The Vision and Pathway for Grid, Microgrid and Emerging Grid Development

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Outline

- **Microgrids: Definition, Types, Size**

- **The Navy Yard Microgrid**

- **DOE-Microgrid RD&D Project**

- **Project Objectives**

- **Vision and Pathway for Future Microgrids**

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Definition of Microgrid

- **DOE Definition of Microgrid:**

  "A group of interconnected loads and distributed energy resources (DER) with clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid and can connect and disconnect from the grid to enable it to operate in both grid connected or island mode."

- **The goal is to enhance reliability and resiliency**

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Types of Microgrid by Purpose

- **Customer microgrids or true microgrids (µgrids)**
  - are self-governed, and usually downstream of a single point of common coupling (PCC).

- **Utility or community microgrids or milligrids (mgrids)**
  - involve a segment of the regulated grid.

- **Virtual microgrids (vgrids)**
  - cover DER at multiple sites but are coordinated such that they can be presented to the grid as a single controlled entity.

- **Remote power systems (rgrids)**
  - not able to operate grid-connected, isolated power systems involve similar technology and are closely related.

- **©2015 Microgrids at Berkeley Lab**

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Types of Microgrid by Size

- **Megagrid:**
  - **Microgrid at transmission level: 100s of MVA (above 120-kV)**
    - **Ex: Large windfarm with storage**

- **Minigrid or Milligrid:**
  - **Microgrid at primary or medium voltage distribution level: 10s of MVA (15 to 25 kV)**
   - **Ex: Distribution substation**

- **Microgrid:**
  - **Microgrid at secondary or low voltage level: 1 MVA and less**
    - **Ex: Feeder segment serving a small commercial and/or large group of residential customers**

- **Picogrid:**
  - **Microgrid at secondary or low voltage level: 100 KVA or less**
    - **Ex: Feeder segment (lateral) serving small group of customers**

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Example: 18-Bus Radial/Looped Microgrid (Potential Islands)
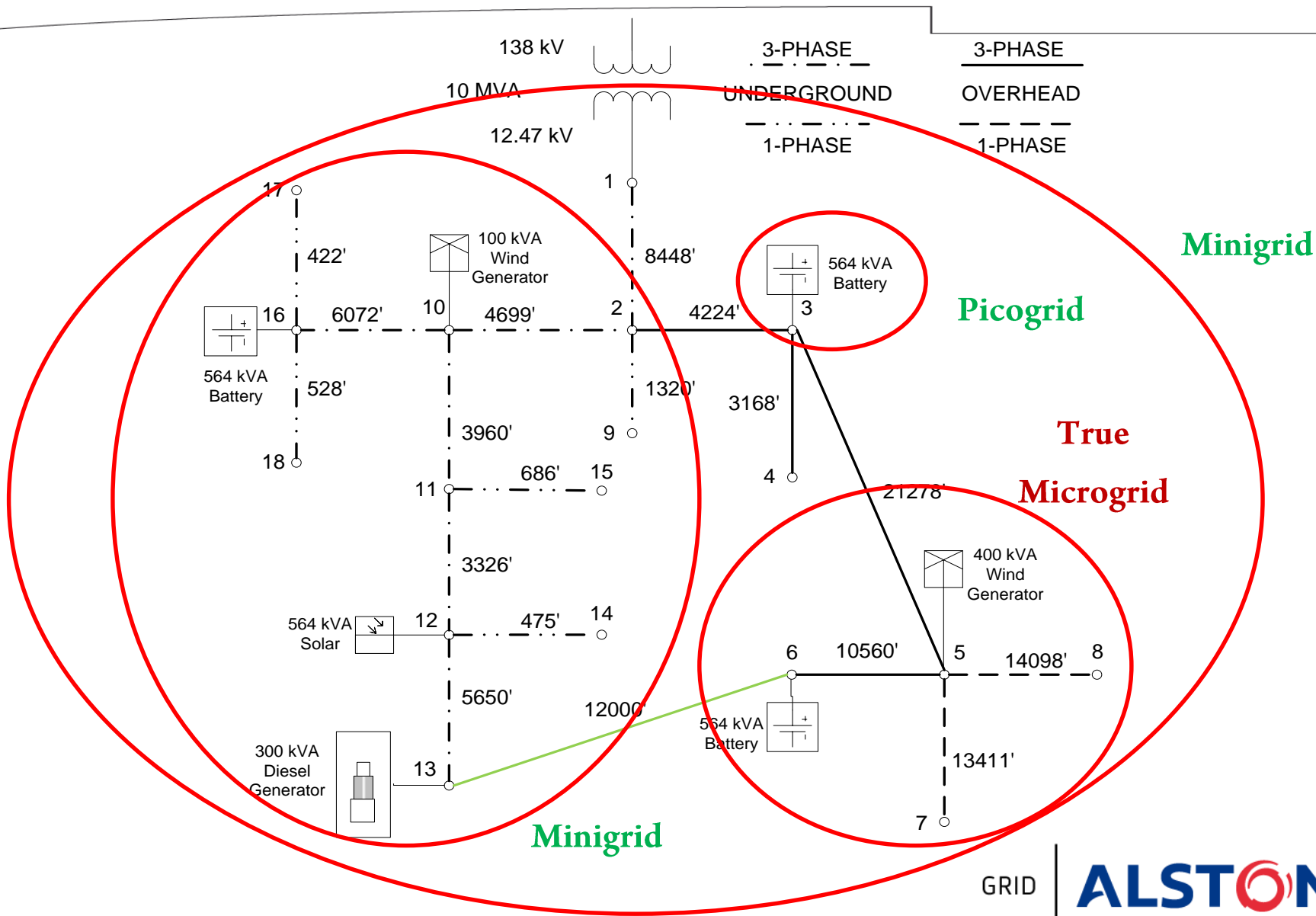
DOE – The TNY RD&D and Testing for PIDC

