

Smart Grid and Microgrid Research & Deployment at the Philadelphia Navy Yard



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ISSUES

- Over 35 states have mandated Renewable Portfolio Standards (RPS) requiring up to **33%** from renewable energy sources.
- The current grid is stable and can handle fluctuations up to about **15%**.
- With distributed and **movable loads** (e.g., electric vehicles) and distributed sources, power will have to **flow bidirectionally** as needed.
- With the growth of residential solar photovoltaic (PV) systems, building integrated PV system and utility scale Wind and Solar PV, the grid will have **diurnal sources whose output fluctuates** frequently.
- The power generation cycle will not be aligned with the daily power usage cycle for some renewables (e.g., wind) and **energy storage** will be needed to utilize it fully.
- Power distribution will be organized from small-scale **nanogrids**, to **larger microgrids**, to being integrated with utility scale power grid.

NAVY YARD UNREGULATED MICROGRID

- Legacy system from 125 years as an active military base & shipyard
- 1,000 acres acquired in 2000
- Now a **mixed-use** urban redevelopment zone
- Factor of 3 grown anticipated according to master plan
- Congested area served by PECO in PJM's region
- Grid is **unregulated**, permitting flexibility in implementing configurations



TENANTS WITH DIFFERING LOAD PROFILES



- Over 115 companies and 3 Navy activities
- More than 8,500 employees
- Expected to reach 30,000 employees
- Industrial, Office, R&D, Data
- Future Residential, Hotel



MASTER PLAN/LOAD TYPES



MASTER PLAN/LOAD TYPES



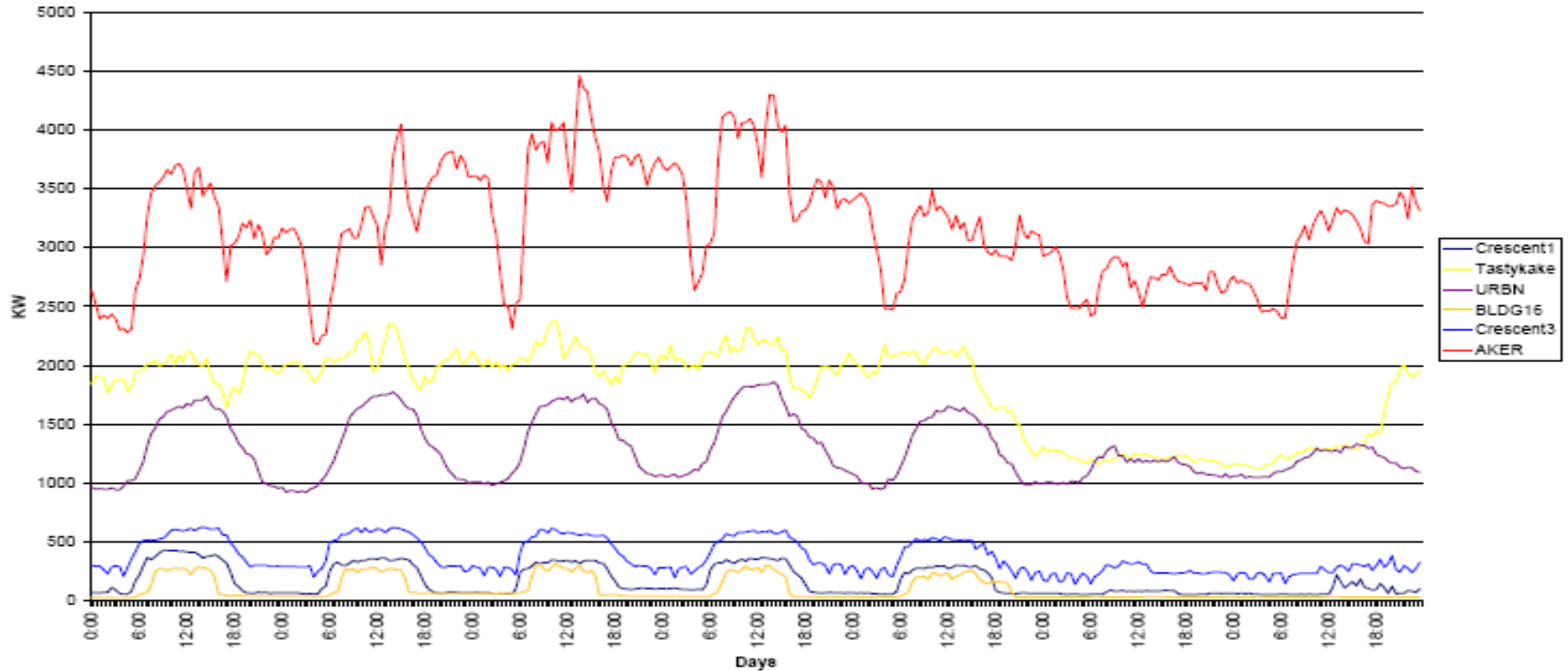
MASTER PLAN/LOAD TYPES



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NAVY YARD TENANT LOAD PROFILES

