DC PLUG™

Making your electric system more resilient.™

DC Power Line Undergrounding (DC PLUG)

National Summit On Smart Grid and Climate Change

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December 2, 2014

Background and History

- Severe weather events from 2010 to 2012 challenge the electric system's resiliency
  - Severe thunderstorms
  - Snow-mageddon
  - Hurricane Irene
  - Derecho
  - Hurricane Sandy
- Mayor's Executive Order established Task Force to evaluate options to improve resiliency during severe weather events
- Task Force members represent a broad cross section of stakeholders (DC governments, OPC, utilities and residents)

Task Force Evaluation and Recommendation

- Feeders are primary distribution power lines that provide service to about 1,100 people within a neighborhood

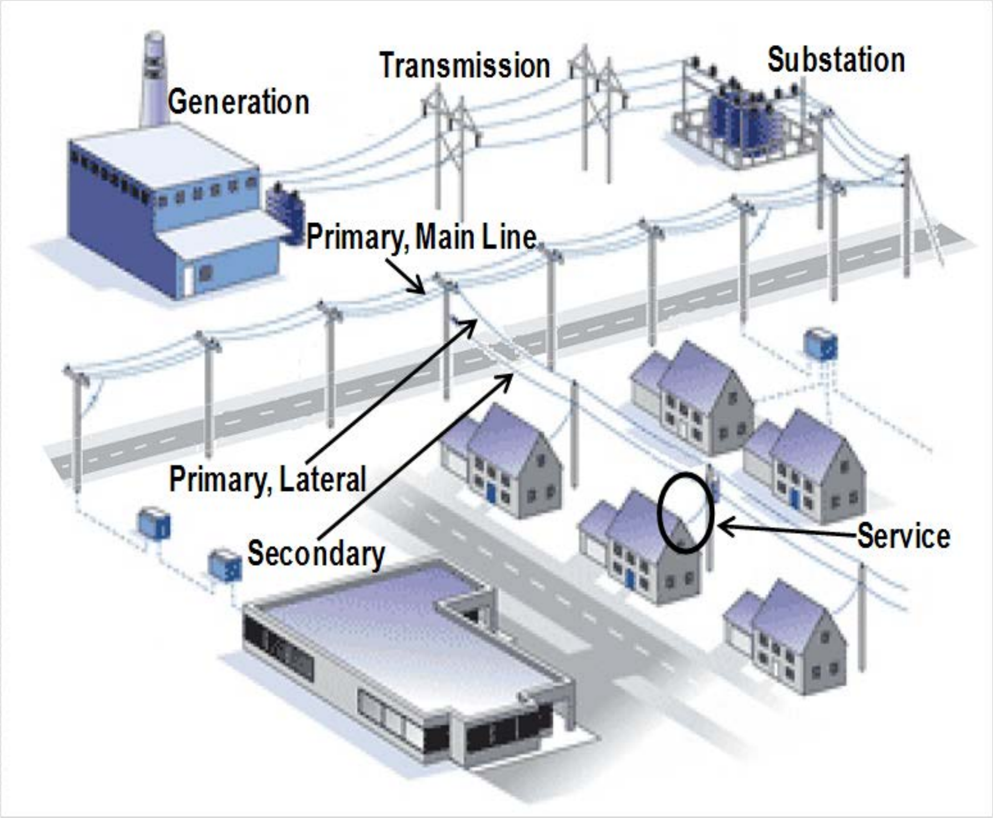
- The Task Force used a model to analyze outage data and service value to the community for all overhead feeders in DC

- The recommended criteria for choosing which feeders would be moved underground:
  - Average of outage frequency
  - Duration of outages
  - Economic impact

- The final recommendation is to move underground the mainline and lateral primary lines as well as the transformers of the least reliable feeders in Wards 3, 4, 5, 7 and 8