- The Navy Yard is (TNY) is located in Philadelphia

- It is managed and operated by the Philadelphia Industrial Development Corporation (PIDC)

- Attract small commercial and industrial and commercial customers

- It is classified as an independent utility

- It can operate either as an autonomous microgrid or as interconnected microgrid with PECO

- Three major goals:

    – Smart meters/ AMI

    – Smart Grid NOC

    – Substation Automation

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The TNY RD&D and Testing for PIDC Project Overview - Background

Project Prime Community Partner PIDC - Overview

Demand Growth Scenarios (MW vs YEAR, 2012–2022)

Legend: Business as Usual – 100% Utility Fed; On-Site DG and Storage; Grid and Building Energy Efficiency

Cumulative Usage decrease – over 61,000 MWh

Optimized Scenario & Business Plan

Business as Usual – 100% Utility Fed

– All PECO supply
– No On-site generation (DG)
– No proactive EE or DR effort

Utility Demand - 82 MW

Grid Capacity Upgrades $35M

On-Site DG

Grid Programs:
– Natural gas DG
  ➤ 6 MW Peak Reduction
  ➤ 3 MW CHP (data center)
– 1 MW Solar PV
– 600 KW Fuel Cell

Utility Demand - 72 MW

Stand Alone Energy Projects $25M

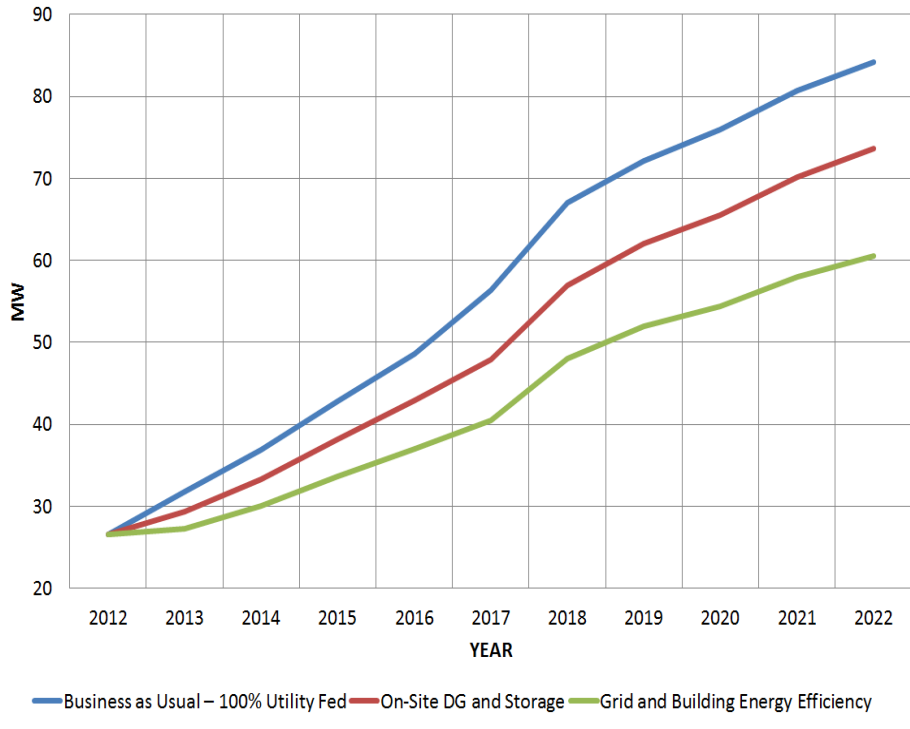**SG Infrastructure / Priority Repairs / Demand Response & Energy Efficiency**

