (ETO) mission is to lead Duke Energy in the identification, evaluation, development, and application of emerging technologies - technologies that may not be ready for wide-scale deployment for another 3-10 years; to identify related business opportunities and risks; and to transfer technologies to the business units to optimize value in a dynamic technology, customer, and regulatory environment. The ETO is continuing to evaluate emerging technologies such as battery storage, microgrids, and other grid-related technologies with significant updates listed below.

Microgrids

The US Department of Energy defines a microgrid as a group of interconnected loads and distributed energy resources (DER) within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid is able to connect and disconnect from the grid to enable it to operate in both grid-connected or island-modes. Microgrids owned and operated by Duke Energy enhance resiliency, improve reliability, and deliver economic and environmental benefits to participating and non-participating customers. Non-participating customers will benefit from increased reliability to critical service facilities, emergency services, and/or other public purposes served by a microgrid. In addition, to the extent a microgrid is able to provide support to the grid, all customers benefit. This represents a potential value stream for the microgrid that may be supported by non-participating customers, as determined by the appropriate authorities.

Integrating advanced protection and control technologies with DER in a microgrid supports the rapid operation of automated devices in response to an outage or power quality issue. Ultimately, this enhances the resiliency and reliability of customer electric supply. During a regional outage event, power generated by renewable technologies cannot be transmitted to the grid; the standard operating procedure is to isolate the assets. Microgrid technologies, however, allow the renewable assets and other DER within the microgrid to continue generating power for participating customers. Through multiple pilot projects and partnerships, Duke Energy is testing various microgrid control modes to evaluate and demonstrate how microgrids will automatically respond to and re-synch to the grid following outages. Current pilot projects include the McAlpine microgrid in South Charlotte and the Coalition of the Willing microgrid in Mount Holly.

As successfully demonstrated in the summer of 2015, the McAlpine microgrid enables one of the city of Charlotte-owned fire stations to remain fully operational during periods of prolonged grid outages. Off-the-shelf microgrid islanding switches paired with distributed generation (DG), such as solar arrays and battery storage, allow for the testing and planning of various outage scenarios in order to improve grid resiliency. This project is unique in that all of the microgrid assets are installed on the distribution circuit. The project demonstrates a solution for meeting energy security needs for public sector critical service facilities with microgrid technologies. The McAlpine microgrid is also expected to inform innovative business models for future customer products and services.

The Coalition of the Willing effort was developed as a result of the needs identified from the rapid adoption of DER. DER requires faster response times, reduced costs, better safety, and improved reliability. The Coalition of the Willing effort is a non-proprietary, multi-phased project to break down proprietary and operational "siloes" and to prove that enhanced operation can be achieved economically through use of a distributed intelligence platform. Phase II of this effort includes the installation and operation of a lab scale microgrid system at the Mount Holly facility. This microgrid will utilize renewable resources – solar and battery energy storage – and will operate it with an Open Field Message Bus distributed intelligence platform with wireless communications to devices. Mt. Holly will provide a dynamic use case – an islandable operational microgrid – to test true interoperability across devices and applications. Duke Energy is partnering with multiple vendors to successfully install and demonstrate this inverter-based microgrid. Following the Mt. Holly lab testing, a field test of the same concept will be conducted at the Marshall site with an additional Li-ion battery solution added to the current DER mix.

Energy Storage

Distributed energy storage continues to gain momentum as a viable solution as the price of batteries continues to drop and utility operators experience more installations on the system. Nationwide, Duke Energy owns nearly 15% of the grid-connected operating battery storage, and the Company is continuing to evaluate additional opportunities.

Batteries offer flexibility by being able to perform a multitude of functions. Distributed batteries have the ability to offer capacity, spinning reserves, solar and wind smoothing, loss reduction, outage ride-through and other system benefits. In addition to the projects discussed in previous filings, Duke continues to evaluate and demonstrate these many capabilities at different points on the grid.

<u>Distributed Energy Storage Projects in the Carolinas</u>

Three projects are in the planning and development stages at present, and field installations are expected to be completed by the end of 2016, as listed below:

Rankin Battery Storage - Repowering
Located at the Rankin substation in North Carolina, the project originally tested a 402-kilowatt (kW) battery linked with a commercial solar installation located 3 miles away. The original solution testing was completed earlier in the year, and a new hybrid distributed storage solution is being designed for future testing. This novel solution will pair two storage technologies - a high energy battery solution with a high power capacitor solution. Total system rating is expected to be in the 300 kW range.

Marshall Energy Storage
The currently installed 1.2 MW solar and 250 kW Energy Storage System at this site are being utilized to develop algorithms to manage distribution-tied DER integration. The work is being developed and tested in partnership with UNCC EPIC Center. Self-learning forecasting routines will incorporate weather, circuit and usage data to best determine how to operate DER at different times of the day and seasons to offset voltage rises on the circuit and fluctuations due to solar intermittency and to reduce voltage regulator operations.

