NESEA™
NORTHEAST SUSTAINABLE ENERGY ASSOCIATION

Islands of Power – Microgrids Enabling Technology for Energy Resiliency

Course Number: BE1534

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Course Description

The purpose of this course is to define the key characteristics of a microgrid, discuss the operational and functional attributes and benefits, offer specific examples of microgrids, and discuss the core drivers, considerations for implementing successful microgrid projects.

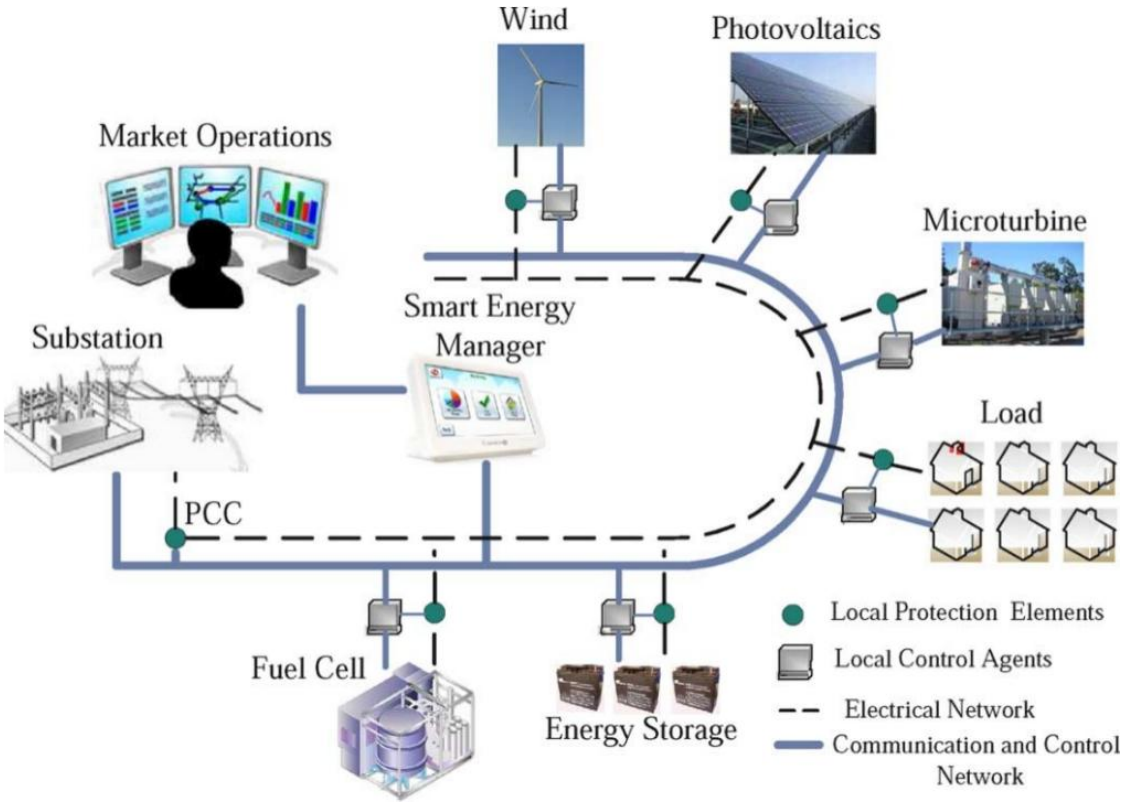
Learning Objectives

At the end of the this course, participants will be able to:

1. Define the key attributes of a microgrid and understand how microgrids relate to the overall energy grid
2. Understand the overall U.S. market for microgrids
3. Discuss examples of microgrid installations – what benefits they are providing and why
4. Understand how and why different types of end use customers pursue and configure migrogrids

What is a Microgrid?