Customer programs:
– 20% EE goal by 2022
– Navy DOD mandates
– B-T-M Demand Reduction

Utility Demand - 60 MW

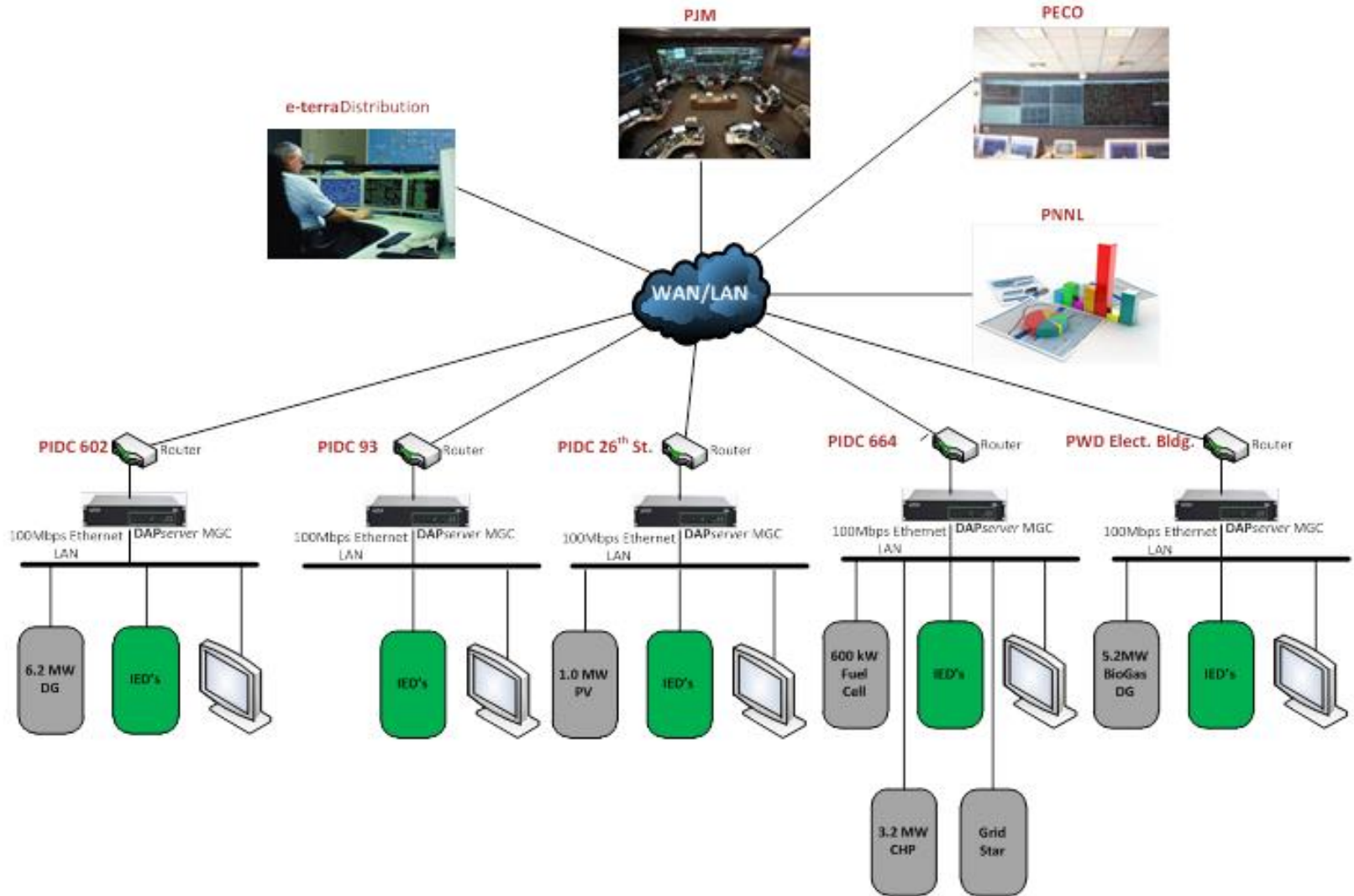**Smart Grid & Operation Infrastructure $35M**

