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Via E-mail and US Mail

Ms. Alisa Bentley
Commission Secretary
Delaware Public Service Commission
861 Silver Lake Blvd. Suite 100
Dover, DE 19904

June 6, 2014

DK
Kevin
Amy
Scott

RE: PSC Docket 13-152

Dear Ms. Bentley,

Enclosed please find the original and ten (10) copies of the Testimony of CRI witness David T. Stevenson. Finding no Service List for the Docket, I am sending copies by e-mail to the latest Service List for Docket No. 13-115 as Docket No. 13-152 derives from the former.

Sincerely,

David T. Stevenson

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Evaluation of the Proposed "Delmarva Delaware Capital Distribution Construction Plan 2014 – 2018" PSC Docket 13-152

Prepared for: Caesar Rodney Institute

Prepared by: Alternative Strategies Consulting, LLC
David T. Stevenson 6/2/14

Table of Contents

Topic	Page Number
Executive Summary	**3**
Methodology	**6**
The Rationale for Improving Electric Grid Reliability	**7**
Major Outage Events	**9**
Evaluating "Delmarva Delaware Capital Distribution Construction Plan 2014 -2018"	**11**
Customer Driven Improvements	**11**
Load Growth	**11**
Underground Residential Distribution	**12**
Feeder Improvements	**12**
Substations	**14**
Switchgear Replacement	**16**
Transformers	**16**
Distribution Automation	**17**
Other Reliability Spending	**17**
Conclusion	**18**

Executive Summary

Delmarva Power & Light Company (Delmarva) submitted a petition on March 22, 2013 to the Delaware Public Service Commission (Commission) to increase electric base rates by $42 million. A primary driving force for the increase was Delmarva's plan to spend $397 million over the following five years in infrastructure investment "to enhance and maintain reliability of the Company's system". Docket No. 13-115 was opened. The docket was resolved by Commission Order No. 8549 on April 2, 2014, which approved a rate increase of approximately$15 million.

The Commission Staff requested Docket No. 13-152 be opened on April 16, 2013 to explore spending on reliability as the Company's reliability performance record was already exceeding the guidelines set in Regulation Docket No. 50 in 2006 ("Delaware PSC Electric Service Reliability and Quality Standards", hereafter "Docket 50"). At issue was both whether the Company's spending plan was appropriate and whether reliability guidelines need to be updated.

The mission of CRI's Center for Energy Competitiveness is to encourage policies that lower the price of electricity to at least the national average. However, there is one attribute of the electric grid more important than price, and that is reliability. Reliability covers not only the industry technical definition of "blue sky" reliability, but also includes system resiliency to allow quick recovery from major outages. CRI supports Delmarva's reliability investment plan, and recommends the docket be kept open to further consider needed substation hardening investment.

Delmarva's plan increases reliability investment levels over the recent past. The entire industry needs to catch up on spending on aging infrastructure and new technology. Almost 60% of Delmarva's transformers are over thirty years old when life expectancy ranges from thirty to forty years. Similarly, as much as 60% of Delmarva's Feeders need upgrading, and Distribution Automation upgrades have only been added to about 10% of the Feeders that could benefit from this technology. Aging switch gear and underground cables must also be replaced. Spending actually declines 19% by 2018 from 2013 in inflation adjusted dollars (1.5%/year) as many programs will be complete over a five to ten year period.

The reliability guidelines need significant updating to meet customer needs and expectations during extreme Major Outage Events (MOE). This would include hardening the system to resist damage from flooding during major storms, physical attacks, cyber attacks, and Electromagnetic Pulses (EMP), and to make the system more resilient to allow faster recovery from an extreme MOE such as super storm Sandy. Improving hardening and resiliency will lead to a temporary increase in capital spending and further marginal rate increases.

There are several major trends that suggest now is the time to increase investments:

1) Supply side electric prices have come down and should be stable for the near future allowing more room for distribution side increases
2) Long term additions of distributed energy such as wind and solar power may lower revenue and make it difficult for distribution companies to invest in infrastructure as has happened in Europe. In ten years Delaware will have about the same percent of

renewable power as Germany has now. To emphasize the point, Barclays just lowered the investment rating for utilities in states with a high concentration of distributed energy.

3) A series of wide spread, long duration outages has raised public awareness of the need for better system hardening and resiliency
4) The eventual retirement of key individuals in the engineering division will reduce institutional memory for Delmarva in the future
5) Expected cost savings from the merger of Pepco and Exelon will partially offset the rate impact of infrastructure investment

The first step is to establish appropriate goals for both blue sky reliability, and for MOE's. In Docket 50 the Commission established the System Average Interruption Duration Index (SAIDI) must not exceed 295 minutes per customer per year, excluding MOE's. Delmarva's SAIDI was 146 minutes in 2012. CRI believes the standard should be reduced to 150 minutes, the average performance of comparison utilities presented on page 9 of Delmarva's Public Comment Session documents. According to Delmarva, the infrastructure spending plan would reduce SAIDI to 115 minutes by 2018.

No standard exists for measuring hardening or resiliency per se. We note Delmarva Maryland prepared a report for the Maryland PSC titled "Long term Resiliency Assessment" dated 9/3/2013, for Case No. 9298. Capital spending alternatives were considered to limit the number of days it would take to restore service to 95% of customers in one, two, three, or four days, assuming a maximum percent of customers experiencing an outage during an MOE reached 40%, 50% or 75%. Investment requirements to meet these standards varied from $1.8 billion to $4.6 billion with residential electric rate increases of 50% to 127% over a ten year period. Rate increases of this magnitude would not be acceptable as "Willingness to Pay" research shows 60% of customers only willing to pay 1% to 10% additional cost for reliability above existing levels. Any further increase would be on top of the most recent 1.5% increase.