An integrated energy system network consisting of Distributed Energy Resources & multiple electrical loads and/or meters operating as a single, autonomous grid. Can operate either in parallel to or “islanded” from the existing utility power grid. Can interact with the utility’s grid network in real time, and can optimize system performance and operational savings



Microgrid Value Propositions

- **Reduced Cost** – Lower overall delivery costs and less exposure to price volatility
- **Reliability** – Higher quality with less downtime
- **Resiliency** – Security & independence
- **Green Power** – Manage loads to coincide intermittent renewables / optimize efficiency
- **Power System** – Better provisioning of services

Microgrid Definitions

There is no common, agreed upon definition currently for a microgrid. Key stakeholders have defined similarly. Examples:

Uses the term “Distributed Resource Island Systems” – that

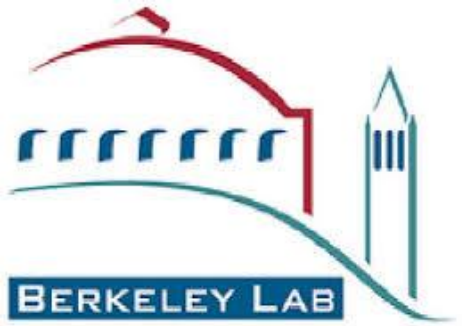
- Have **Distributed Resources** & load
- **Can disconnect** from the area Electric Power Systems (EPS)
- Are **intentionally planned**

Microgrid Definitions

Sandia National Laboratories

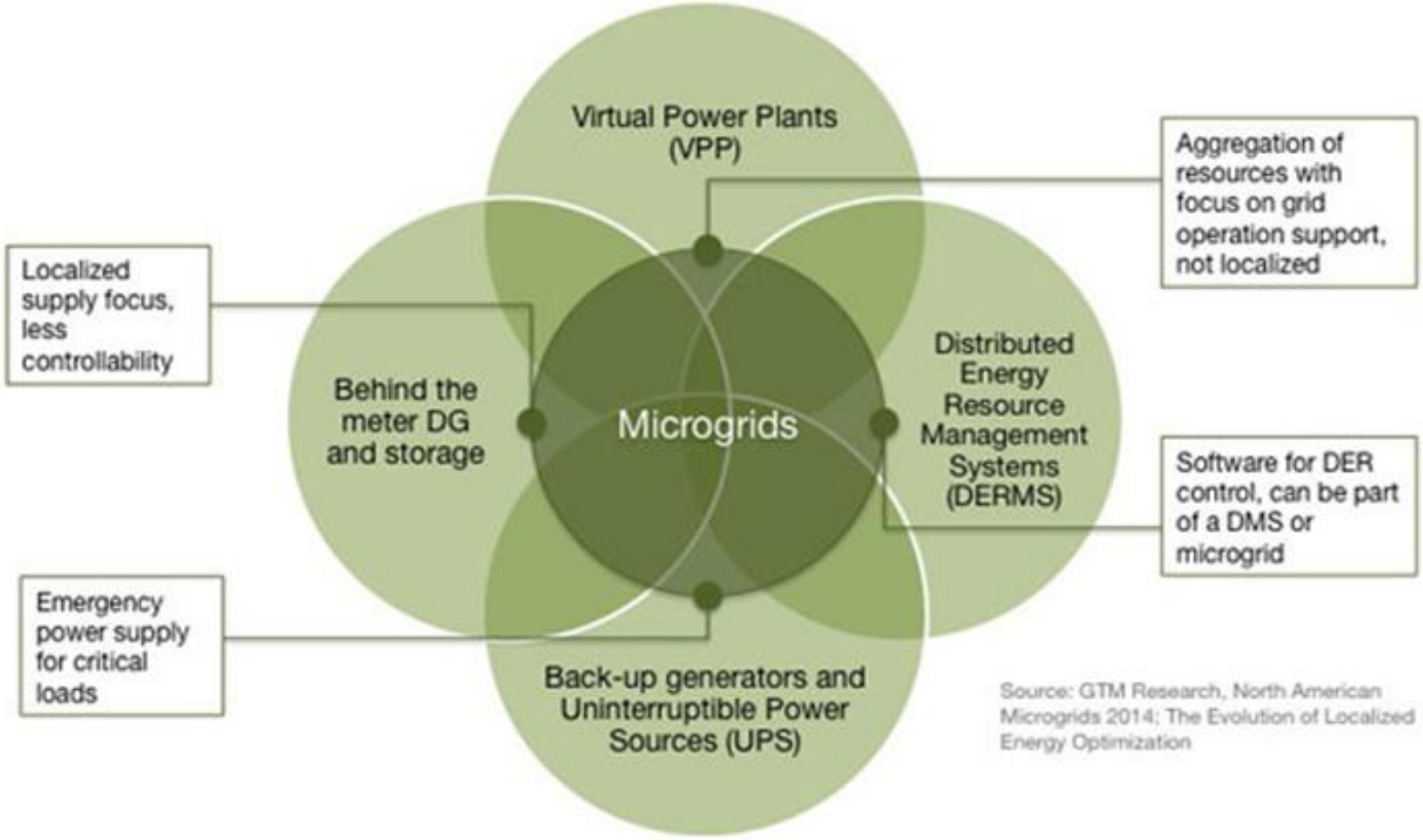
A group of **interconnected loads and distributed-energy resources** within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can **connect and disconnect from the grid** to enable it to operate in both grid-connected or **island-mode**."