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The TNY RD&D and Testing for PIDC
Four Potential Microgrids
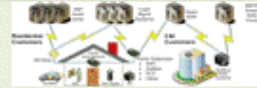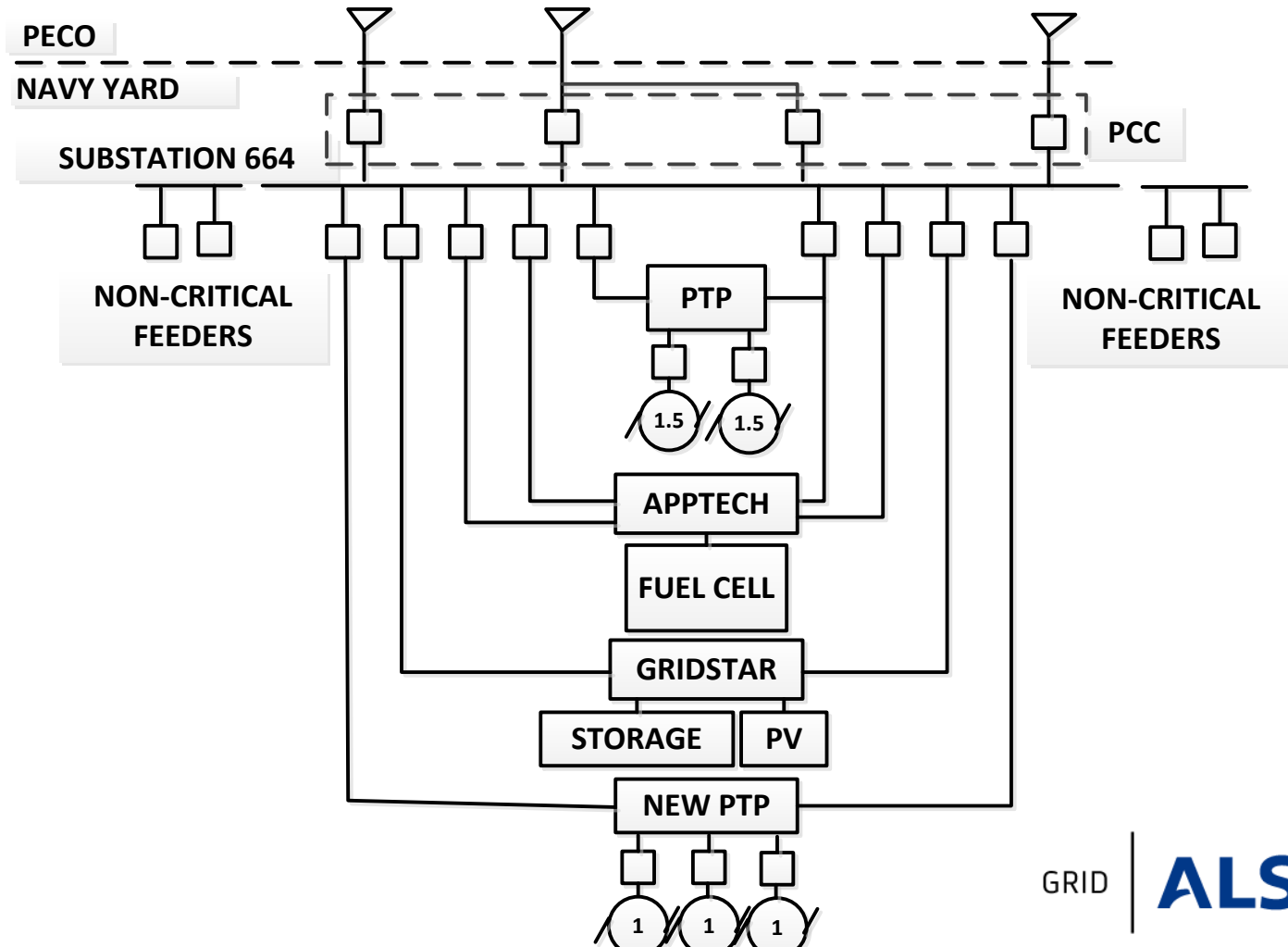
The TNY RD&D and Testing for PIDC Vision and Pathway