Marshall site project is planned to be expanded to include development of a method for remotely determining when DER is out of synchronism with central generation or central grid signals for voltage and frequency. The test plan is to (1) prevent the DER from sustaining an unintentional island with the local distribution feeder in an improved way from current methods and (2) allow the DER to control an orderly disconnection and connection of an intentional island to the larger grid, based on these signals. Current methods are effective at low DER penetration levels, but are expected to perform crudely at higher penetration levels. These methods have high potential to enable higher DER penetration levels that can allow DER to operate much more smoothly on the grid.

Home Energy Storage
Robust battery solutions are emerging for residential applications. A technology test is currently being designed to install multiple units to validate technical and performance capabilities.

These field tests continue to inform Duke Energy's infrastructure strategy. Previous field test observations have also emphasized the need for a slightly larger penetration of distributed energy storage solutions to properly capture the stacked value benefits these solutions may offer. This insight coupled with the need for developing a seamless system integration process is expected to lead to a larger integration focused battery project in the near future.

Low Voltage Power Electronics (LVPE)
LVPE systems are a collection of semiconductor components, capacitors, telecommunications, and control circuitry used to provide a high level of flexible control to power distribution networks. These units autonomously and rapidly react to changing grid conditions via the

distributed and dynamic control of power flow. Voltage levels can be kept constant, in real time, to adjust for voltage drop across the distribution transformers and changing loading conditions on circuits where these systems are installed.

Initial beta field testing for an LVPE system was recently concluded, and validated many of the applications and use cases. Field tests evaluated the use of these systems to manage power flow and peak demand, provide volt-VAr optimization, enhance power quality, provide outage and fault detection capabilities, and smooth solar PV intermittency. Additionally, providing voltage control from LVPE on the secondary side of the distribution transformer can have multiple effects on service to the customer, such as consistent voltage, improved VAr support for customer loads, and identification of low voltage areas on a circuit. While not confirmed in the limited scale beta test, multiple units installed on a circuit could also have the ability to eliminate VAr flow and influence overall primary voltage, leading to a flatter voltage profile from substation to the end of the circuit. These additional use cases as well as other LVPE solutions will continue to be evaluated in lab and field tests. Due to the benefits demonstrated, Duke Energy is currently evaluating the need for a larger pre-scaled field test of LVPE prior to committing to deployment.

7. Customer Information Transfer

Reference	Requirement
NC R8-60.1 (c) 7	A description, if applicable, of how the utility intends the technology to transfer information between it and the customer while maintaining the security of that information.

Large Commercial & Industrial and Special Customer AMI Conversion

This project falls under the existing Advanced Metering Infrastructure, and the transfer of information is managed the same as described within the 2014 Plan.

Walk-by Meter Reduction

This project falls under the existing Advanced Metering Infrastructure, and the transfer of information is managed the same as described within the 2014 Plan.

AMI Expansion

This project falls under the existing Advanced Metering Infrastructure, and the transfer of information is managed the same as described within the 2014 Plan.

8. Third-Party Utilization and Information Transfer

Reference	Requirement
NC R8-60.1 (c) 8	A description, if applicable, of how third parties will implement or utilize any portion of the technology, including transfers of customer-specific information from the utility to third parties, and how customers will authorize that information for release by the utility to third parties.

Large Commercial & Industrial and Special Customer AMI Conversion

This section is not applicable as this project does not currently involve the transfer of customer information to any third parties.

Walk-by Meter Reduction

This section is not applicable as this project does not currently involve the transfer of customer information to any third parties.

AMI Expansion

This section is not applicable as this project does not currently involve the transfer of customer information to any third parties.

9. Reliability & Security

Reference	Requirement
NC R8-60.1 (c) 9	A description of how the proposed smart grid technology plan will improve reliability and security of the grid.

The description for each new technology project listed under Section 1, and the benefits described in Section 4, outline the specific impact each project will have on the reliability and security of the grid. Additionally, the investments as a whole will provide synergies resulting in greater overall value in improving grid security, reliability and resiliency, while also creating greater efficiencies and improving safety and sustainability. While some investments clearly add new capabilities, others capitalize on opportunities to upgrade the grid with automated and intelligent systems that will work together and optimize the electric grid. As articulated, many of these new devices are integrating into the command and control systems, such as the DMS described earlier. This integration of grid equipment and information technology systems begins to posture Duke Energy's electric grid for the challenges and opportunities of the future.

Grid modernization investments will continue to be driven in partnership with customer needs and desires, as well as grid reliability and resiliency improvements. New products and services will also drive new technologies on the electric grid, and transform the way customers interact with the Company.