Microgrid Definitions



"A localized **grouping of electricity sources and loads** that normally operate connected to and synchronous with the traditional centralized grid (macrogrid), but **can disconnect** and function autonomously as physical and/or economic conditions dictate...have "**islanding**" capability and have the capability to coordinate and **distribute energy** supplied from one or more generation sources to a network of users in a spatially defined area."

How Does a Microgrid Intersect With Other Distributed Resources?



What are the Ownership Models for a Microgrid?

<table>
<tr><th colspan="8">Physical Microgrid</th></tr>
<tr><th colspan="2">Utility</th><th colspan="6">Non-Utility</th></tr>
<tr><th colspan="2">Owns Wires</th><th colspan="3">Own Use</th><th colspan="2" rowspan="2">Own Use w/ Some Merchant Sales</th><th rowspan="2">Merchant Only</th></tr>
<tr><th>Owns Generation</th><th>Non-utility generation</th><th colspan="2" rowspan="2">One Owner</th><th rowspan="2">Multiple Owners</th></tr>
<tr><th>Manages Controls</th><th>May/may not manage controls</th></tr>
<tr><td>VERTICALLY INTEGRATED</td><td>UN-BUNDLED</td><td>CAMPUS 1</td><td>CAMPUS 2</td><td>JOINT OWNER-SHIP / CO-OP</td><td>CAMPUS 3</td><td>JOINT OWNER-SHIP / CO-OP</td><td>INDEPENDENT PROVIDER</td></tr>
<tr><th colspan="8">Virtual Microgrid</th></tr>
<tr><td colspan="4">UTILITY AGGREGATOR</td><td colspan="4">NON-UTILITY AGGREGATOR</td></tr>
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Source: NYSERDA

Microgrid Example: Santa Rita Jail (Alameda County, CA)

- **Needs**: Has 19 housing units for up to 4,000 inmates; the jail needs 3 MW of constant power
- **Costs / Savings** : An $11.7 Million project – saves the jail $100,000 annually on energy costs. Funded through U.S.DOE, CEC PIER; CERTS Microgrid Demo
- **Goal**: Reduce the peak load on the local PG&E (utility) feeder by 15%
- **Distributed Energy Installations**:
  - ✓ 1.2 MW rooftop solar PV system
  - ✓ 1 MW fuel cell power plant with heat recovery for facility hot water and space heating
  - ✓ Five 2.3 kW wind turbines
  - ✓ Two 1.2 MW emergency backup diesel generators
  - ✓ 2 MW advanced energy storage system
  - ✓ 12 kV sub-cycle static disconnect switch
  - ✓ CERTS smart grid control logic