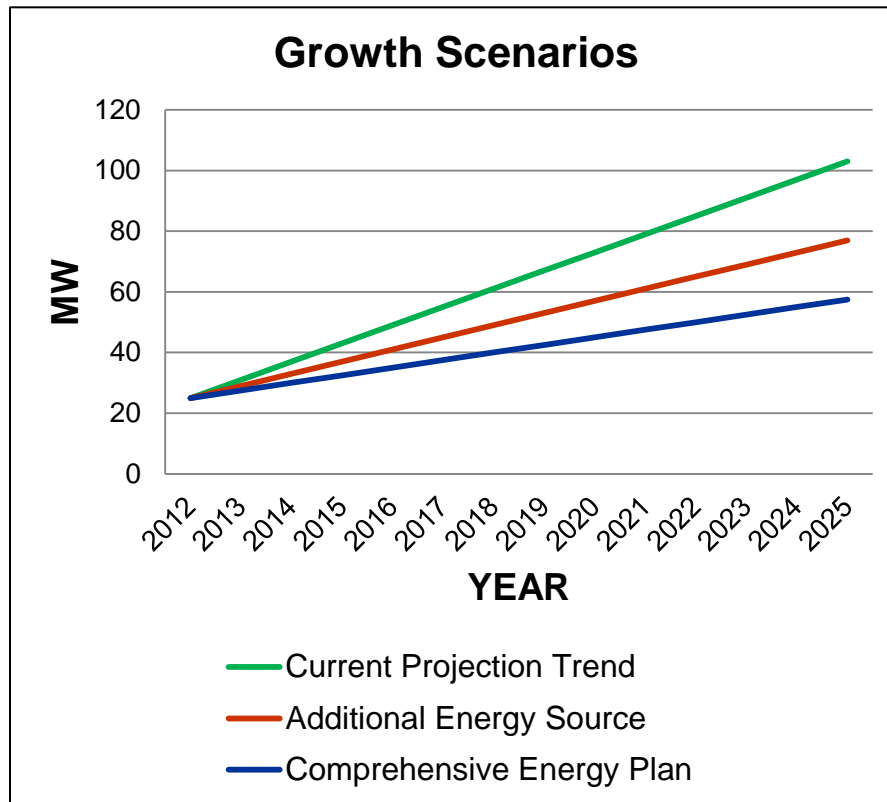


ENERGY MASTER PLAN

The Five-Point Action Plan

- **“Smart Grid” Infrastructure:** Generation, Distribution, Storage, System Reliability and Smart Infrastructure
- **The Business Model:** Tariffs, Procurement, Ancillary Services, Other System Revenues and Business Modeling
- **Building Owner Opportunities:** Building Management, Efficiency, Distributed Generation/Storage and Strategic Islanding
- **Test Bedding Outreach and Protocols:** Scaling Up Technology & Other Innovative Solutions
- **Carbon Reduction and Sustainability:** Demonstrate best practices to achieve economic growth will reducing carbon output

Balancing Supply and Demand



Comprehensive Energy Approach

- Reduce PJM Demand
- Minimize Capital Investment
- Improve Energy Pricing
- Reduce Carbon Footprint

Opportunities for DG & Load Optimization

- Micro-turbine/CHP
- Fuel Cell/Solar
- High performance Buildings

Smart Grid Implementation

- Distributed Energy Resource Management
- Demand Response
- Smart Meter
- Distribution Management
- Microgrid Evolution

MICROGRID EXPANSION PLANS

PECO Grays Ferry Substation

PECO Southwark Substation



100+ miles of underground cable

158 Transformers

107 pieces of Switchgear

490 total-kWh meters

7 digital time of use meters

66 Customers

DOE Grid**ST**★**R** CENTER OBJECTIVES

- **Smart Grid Training Application Resource Center**
- **Education and Research** Mission
- **Train the Trainer:** Cultivate the credentials of instructors at all levels
- **Develop partnerships** / pipelines for talent through industry partnerships and consortia
- **Build joint training and research facilities** to serve system performance and education programs
- **Attract talent** into energy efficiency and renewable energy fields

DOE Grid**STAR** CENTER FOCUS AREAS

- **Research**
 - **Creation of a test micro grid**
 - **Plug-and-Play test opportunities**
 - **Prototypes**
 - **Value Proposition**
 - **Robustness**
 - **PJM Ancillary services**
- **Education**
 - **Workforce development/training**
 - **Job creation/economic development**