Preferred Undergrounding Scenario

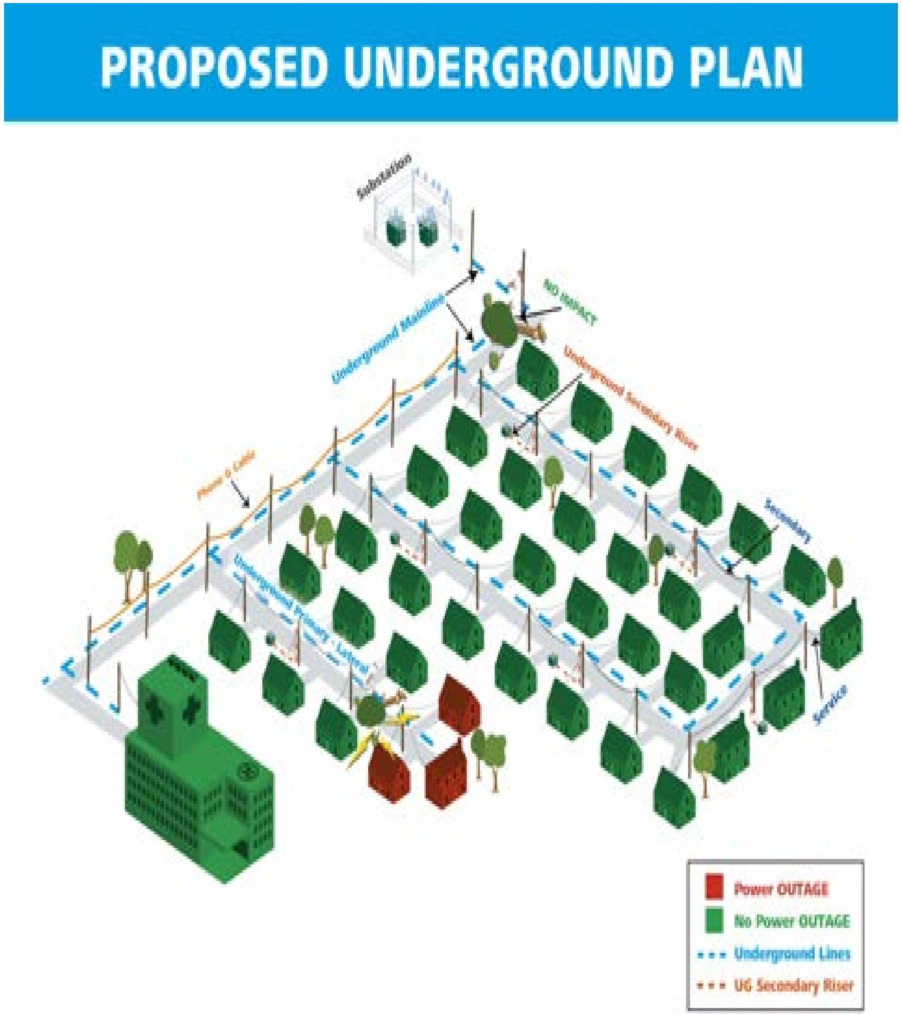
Underground High Voltage Mainline and Laterals Retain Secondary Overhead



- This scenario would eliminate the majority of overhead causes of outages ;
- Eliminates outages that occur on blue sky days, normal storm days or during major storms;
- All high voltage lines , switches, transformers and equipment will be removed form the poles after transfer;

Undergrounding Scenarios

- The preferred scenario has the best balance between cost and reliability improvement;
- If an outage does occur it will only impact a few customers not everyone on the feeder;
- By eliminating the larger outages on the primary wires crews will be able to respond faster to the individual outages that in the past were the last to be restore.
- An initial program over the next 5 to 7 years could provide benefits to over 60,000 customers.



Undergrounding Scenarios

District of Columbia (All Outages Percent of overhead)	Cost ($Billions)	Customer Frequency (SAIFI)	Customer Duration (SAIDI)
1. UG main line w/OH secondary	$1.93	56%	45%
2. UG laterals w/UG secondary	$3.30	44%	55%
3. UG main line and laterals w/OH secondary	$3.00	97%	92%
4. UG main line and laterals w/UG secondary	$5.11	100%	100%
5. UG laterals w/OH secondary	$1.33	42%	47%

Option 3 obtains 97% of the benefits at 60% of the cost for the lines undergrounded

Achieves the goal to reduce outages during major storms in the most cost beneficial method

The cost identified in the table above represent the cost to underground the entire overhead system for each option. The recommendation is to complete approximately one third of this cost in this phase of the project ($1 billion)