Our consultant's work (see page 9), suggests these long duration outages would only occur in extreme MOE's involving outages in a large number of regional utilities. Only 10% of outages are this extreme. In such circumstances mutual labor assistance programs do not work as neighboring utilities are also experiencing heavy outages.

We recommend specific guidelines and implementation timelines be set for major distribution sub-systems with progress measured by the percent of project completion annually. Workshop sessions for the parties would be the best way to establish these guidelines, and a reasonable capital budget. Suggestions include:

1) All sub-stations, and pad mounted Transformers and Automatic Transfer Switches located in the latest FEMA defined flood zones will be evaluated for flood mitigation options. If appropriate, installation of flood walls, raising equipment, and equipment relocation should be completed in three years.
2) All high voltage transformers will be evaluated for mitigation against physical attacks with implementation completed in one year using standards currently being designed by the North American Electric Reliability Corporation

3) All high voltage transformers will be evaluated for mitigation against Electromagnetic Pulse level three events using surge arrestors, blocking devices, and faraday cages as appropriate with implementation completed in five years
4) A major problem in Super Storm Sandy was the lack of motor fuel so people involved in long term outages could drive out of the affected areas. Consideration needs to be given to developing distributed back up generation capabilities for critical gasoline stations that agree to be part of an emergency program. This might include adding quick connects to stations for mobile generators, and purchasing an inventory of generators to provide emergency power. Rebuilt 60, 100, and 125KW diesel generators installed in shipping containers with auto lube tanks, and fuel tanks can be purchased for about $20,000 each ($300 to $400,000 new). FEMA money may be available to cover the cost of the program. Implementation should be completed in one year.
5) Raise, or otherwise secure, Remote Telemetry Units that are connected to control units to minimize the potential for computer hacking
6) Consider adding an expectation to the Docket 50 standard for Regional Major Outages Events exceeding one half million customers will add 17 hours of restoration time for each million customers affected. This would primarily be used as a yardstick in post-mortem investigations.

Besides establishing the above guidelines CRI offers several other recommendations:

7) The Commission should consider changes to the net metering rule so that customers using distributed power are only refunded supply charges; this would make more money available for distribution system upgrades. (Solar installations only generate power about five hours a day, but can produce up to 110% of the daily energy requirement. The rest of the day power is drawn from the grid setting up a situation where the grid acts as a battery but nothing is paid for the service)
8) More aggressive undergrounding for poles repeatedly involved in vehicle accidents to reduce accident injuries, and to reduce outages
9) Add "Willingness to Pay" question for reliability improvements to customer satisfaction surveys, and questions on reliability versus resiliency
10) Consider a future divestiture of Delmarva's downstate service territory for possible acquisition by the Delaware Electric Cooperative to increase the potential for downstate radial lines to be looped

CRI notes the additional spending suggested above will further improve "blue sky" reliability as well as hardening and resiliency. While not part of this Docket, Delmarva's natural gas infrastructure should also be evaluated for opportunities for hardening and resiliency improvements. We would look to Delmarva to prepare a spending plan and estimated impacts on rates with a comparison of adding to base rates or creating a surcharge since this would be a one-time spending plan. If a surcharge is used it could be shown on customer bills with a name such as "Operation PowerShield" so customers will understand the reason for the rate increase.

Methodology

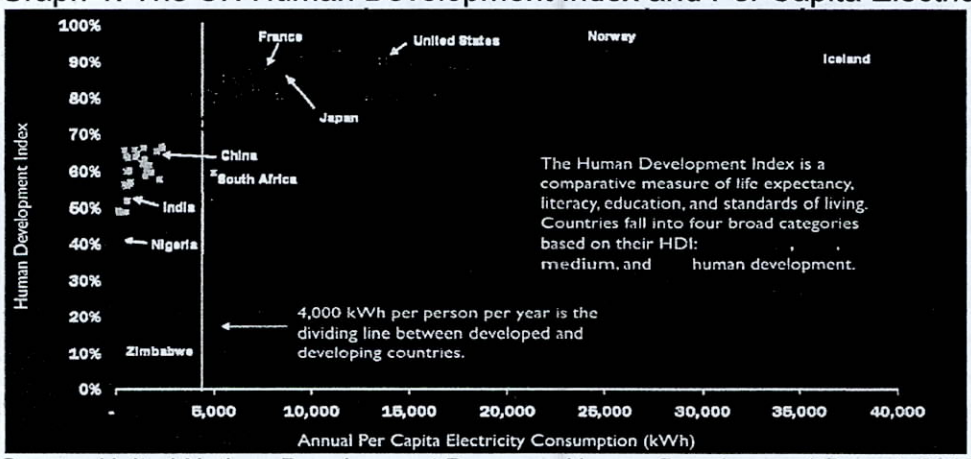
Our consultant analyzed Delmarva's report titled "Delmarva Delaware Capital Distribution Construction Plan 2014 – 2018", and concluded interviews with Bryan L. Clark, Manager – Asset Performance & Reliability, Pepco Holdings, Inc. Our consultant compared Delmarva's plan as set forth in the report to numerous other resources including:

1) Delmarva Power Maryland report titled "Long Term Resiliency Assessment" for the Maryland PSC Case NO. 9298, September 3, 2013
2) Public Service Electric & Gas Company report titled "Request for Approval of the Energy Strong Program" for the New Jersey Board of Public Utilities, February 20, 2013
3) Delmarva Power report titled "Reliability Performance and Investment Requirements" available at Delaware public comments sessions in Docket No. 13-115, September 26,2013
4) Caesar Rodney Institute report titled "Should You Be Worried About the Electric Grid?", March 4, 2014 written by the consultant
5) US Department of Energy report titled "Large Power Transformers and the US Electric Grid", June, 2012
6) Executive Office of the President report titled "Economic Benefits of Increasing Electric Grid Resilience to Weather Outages", August, 2013
7) Ventyx GTM Research whitepaper "Coping with Extreme Weather Events", 2013
8) North American Electric Reliability Corporation report titled "State of Reliability 2013", May, 2013
9) North American Electric Reliability Corporation Technical Conference "Remarks of Gerry Cauley, President & CEO NERC", July 9, 2013
10) American Society of Civil Engineers report titled "Failure to Act: The Economic Impact of Current Investment Trends in Electricity Infrastructure", 2011
11) American Society of Civil Engineers report titled "2013 Report Card for America's Infrastructure, Energy", March, 2013
12) Associated Press article by Kantele Franko and Jonathon Fahey titled "10 Years After Blackout, US Grid Faces New Threats", August 10, 2013
13) US Department of Homeland Security, National Cybersecurity and Communications Integration Center report titled"Trends in Incident Response in 2013", December 2013
14) Edison Electric Institute report titled "Out of Sight, Out of Mind", January, 2013
15) US EPA "Calculating Reliability Benefits"
16) Utility of the Future "Underground vs. Overhead: Power Line Installation Cost Comparison", February 1, 2013
17) US Energy Information Agency 2012 Major Outage Event summary Table B2, "Electric Power Monthly
18) US Energy Information Agency 2012 Retail Sales by Utility Form 861

The Rationale for Improving Electric Grid Reliability

Electricity is such an integral part of our daily lives and economic prosperity that even temporary outages cause large inconveniences and loss of income. Delmarva surveys routinely show reliability is the number one customer concern. The United Nations even shows human development is dependent on electric power in the following graph:

Graph 1: The UN Human Development Index and Per Capita Electricity Use



Source: United Nations Development Program, *Human Development Report, 2012.*

The electric grid is a patchwork network of generation, transmission, and distribution companies built over the last 135 years. Regional network managers match supply and demand instantaneously to minimize loss of power. A number of issues have focused our attention on reliability over the last decade:

1) A series of Major Outage Events affecting a large part of regional populations for extended periods including the 2003 blackout (50 million people), Hurricane Katrina (3 million), Hurricane Irene (5 million), and the 2012 Derecho (4 million).
2) Super storm Sandy knocked out power to 8 million customers with 2 million still without power after a week, and some still without power after a month. New Jersey's largest electric distributor, PSE&G reported 90% of its customers lost power.
3) A report card from the American Society of Civil Engineers giving the electric grid a D+ and calculated the gap in expected Distribution System spending and what is needed to maintain reliability would be $57 billion by 2020
4) Homeland Security reported 151 cyber attacks on energy infrastructure some of which are suspected to have been orchestrated by foreign governments
5) Exploding stars, solar flares, and nuclear weapons explosions can send out an electromagnetic pulse (EMP -a wave of charged particles that can induce high currents and failures in electrical equipment).
6) There have been physical attacks on substations
7) The increasing prevalence of electronic interconnectivity in both business and personal lives is increasing the reliance on electricity availability.
8) In the three most recent MOE's Delmarva Maryland reported an average power restoration time of 10.7 hours with some customers out for about four days.
9) Consistently, about 20% of Delmarva Delaware customers are unsatisfied with reliability

10) The EPA calculates the cost of outages to be as high as $425 per each un-served KWh for some industrial customers

Technology exists that can improve performance. The trick is to balance infrastructure investment with the added cost of power. A number of studies consider the value to customers of avoiding outages compared to the willingness to pay for reliability improvements. Most show very limited increases would be accepted for better service including relief from MOE's. A willingness to pay survey was conducted by the Edison Electric Institute titled "Out of Sight, Out of Mind", January, 2013. The study asked what consumers would be willing to pay to move cables underground for better reliability. Assuming this is a surrogate for reliability in general, this report provides one of the more recent results. The report states about 60% of customers would pay at least 1% to 10% more on their bill for better reliability. This suggests there is some room for an increase on top of the base rate increase associated with reliability costs in Docket 13-115 which increased costs to residential customers 1.5%.

The table below compares Delmarva Delaware's infrastructure plan to plans prepared by Delmarva Maryland, and PSE&G in New Jersey..

Table 1: Comparison To Neighboring Utilities

Utilities	Delmarva – DE	Delmarva – MD	PSE&G
# of Customers	301,000	200,000	2,200,000
Circuit Miles	1,600	1,830	23,856
Substations	66	92	246
5 Year Reliability Invest. $ millions	288	2,810[1]	820[2]