The TNY RD&D and Testing for PIDC DOE Objectives

Project / Community Objective	DOE Objective	Project Methodology and RD&SD scope of work	
PIDC service reliability objective support agreement for 100% guaranteed supply to URBAN (3MW load) a C&I Client **PWD service reliability objective** 100% guaranteed supply to waste water plant	*DOE (98%)* *Grid* **Resilience**	**PIDC** -Network 6MW DG and 1 MW solar /storage and support islanded operation **PWD** - Network CHP & BIO-Gas Plant and support islanded operation	RDSD for MG Ops-Planning, Islanding Reconnection Protection DIspatch
PIDC and PWD Sustainability Objective Develop renewable portfolio for local generation and storage as economical viable alternative	*DOE (20%)* *Emission* *Reduction*	**PIDC** –Operate 1 MW community solar / 300 KW storage in the community microgrid **PWD** – Operate Biogas plant together with CHP	RD&D for MG Ops-Planning, Portfolio Dispatch Ops & Control
PIDC Capacity Expansion Objective Develop 20% of local generation as economical viable alternative to meet capacity needs per Energy Master Plan	*DOE (20%)* *System Energy* *Efficiency*	**PIDC** – Optimize import and local generation consisting of 6MW DG, 1 MW solar , 600 KW Fuel cell, 300KW storage, and 3 KW CHP	RD&D for MG Ops-Planning, Portfolio Dispatch Ops & Control

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The TNY RD&D and Testing for PIDC RD&D System: Substation 664 Microgrid

The TNY RD&D and Testing for PIDC
Field Test System: GridSTAR Picogrid

PIDC – The Navy Yard Microgrid System Design

664 SS

Fdr 1392

#2 — EV DEMONSTRATION

#4 — 250KW ENERGY STORAGE SYSTEM

#3 — SOLAR TRAINING

#1 — HOUSE

GridSTAR

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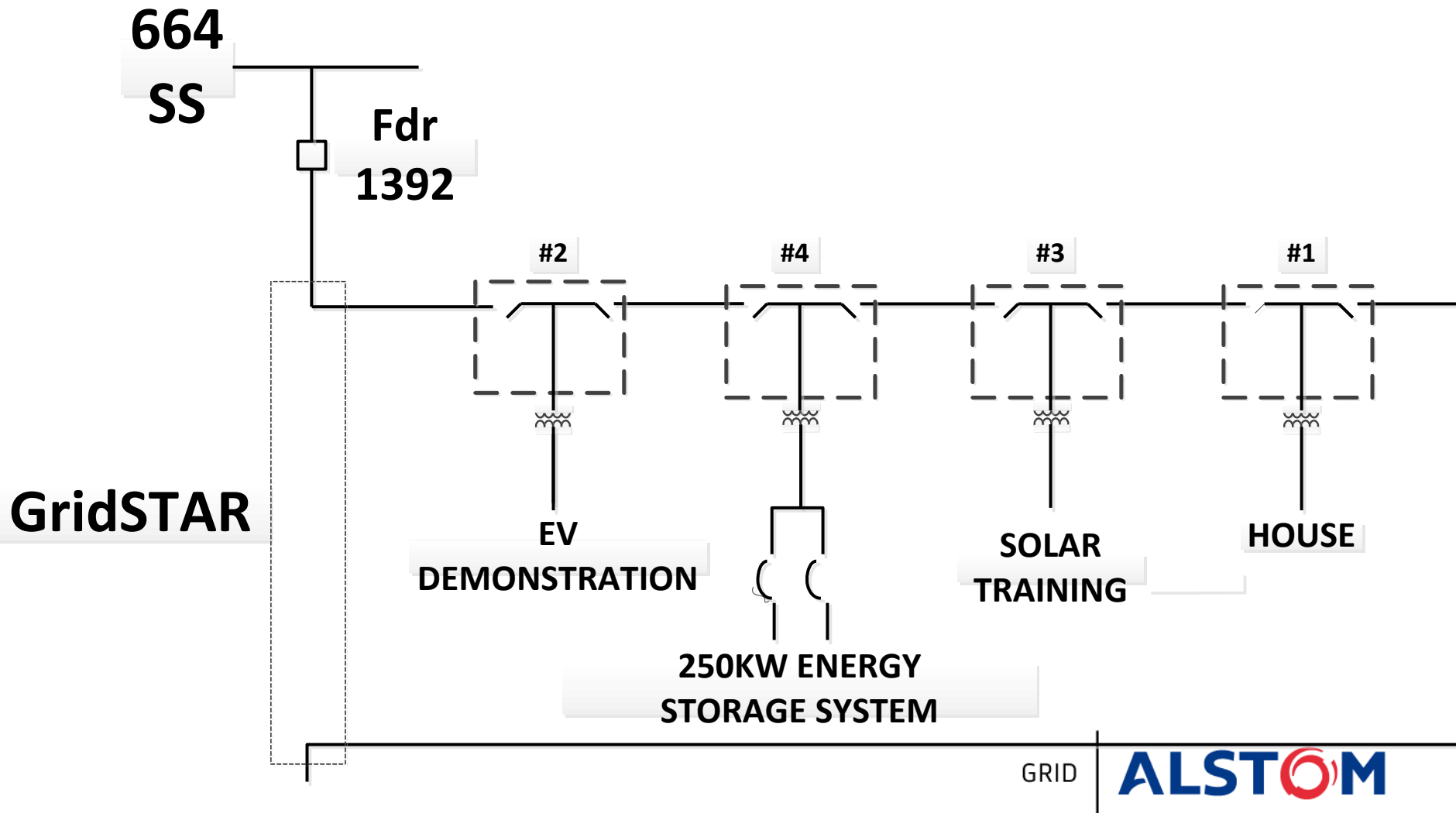# The TNY RD&D and Testing for PIDC Project Objectives