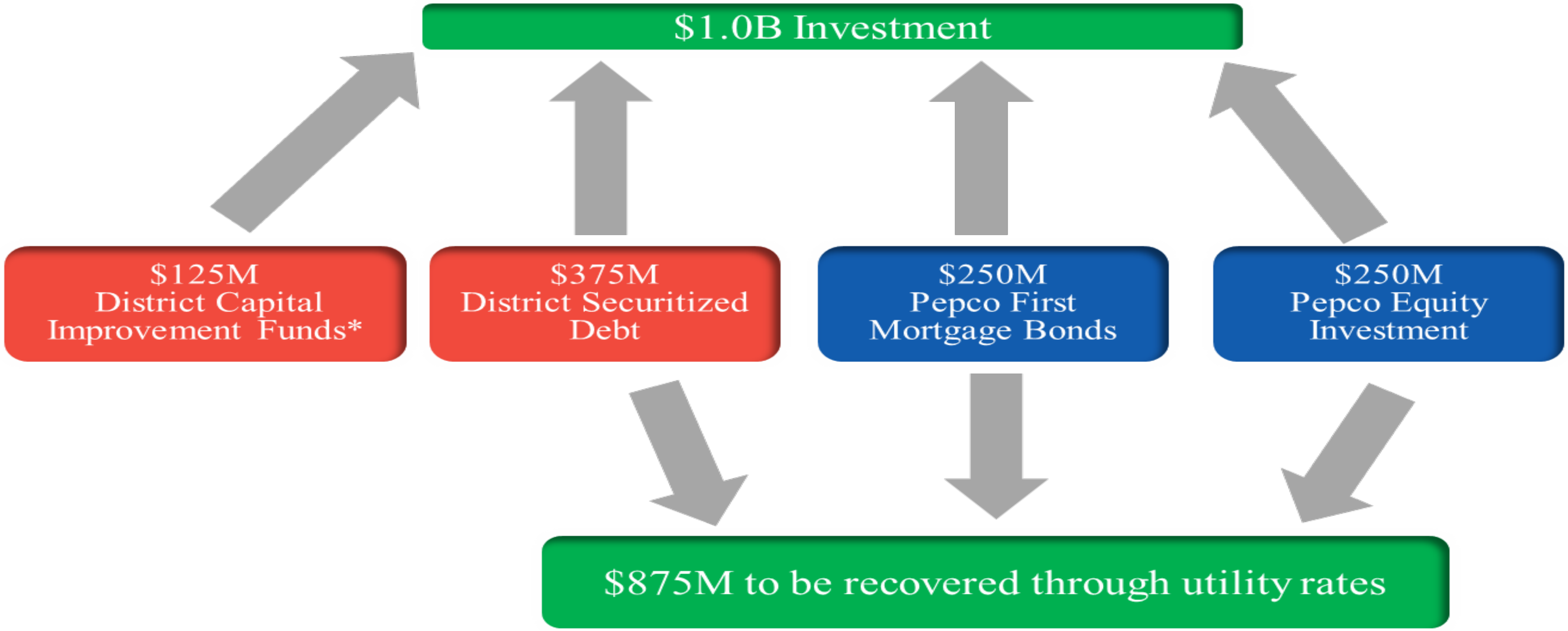
Triennial Plan

- Electric Company Infrastructure Improvement Financing Act (Act) became law on May 3, 2014

- Pepco and DDOT filed a joint Triennial Plan which represents a unique public-private partnership to bury overhead lines to significantly improve electric service during all weather conditions

- Triennial Plan covers 2015-2017 where District of Columbia Department Of Transportation will construct the facilities and Pepco will install the electric distribution for the 21 feeders most affected by outages

Proposed Financing Structure



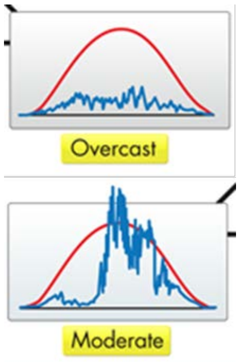
Monthly Average Residential Customer Bill Impact**		
Year 1	**Year 7**	**Year 15**
$1.50	$3.25	$1.41