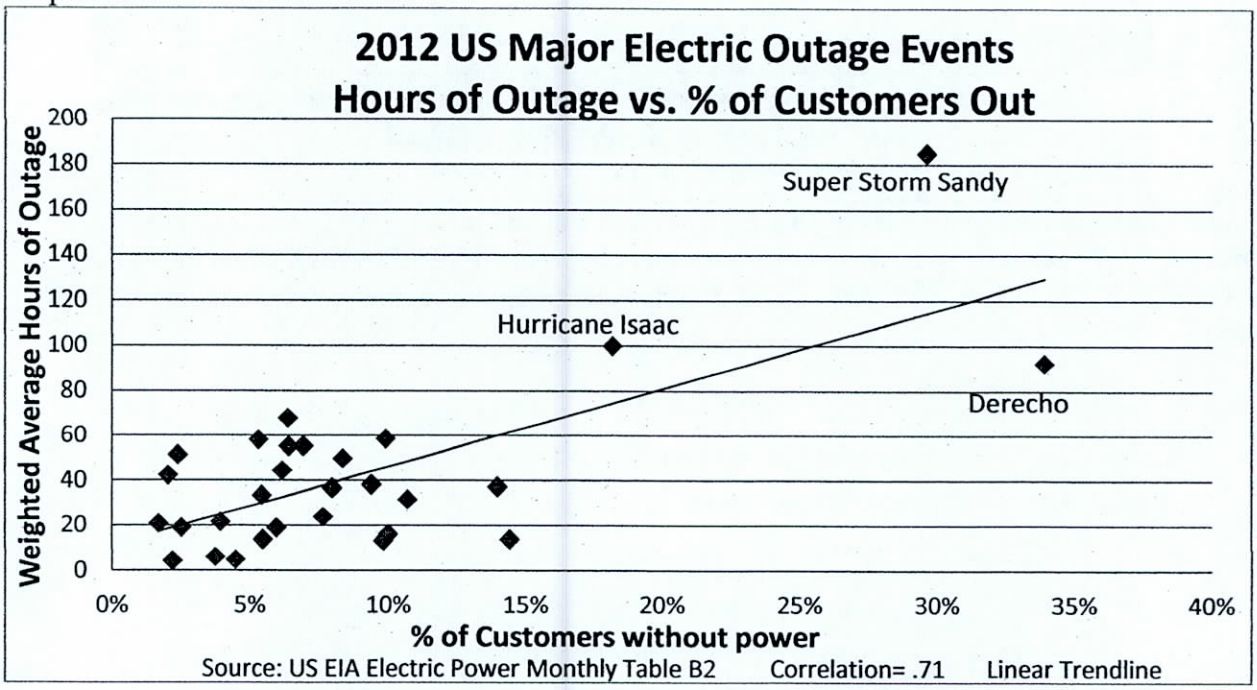
Note 1 – Proposed Infrastructure Plan
Note 2 - PSE&G approved spending, about half the requested amount

Major Outage Events

A Major Outage Event (MOE) is defined by IEEE Standard 1366 as an event that exceeds reasonable design and/or operational limits of the electric power system based on historic system performance (currently 12.56 minutes for Delmarva). Delaware Docket 50 further defines a MOE as one affecting more than 10% of customers. An Electric Distribution Company is supposed to report restoration progress.

A review of 2012 MOE's from around the country (Graph 2) show public utilities are restoring power for severe thunderstorms, winter ice and snow storms, and noreasters, when up to15% of customers are involved, within 60 hours. Individual events impacting multiple utilities are shown as a single data point. However, power restoration in 60 hours was not met for three very large storms; Hurricane Isaac, super storm Sandy, and the derecho that swept through Ohio, West Virginia, Virginia, Maryland, and New Jersey in June, 2012. A derecho is a very intense line of damaging windstorms.

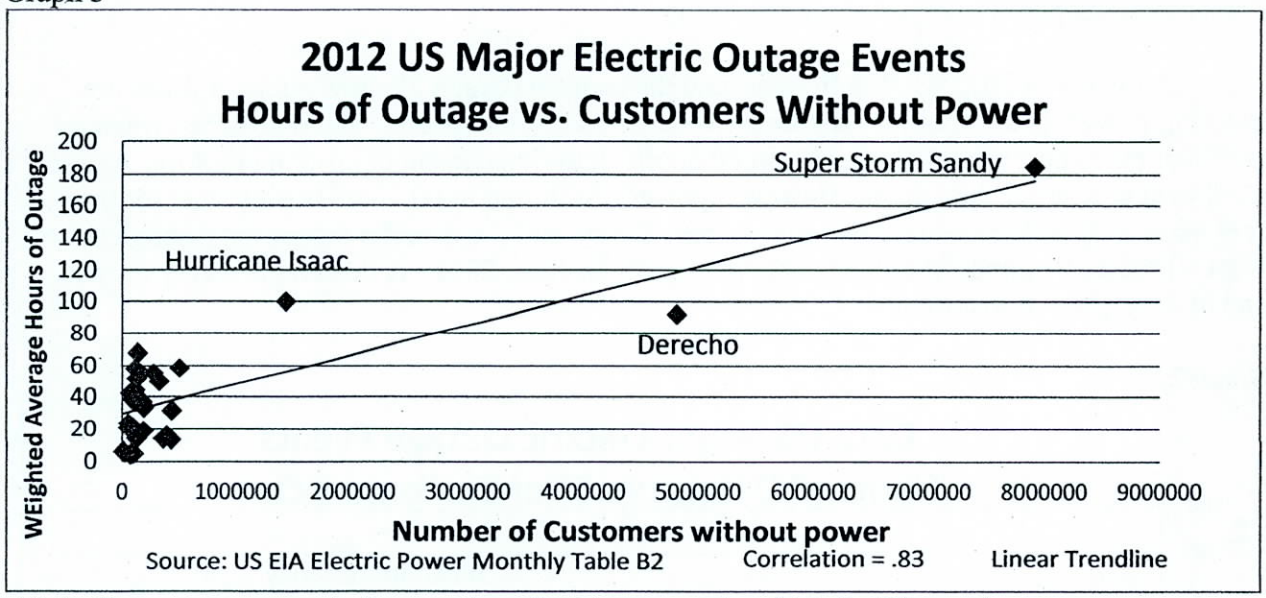
Graph 2



Extremely damaging events may cover a wide area may impact many utilities. Super storm Sandy affected twenty-one utilities in fourteen states, and knocked out power to 8 million customers (Graph 3). In New Jersey, two utilities saw 90% of their customers without power, and it took weeks to restore power. Utilities experienecing this kind of impact rely on mutual assistance agreements for manpower from other utilities to restore power. When very large areas are affected, neighboring utilities can't help as much. With up to one half million people out of power in a region 95% customer recovery in 72 hours can be expected. When regional outages exceed one half million customers an additional 17 hours of restoration time can be expected for each million customers without power. The correlation between the total regional customers without power and the restoration time is 0.83 (0 shows no correlation, and 1 shows perfect correlation). **The PSC should consider adding an expectation to the Docket 50 standard for**