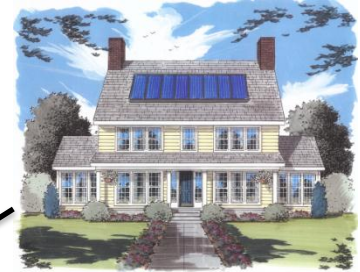
GridST★R TEST MICROGRID PLAN

- **Plug & Play Design; Systems Approach**
- Net-zero energy solar house with home energy management system, smart appliances, and electric vehicle charging station with community energy storage
- Solar-canopied electric vehicle charging stations with associated storage battery plus V2G capability
- Grid-Scale energy storage (ancillary services and DR)
- Additional Solar PV units and training infrastructure
- Building energy management systems & Smart Meters (B2G)
- Smart Distribution Infrastructure (power quality meters & remote switching, and communication)

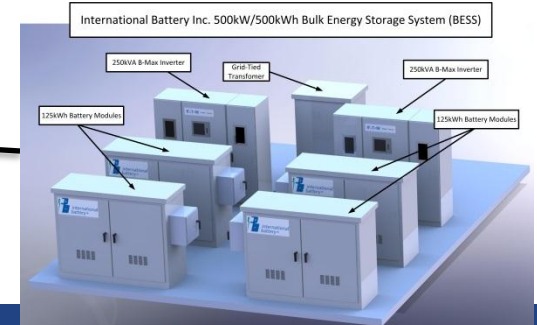
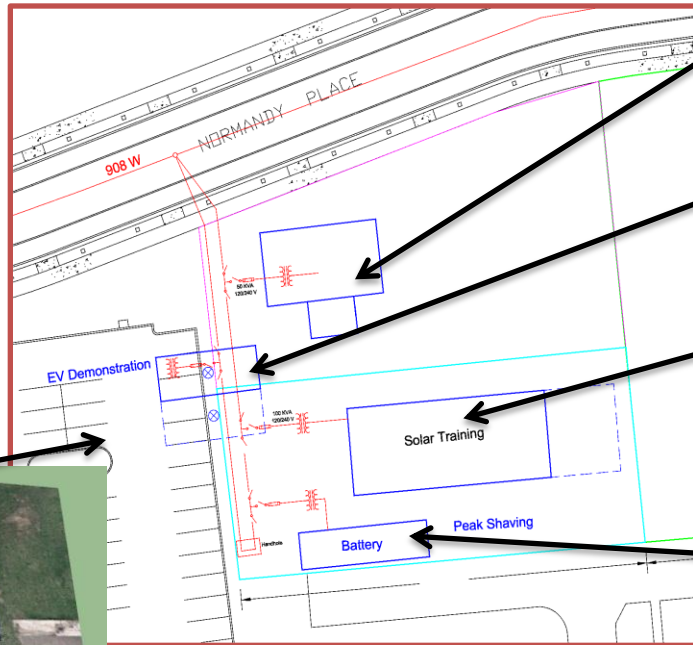
DOE GridSTAR TEST AREA

Plug & Play Test Microgrid

- Solar house with Electric Vehicle charging station
- Electric Vehicle Charging Stations
- Community and grid scale energy storage
- Solar PV units and training infrastructure
- 3 Office Buildings with energy management systems
- Smart Meters and Distribution Infrastructure



3 bldgs



International Battery Inc. 500kW/500kWh Bulk Energy Storage System (BESS)

LARGER SCALE TESTING

- 2 MWh Grid Scale Battery for frequency correction
- Large fuel cell
- Future liquid air energy storage
- Gas turbines for peak loads re-used for peak shaving at other times
- Submicrogrids for mission critical circuits and islanding

DOE “GPIC HUB” MISSION

- The goal of the GPIC EEB Hub is to transform the building retrofit industry from serial fragmentation to integrated systems methods by providing:
 - design tools
 - integrated building systems
 - policy recommendations
 - market initiatives, and
 - skilled workers

to reduce energy use in buildings by **50 percent** that will also stimulate private investment and quality job creation in Greater Philadelphia and throughout the nation.

RENOVATION ENERGY SAVINGS

- LEVEL 1 (Optimize the Building)
 - Follow GPIC-recommended principles to save money on design and delivery cost and use it to finance a deeper green renovation than otherwise could be afforded.
- LEVEL 2 (Connect the Optimized Building to the Smart Grid)
 - Derive a revenue stream from demand reduction programs or ancillary services and use it to afford an even deeper green retrofit

MOVING FORWARD

- Test high penetrations of renewable energy by load adjustment
- Use intense power quality monitoring to understand issues
- Create case studies documenting value proposition and robustness
- Concentrate on energy storage as a solution (home, charging stations, grid regulation, peak shaving)
- Engage in B2G and V2G systems research
- Test prototypes of new equipment
- Document value of ancillary services and revenue gained
- Use remote switching, radial feeds, and loop circuits to demonstrate configurations with bidirectional power flow.
- Demonstrate mission critical configurations with islanding
- Try to become a regional model of planning and execution