C1: MG Islanding Management Module Based on Voltage & Frequency Ranges

Voltage (V) range in per unit (pu)	Maximum islanding time in seconds (s)	Frequency (f) range in Hertz (Hz)	Maximum islanding time (s)
		f > 60.5	0.16
V < 0.5	0.16	f < {59.8-57.0} (adjustable set point)	Adjustable 0.16 to 300
0.5 ≤ V < 0.8	2		
1.1 ≤ V < 1.2	1	f < 57.0	0.16
V ≥ 1.2	0.16		

C2: MG Resynch & Reconnection Management Module Based on ANSI/NEMA/IEEE 1547

Microgrid rating (MVA)	Frequency difference (Δf, Hz)	Voltage difference (ΔV, %)	Phase angle difference (Δθ, °)
1.5-10	0.1	3	10

C3: Frequency and Voltage Management Module (Islanded Ops) Based on ANSI 84.1-2006

C4: Microgrid Protection Management Module (Islanded Ops) Based on IEEE1547
- **Adaptive Protection for Islanding Ops**
- **Fault Detection & Clearing Islanding Ops**

C5: Microgrid Portfolio Optimization & Dispatch Management

C6: Microgrid – System Simulation - Utility Interface & Grid Resiliency Management

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My Vision and Pathway for Microgrid Development

- **New Types of microgrid:**
  - **DC microgrid**
  - **Hybrid microgrid**

- **Automation**
  - **Sensing: New IEDs (Ex: PMUs and μPMUs)**
  - **Control (Ex: Distributed and coordinated control**
  - **Protection(Ex: Advanced architecture,**

- **New materials development and attendant technologies development will make the difference**

- **If recent past is any indication, the future will be brighter**

- **I am very optimistic though I may not live to see them**

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Conclusion on Workshop

- **Fundamental and long-term research is critically needed if Smart grid development in general and DERMS in particular to succeed**

- **It is gratifying to note that three basic science and technology agencies: NSF, JST, DFG and RCN from four powerful countries is a great continuing effort.**

- **Hopefully, more countries will follow suit in joining this cooperative effort for promoting basic R & D.**

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Summary

- **The focus of my presentation is on "microgrid"**

- **Covered the definition and different types of microgrid**

- **The Navy Yard: A unique microgrid**

- **DOE sponsored project on The TNY microgrid RD&D and Testing**

- **My Vision and Pathway for microgrid development**

- **Conclusion: My dream for Smart, emerging distribution microgrid and grid development will come true!**

- **The international cooperation is like four microgrids becoming one large microgrid !!**

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Thank You !

What questions Do You Have?

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