Regional Major Outage Events whereby 17 hours are added to a 60 hour restoration time for each 1 million regional customers out of power over the initial half million. This would primarily be used as a yardstick in post-mortem investigations.

Graph 3

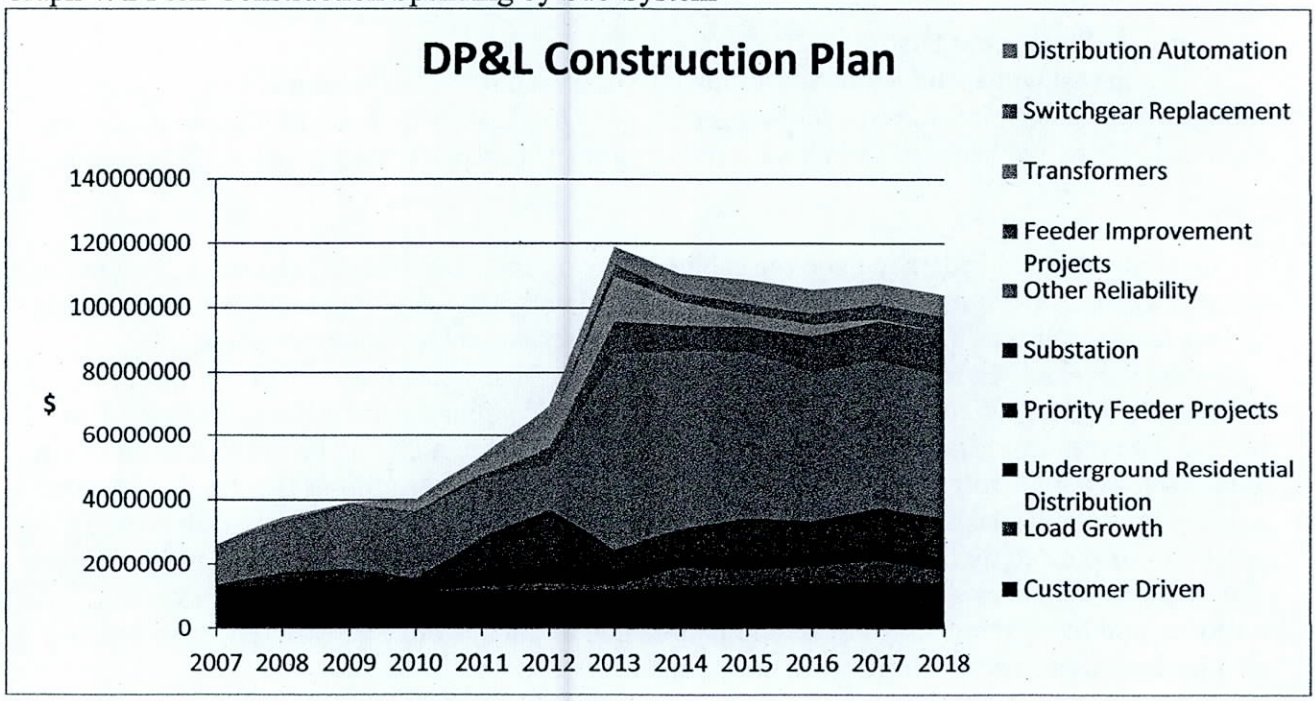


Note: For common events the number of customers out and total utility customers were summed. For each utility the number of customers out were divided by total event customers out and multiplied by utility hours out. Event results were totaled to come up with weighted outage hours.

Evaluating "Delmarva Delaware Capital Distribution Construction Plan 2014 -2018"

Delmarva's process used in developing the plan is comprehensive and professional, and the results are just and reasonable. Spending actually declines 19% by 2018 from 2013 in inflation adjusted dollars (1.5%/year). Spending increases for Feeder and Substation improvements, and declines for most other categories from 2013 levels.

Graph 4: DP&L Construction Spending by Sub-System



Customer Driven Improvements

Delmarva is required to supply service to every customer requesting it. Expansion for existing customers, new customers, relocation of equipment for highway construction, and changes to accommodate distributed generation such as solar photovoltaic systems drives spending. Net metering rules require Delmarva to refund supply, transmission, and distribution cost to solar and wind operations set up on the customer's side of the meter. Power is intermittent from these sources so they export excess power when the sun is shining or the wind is blowing, and import power when it's not. Systems can produce up to 110% of the power they need. These customers work the distribution system harder than a typical customer. CRI **recommends the Commission change the net metering rule so customers using distributed power are only refunded supply charges.** This would make more money available for distribution system upgrades. Solar installations only generate power about five hours a day, but can produce up to 110% of the daily energy requirement. The rest of the day power is drawn from the grid setting up a situation where the grid acts as a battery but nothing is paid for the service. Future spending estimates reflect recent demand, and spending will be relatively constant at about $14 million a year, or about 12% of the total.