* Subject to budget approval
** Excludes RAD customers

Integrated Communications Strategy- DC PLUG Education Plan

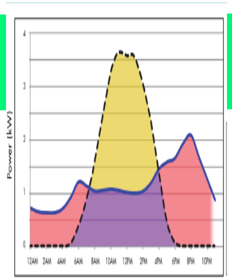
- Comprehensive plan to educate and update District customers and other stakeholders on DC PLUG
  - Responsive and reliable information is critical for successful implementation of DC PLUG.
- Community engagement meetings hosted by DC PLUG team, for each feeder, with a focus on key phases:
  - Project introduction and planning
  - Construction kick-off (what to expect)
  - Progress updates
- Community outreach in coordination with the Mayor’s Office of Neighborhood Engagement, ANCs, OPC, PSC, community meetings, and other forums

How the Grid Provides Value



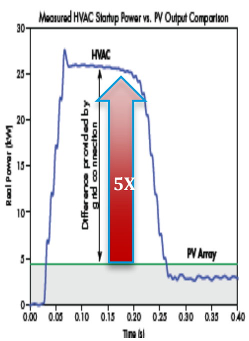
Reliability

- High-quality power in the event of disruptions to DER - **Grid serves as a DER battery**.
- The grid also ensures load requirements are balanced and ensures proper system operation.
- Redundant capacity can be pooled among multiple consumers, rather than each customer having to provide its own backup. This reduces the overall cost of reliability for each customer



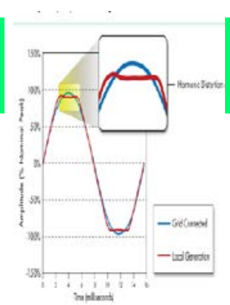
Energy Transaction

- Ability to install any size DER that can be connected to the grid.
- Consumers can transact energy with the utility grid, getting energy when the customer needs it and sending energy back to the grid when the customer is producing more than is needed.
- Shifts risks with respect to the size of the energy resource from the individual user to the utility.



Start-up Power

- Transitions that occur on a minute by minute basis are not apparent, but require large kWh capacity to meet the start-up loads of today’s HVAC and large appliances.
- The grid provides instantaneous power for appliances and devices such as compressors, transformers, and welders that require a strong flow of current (“in-rush” current) when starting.
- A PV system may not start at all unless the PV system is oversized to handle the in-rush current



Voltage Quality and Efficiency

- Instantaneously balances supply and demand, providing electricity at a consistent frequency.
- Grid connectivity enables rotating-engine based generators to operate at optimum efficiency.
- Without the grid, DER output will have to be designed to match the inherent variation of load demand. This fluctuating output could reduce system efficiency as much as 10%–20%

Renewable Energy – A Paradigm Shift Driving DER

Federal and State

- Fighting global warming.
- Reducing dependency on fossil fuels.
- Improving the efficiency of the grid.
- Creating better reliability thru distributed energy resources.

Utilities

- Some have invested in the installation of solar – NRG, Next Era, PSEG, Constellation, etc.
- While some are actively investing, the majority are taking a wait-and-see approach.
- All recognize the challenge intermittency brings to the industry.

Customer

- Believes the grid is a two way street - - can import or export power at will
- Many do not understand their dependency on the grid, in spite of having a PV system
- Most now believe they are providing the electric grid a favor for which they should be compensated – at least by continuing the NEM rate

- So far, rapidly expanding deployments of DER are ***connected*** to the grid but not ***integrated*** into grid operations.
- Grid-connected **DER benefits from the electrical support**, flexibility, and reliability that the grid provides, but are **not covering their costs** that deliver those benefits.
- **Utilities are not realizing the full value of DER** with respect to providing support for grid reliability, voltage, frequency, and reactive power.

With PV growth projected to increase in scale and pace over the next decade, now is the time to consider lessons from Germany and other areas with high penetration of distributed resources.

Customer Interconnection Process:

Customer Facing: Green Power Connection Team receives customers' interconnection requests, processes applications, and manages the overall customer experience.