Microgrid Example: UC San Diego Campus

Equipment	
Prime movers	2 Solar Turbines Titan 130 13.5-MW combustion turbine generators (combined cycle)
	1 Dresser-Rand 3-MW steam turbine
Emissions control	Solar Turbines SoLoNO$_x$ (dry low emissions)
Chilled water	Murray-Tuthill steam-driven centrifugal chiller
Thermal storage	3.8 million gallon cold water storage tower from PDM to meet peak cooling needs
Operation	
NO$_x$ emissions level	1.2 ppm annual average (permitted level is 2.5 ppm)
Gross thermal efficiency	70%
Net efficiency	66%
Costs	
Capital cost	$27 million
Avoided electricity purchase costs per year	$8,040,000
Payback (years)	5

The campus can provide 85% of its own energy needs (“islanded”) and the remaining 15% of power provided by SDG&E (utility)

Overview
Building Based Microgrids

- Buildings are building blocks of communities
- Goal: Power Resiliency that pays for itself
- Approach: One building at a time
- Technology
  - Solar PV, Batteries, Generators, Fuel Cells
- Developing Microgrid Projects
- Distributed building microgrids

Buildings of the Future:
Smart Power Plants

THE HUDSON COMPANIES

MHG ARCHITECTS PC
FXFOWLE ARCHITECTS LLP

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Technology – Resilient Power

- Has backup power capability
- Has an attractive payback
- Is environmentally friendly

Combined Heat and Power

Energy Storage

Solar PV

Backup Generator

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Technology – Integration and Smart Controls

- Managing various modes of operation
- Grid-tied vs Island modes
- Reliability and Redundancy

Benecia City Hall – Geli EOS Web Dashboard

Critical Loads in Multifamily Buildings

- Elevators
- Water pumps
- Common area lighting
- Telecom
- Security cameras
- Servers / Computers
- Fire alarm

Water Booster Pumps

Grid Connection

Developing Microgrid Projects Business Model

Building

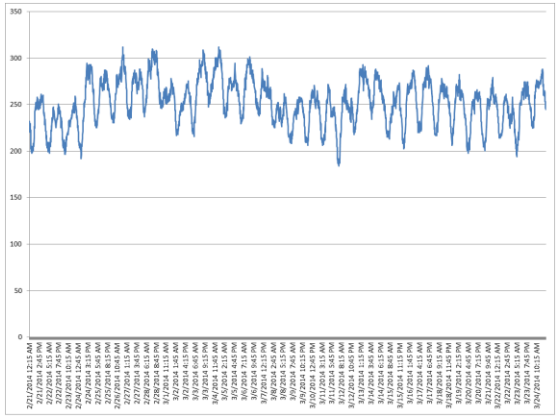
- Peak Shaving
- Backup Power
- Lower consumption
- Incentives

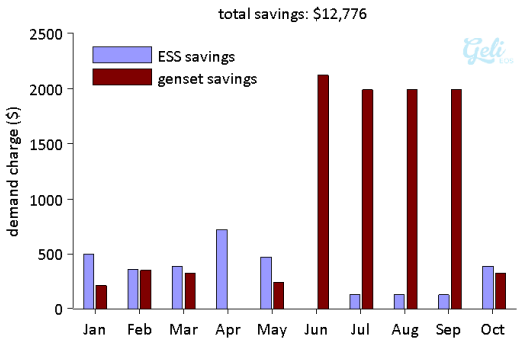
Utility

- Lower System Peaks
- Higher Reliability
- Active Network Management
- Less need for upgrades