Load Growth

Delmarva's load growth is actually falling about 1% a year but demand shifts as customers stop or expand service. For example, Amazon opened a major new distribution center

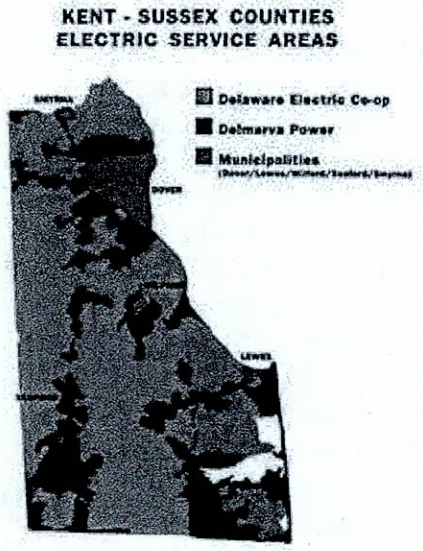
in Middletown but Evraz Steel closed in Claymont. These types of changes require infrastructure investment. Delmarva uses 3-4 year forecasts for known demand additions, and 10 year forecasts to determine historic growth and saturation trends. Avoiding saturation of a substation and feeder does improve reliability. Spending plans spike at about $6 million a year from 2014 to 2017 and then drop below $4 million for 2018, and equals about 4% of total spending. CRI has no recommendations to change this process.

Underground Residential Distribution

Delmarva will spend about $4 million a year, or about 4% of the capital budget, replacing failing cables. This reinforces the problems of relying too heavily on expensive undergrounding discussed below. We support Delmarva's spending plans to replace failing underground cables.

Feeder Improvements

High voltage Feeders include the cables, poles or undergrounding, cross arms, grounding and guy wires, animal guards, pole transformers, insulators, tap fuses, and sectionalizing devices leading from a substation to a lower voltage customer service cable. Many customers are connected to a single Feeder so failures disrupt service to many customers. About a third of Delmarva's feeders have tie-ins to other Feeders to allow looping for redundancy in case of an outage. The rest are radial lines that gradually reduce cable size and voltage out to a termination point. This is a relatively low percent of looping compared to other utilities that partly reflects building on a peninsula, and partly reflects a limited downstate service territory. Delmarva's system is surrounded by the Delaware Electric Cooperative and various municipal utilities (see map below). Delmarva's control centers cannot see operationally into the other service territories and the systems may not be compatible due to voltage or cable differences so looping outside Delmarva's service territory is not possible.



CRI recommends consideration be given to divestiture of Delmarva's downstate service territory for possible acquisition by the Delaware Electric Cooperative. Not only

would there be significantly more opportunities for Feeder tie ins for looped service, there would be a potential immediate rate reduction of about 20% for downstate customers.

High winds, heavy ice or snow, falling trees or limbs, animals, lightning, and traffic accidents combine to make Feeder problems the most common form of outage. Docket 50 requires Delmarva to correct problems on the 10 poorest performing feeders. Delmarva annually includes an additional 20 Feeders for improvement. There are 277 Feeders and the company expects to have improved all Feeders by 2018-2020. Feeders are selected based on the poorest weighted average System Average Interruption Frequency Index (SAIFI), (75%), and SAIDI (25%).

Individual Feeders are analyzed for outage causes, such as time of day, weather, equipment design and condition, and load. Physical inspections are also done. The lowest cost option that meets safety, service, and technical requirements is selected to correct the deficiencies.

Tactical Remediation Efforts include:

- Installing animal guards
- Replacing blown lightning arrestors
- Replacing deteriorated poles and cross arms
- Re-tensioning slack spans and install spacers
- Replacing deteriorated insulators
- Replacing transformers
- Replacing fuses and lateral tap fuses
- Installing sectionalizing devices (see Distribution Automation)
- Pruning or removing trees
- Replacing missing ground and guy wires
- Reducing pole spacing

Strategic Remediation Efforts include:

- Installing larger class poles
- Installing double or fiberglass cross arms
- Installing double dead ends
- Installing stronger tree wire to support limbs
- Re-routing overhead lines or using selective undergrounding

A new 138 kV Feeder costs $385,000 a mile while improvement might cost a third to a half as much. Undergrounding the same entire Feeder would cost $2 million a mile plus repair and replacement is five to ten times as much as overhead lines. Underground cables also take longer to find and repair a problem. CRI and Delmarva discussed a situation where a certain line of poles have been repeatedly hit by cars. The right of way is too small to move the poles, and strengthening the poles would increase injury. Moving the poles underground is the best option. **CRI recommends Delmarva take a more aggressive approach on selective undergrounding for poles repeatedly involved in vehicle accidents.**

The ten year Feeder Improvement Plan is similar to plans at PSE&G and Delmarva Maryland. Feeder Improvements impact reliability, hardening, and resiliency and is a winning option for all ratepayers. CRI supports Delmarva's plan to increase Feeder Improvement spending from $13 million in 2013 to $18.5 million in 2018, an average of 15% of total spending over five years.

Substations

Substations are points in the power system that transform, route, and switch electricity off and on. To minimize power loss in transmission, long distance transmission lines run at very high voltages. Electric power gets stepped up by voltage transformers for transmission or gets stepped down at the sub-stations for local delivery. Substations are on medium to large protected properties that supply Feeders. Thousands of customers are impacted by substation outages. Delmarva has a detailed maintenance and replacement plan for substation equipment that includes routine maintenance, testing, and inspections to industry and manufacturer standards. Key pieces of equipment, such as, transformers, breakers, lightning arrestors, and other large pieces of equipment have secondary backup systems.