NET ENERGY METERING GENERATORS

0 – 50KW

- Application required based on size
- GPC Team review

Active on the System:
– 78.2 MW & 9,994 Customers

Pending on the System:
– 18.5 MW & 2,176 Customers

>50 – 250KW

- Pre-Screen (very high level review)
- Ensures systems at the end of rural feeders won't cause a problem
- Reviewed by DERP&A, Engineering, System Protection

Active on the System:
– 32.1 MW & 266 Customers

Pending on the System:
– 12.2 MW & 94 Customers

Greater than 250KW

- Screen (or static level load flow review)
- Determines if a larger system will have an impact requiring a more detailed study (feasibility, impact, facility studies)

Active on the System:
– 84.8 MW & 129 Customers

Pending on the System:
– 58.7 MW & 55 Customers

- The requirement to do the different levels of study is necessary to protect both the customer and the grid and ensure no adverse impact
- Doing the load flows with all active and pending PV mapped onto the circuit and occasional aggregate analysis will catch areas that may become a voltage problem due to concentrations of small units

WHOLESALE MARKET GENERATORS

PJM (All Fuel Sources)

Active on the System:
– 7,140 MW
– 71 Customers

Pending on the System:
– 9,740 MW
– 76 Customers

BEHIND THE METER GENERATORS

Non-NEM/Non-PJM

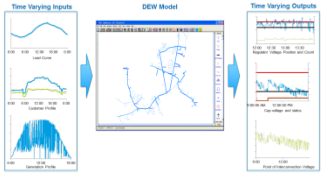
Active on the System:
– At least 84.0 MW
– At least 15 Customers

Pending on the System:
– At least 40.0 MW
– At least 6 Customers

What PHI is Doing to Address the Challenges of DER

Engaging Regulators and Public Officials: Engaging FERC, State public officials, DOE and other industry groups to better understand the benefits and challenges associated with all types of DER

Modelling & Analytics: Advanced load flow being implemented, Distributed Energy Resources Planning and Analytics department formed, technical and financial analysis of Micro grids



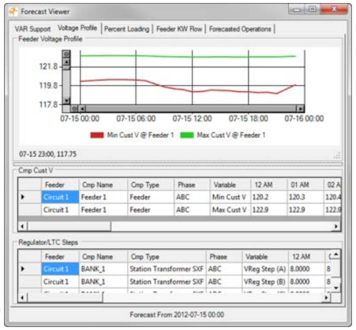
Collaborative R & D: Inverter technology, advanced voltage regulation control, penetration studies with a variety of different partners.

- Hosting Tests based on modeling Advanced Volt/VAR Control, smart inverters and AMI to monitor and provide control for small size inverters
- Implementing Cellular telemetry for systems over 2 MWs
- Integrating PV output data into Distribution Automation schemes
- Reviewing feasibility of online application and approval process

DOE Sunrise Project

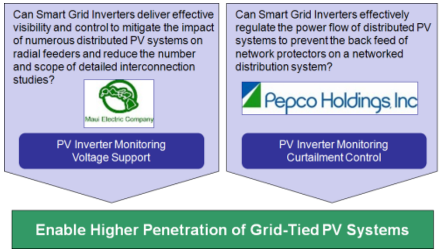
- Model-Based Analysis to simulate the impact solar has on the grid.
- This project is testing advanced voltage regulation strategies to find the most cost effective way to use existing and new equipment as penetration rates of DERs increases.
- It will model both autonomous and central controlled approaches.
- PHI is partnering with:
  - Electrical Distribution Design (DEW software development/technical)
  - Clean Power Research (solar Irradiance data)
  - Rutgers University (economic analysis)

Control can be run against simulator or real system through connection to SCADA



DOE Sunshot Smart Grid Inverter (SGI) Project

- Pilot using AMI data and an algorithm from Silver Spring to dynamically set the power factor and overall watts for inverters.



HNEI	Project Lead
Maui Electric Company	Co-Utility Lead
Pepco Holdings Inc	Co-Utility Lead
Hawaiian Electric Company	Co-Utility Lead
Silver Spring Networks	Technology Lead
OG&E	Inverter Testing Lead
SolarCity	Co-Services Lead
RisingSun Solar Electric	Co-Services Lead
Fronius	Inverter Technology Lead
Hitachi	Inverter Technology Provider

Key Takeaways

- Increasing penetration of solar, DG and microgrids will present new challenges from an engineering and process perspective

- The Grid adds value for Distributed Resource capabilities and needs to be expanded to include increased resiliency so that together customers will be less impacted by server weather events

- Distributed Resources need to be integrated with the grid and managed in a way that maximizes the value of the grid and the DG

- Utilities, regulators, technology providers, and customers to fully integrate DG with the Grid need to work together to maximize new sources of value offered by these opportunities to build the best electricity system of the future that delivers value & affordability to customers and society.