Transformers are especially critical. High voltage transformers tend to be custom built units and can cost millions of dollars, weigh up to 800,000 pounds, can be the size of a garage, and can require from months to years to build, transport, and install. Transportation often requires special trucks and permits. There is a very limited inventory and the lack of a standard design limits interchangeability. There are relatively few suppliers and ramping up production volume has minimal potential in a crisis. If a large number of transformers went offline at the same time power would be out over a wide area, possibly for months. Recent studies point to transformer vulnerabilities:

- Cyber Attacks - The grid is becoming smarter with such technologies as Distribution Automation added to improve efficiency and to repair problems faster, and Smart Meters to provide customer feedback on usage to reduce peak demand. This increased electronic interconnection has increased our vulnerability to cyber attacks. The Department of Homeland Security reported 151 cyber attacks on the electric industry in 2013. A year ago, the outgoing Homeland Security Secretary, Janet Napolitano, stated, "Our Country will, at some point, face a major cyber event that will have a serious effect on our lives, economy, and the everyday functioning of our society". Besides random hackers, China, Russia, and North Korea all have dedicated military operations to find ways to disrupt our power grid in times of conflict. Government, security firms, and the electric industry are cooperating to design more secure systems.
- Physical Attacks - At 12:58 AM, April 16, 2013 a coordinated attack by multiple assailants began on the Metcalf substation in San Jose, CA, which serves Silicon Valley. Phone and cable lines were cut, and multiple snipers fired over 100 rounds at the transformer cooling systems over a nineteen minute period disabling seventeen high voltage transformers. It appears to be a sophisticated attack with a scout providing a flashlight signal to start and stop the attack just before police arrived. The bullet casings were finger print free and there appeared to be firing locations set up before the attack. There have been no arrests. It took twenty-seven days to repair the damage. This could have been a dress rehearsal for a more widespread attack. Sub-stations have been

vandalized in the past but nothing like this. A simulation run by the Federal Energy Regulatory Commission (FERC) showed that taking out as few as nine critical substations out of a total of 55,000 could shut the entire grid down for months. FERC has charged the electric industry to come up with a plan to "harden" transformers.

- Electromagnetic Pulses (EMP) - Exploding stars, solar flares, and nuclear weapons explosions can send out a wave of charged particles that can induce high currents in electrical equipment. The current can cause transformers to overheat, catch fire, or explode. A solar flare knocked out power to six million customers near Quebec on March 13, 1989. Solar flares occur all the time but solar "super" flares occur every few centuries. A flare estimated to be three times as powerful as the one that knocked out power in Quebec occurred on Sept. 1, 1859. It knocked out some telegraph stations and allowed others to be operated without the usual electric battery supply. According to John Kappenman of Storm Analysis Consultants, who studies the impacts of flares on the electric grid, if a super flare like the 1859 event hit today it could take out the entire grid for weeks or months. A single nuclear warhead could do the same if exploded over the central US at an altitude of about 270 miles. The Congressional EMP Commission proposed the SHIELD Act to spend $2 billion on known hardening technologies, such as surge arrestors, blocking devices, and faraday cages, to protect high voltage transformers. The Act has not been passed.
- Storm Damage – Super storm Sandy knocked out power to 8 million customers with 2 million still without power after a week, and some still without power after a month. Hurricane Katrina knocked out power for 3 million people and some were still without power a month later. Most of the damage was related to flooding and wind. Sub-stations can be hardened to resist flooding by raising critical equipment above predicted flood levels, adding flood walls, or relocation. Spare transformers can be set up and energized. Mobile transformers with mobile ready terminals can replace smaller permanent transformers.

There is no more important goal for hardening and resiliency than upgrading substations. CRI supports the Delmarva plan to spend about $5.5 million a year on substation improvements, or 4% of total spending. In addition, Delmarva has an aggressive program to build spare part inventory including more mobile transformers along with transformers that are tunable for voltage to provide flexibility.

CRI recommends further aggressive goals to harden substations:

1) **All sub-stations, pad mounted transformers and Automatic Transfer Switches should be evaluated for flood mitigation options if located in the latest FEMA defined flood zones. If appropriate, installation of flood walls, raising equipment, and equipment relocation should be completed in three years.**
2) **All high voltage transformers should be evaluated for mitigation against physical attacks using upcoming standards currently being designed by the North American Electric Reliability Corporation, with such evaluation being completed within one year.**
3) **All high voltage transformers should be evaluated for mitigation against EMP level three events using surge arrestors, blocking devices, and faraday cages as appropriate with evaluation and implementation completed in five years**

Delmarva Maryland reports flood walls will cost about $3 million/substation and expects flood walls to be needed at 9 of 92 substations. PSE&G expects to spend $21 million/substation on hardening 29 out of 246 substations. The PSE&G plan includes raising equipment and some substation relocation which is much more expensive than flood walls but will be more effective in some cases. PSE&G is working with vendors to develop waterproof pad mounted transformers and Automatic Transfer Switches, and Delmarva should be prepared to take advantage of equipment improvements.

Switchgear Replacement

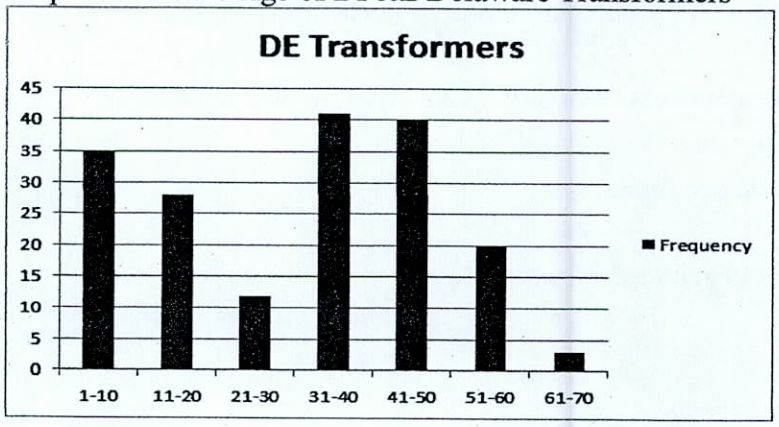
In 2010 a major summer electric outage occurred that affected 20,000 Atlantic City Electric customers. ACE is a sister company to Delmarva. The outage was traced to the failure of two metal clad switches in one substation due to corrosion. Subsequently, all substation switchgear in ACE and Delmarva were inspected and a significant replacement program was devised to prevent further failures. Delmarva reports, "Several of these switchgears have been in service for over thirty years and availability of parts is becoming an issue. The technology has advanced with solid state electronics replacing electro-mechanical relays, vacuum breakers are available instead of air circuit breakers, the units are more compact, and the structures are coated with material designed for better corrosion resistances." At the same time control room roofs and HVAC systems will be upgraded to minimize future corrosion problems.

Substations have been prioritized for switchgear work and expenditures will average about $4 million a year. This work will cost $23 million between 2014 and 2018, or 4% of capital spending. CRI supports Delmarva's plan to upgrade switchgear.

Transformers

As discussed above transformers are expensive and have a long lead time for replacements. The company is making a major investment in transformers including both replacements and mobile units. Transformers are generally expected to last thirty to forty years. Graph 5 below, provided by Delmarva, shows the ages of the system transformers. Almost 60% of the systems transformers are over thirty years old lending urgency to buying back up transformers. Spending peaked at $14 million in 2013 and will be complete by 2017. Total investment will be $29 million over the five year forecast period, or 4% of total capital investment. CRI is extremely supportive of this plan.

Graph 5: Relative Age of DP&L Delaware Transformers



Distribution Automation

Distribution Automation (DA) allows a Feeder to automatically reconfigure itself in an equipment outage. Better reliability results by isolating the outage to reduce the number of customers affected, and by identifying the exact location to allow faster repair. The fundamental building block of DA is Automatic Sectionalizing and Restoration (ASR), which uses automated switches, controllers, smart sensors, and substation electronic relays to re-route power around the outage. Wireless communication equipment sends and receives information to the Supervisory Control and Data Acquisition (SCADA) central control system. Delmarva Maryland predicts DA will improve SAIFI by 14% on sectionalized Feeders, and Pepco saw a 22% improvement in its Feeders.

It is important to understand the limitations of these systems. They only work when multiple Feeders are tied together to create looped, or redundant service. Only about a third of Delmarva's Feeders are looped with minimal opportunity to expand that number. Secondly, in a MOE, so many outages are occurring at once that DA can add confusion so the system has to be turned off. DA has also been described as masking symptoms of a system that needs the more basic benefits of Feeder Improvement discussed above.

Delmarva prioritizes Feeders for DA that had three or more lockouts over the most recent two year period, and can be tied in with another Feeder. Money is saved by serving more than one Feeder from the same substation ASR equipment.

Delmarva has added DA to 8 Feeders to date or 3% of the system. Delmarva will spend about $7 million a year, or about 6% of the capital budget on DA, adding about 7 Feeders a year. Spending should continue at this level for about ten years. DA communication is carried out with widely distributed Remote Telemetry Units (RTU) over secure communication lines. CRI supports Delmarva's spending plan on DA. **CRI recommends raising, or otherwise securing RTU's that are connected to a control unit to minimize the potential for computer hacking.**

Other Reliability Spending

This includes spending for a wide variety of projects listed below:

- Emergency restoration

- Miscellaneous distribution improvements – small projects affecting few customers
- Customer reliability improvements – small projects affecting few customers
- Wilmington Network Upgrades
- Pad mount transformer replacements
- NERC lines upgrades
- Christiana Substation duct bank replacement
- Re-closer replacements
- River crossing cable projects
- Tree wire / spacer cable projects
- Avian protection projects
- Salvage and scrap projects
- Pole replacements and reinforcements
- Pole top transformer replacements outside of feeder projects
- Voltage conversion projects
- Substation Physical Security upgrade

Other Reliability spending will fall from $61 million in 2013 to $45 million in 2018, and will total $307 million or 47% of capital spending over five years. CRI supports Delmarva's spending plan on other reliability issues.

Conclusion

Overall, Delmarva's plan increases reliability investment levels over the recent past to catch up on spending on aging infrastructure and new technology. Almost 60% of Delmarva's transformers are over thirty years old when life expectancy ranges from thirty to forty years. Similarly, as much as 60% of Delmarva's Feeders need upgrading, and Distribution Automation upgrades have only been added to about 10% of the Feeders that could benefit from this technology. Aging switch gear and underground cables must also be replaced. Spending actually declines 19% by 2018 from 2013 in inflation adjusted dollars (1.5%/year) as many programs will be complete over a five to ten year period.

The reliability guidelines need significant updating to meet customer needs and expectations during extreme Major Outage Events (MOE). This would include hardening the system to resist damage from flooding during major storms, physical attacks, cyber attacks, and Electromagnetic Pulses (EMP), and to make the system more resilient to allow faster recovery from an extreme MOE such as super storm Sandy. Improving hardening and resiliency will lead to a temporary increase in capital spending and further marginal rate increases.

CRI supports Delmarva's reliability investment plan, and recommends the docket be kept open to further consider needed substation hardening investment.