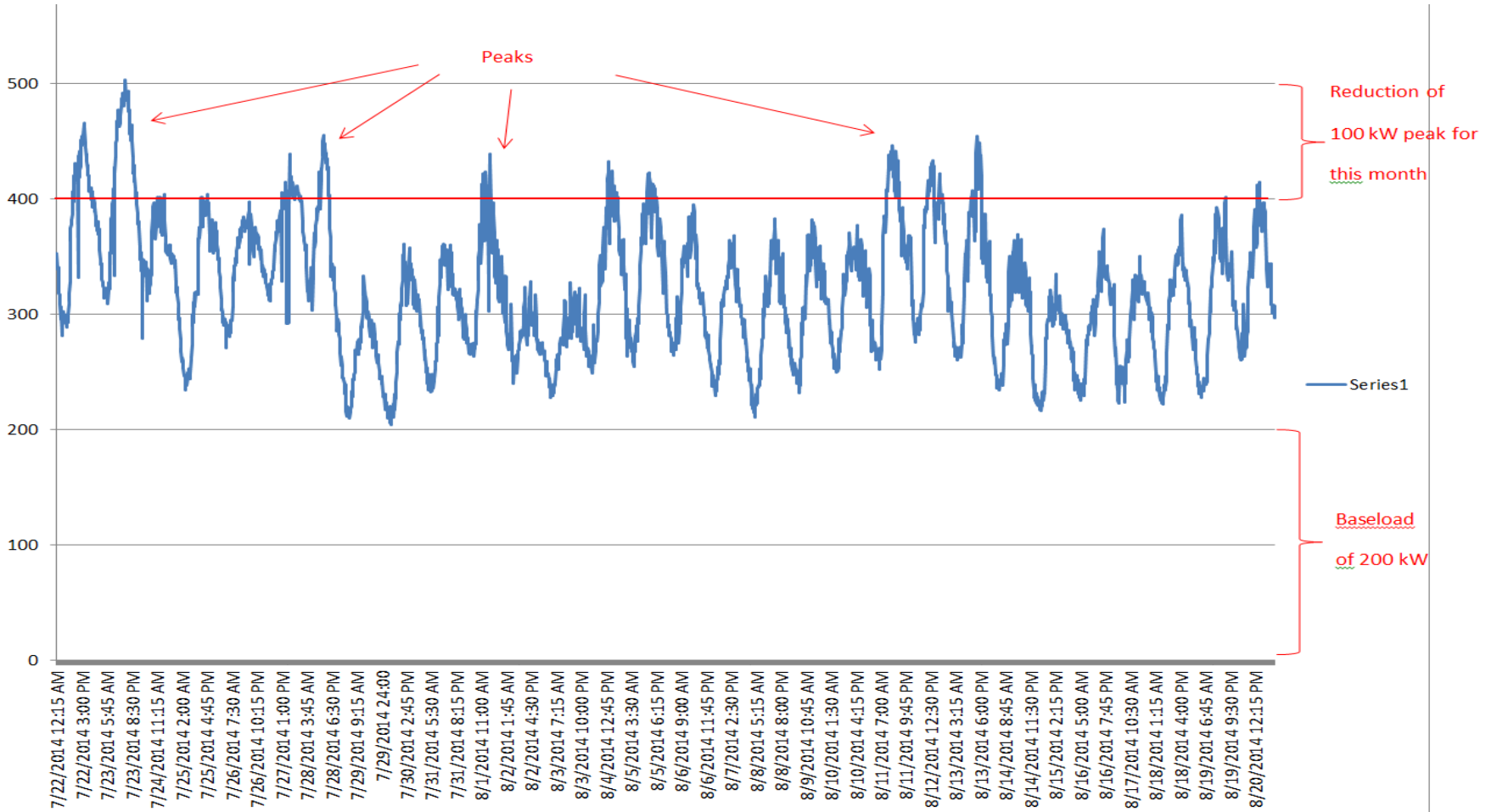
Developing Microgrid Projects Feasibility Study

- Analysis
  - Utility Bills / Interval Data
  - Simulation / Modeling
  - System Sizing
  - Building Plan Review
- Technology Vendors
  - Approved products by AHJ's
  - Commercially available / Track record
- Project Specification for Pricing
  - Drawing Set / Book Specs





Developing Microgrid Projects
Interval Data



Developing Microgrid Projects
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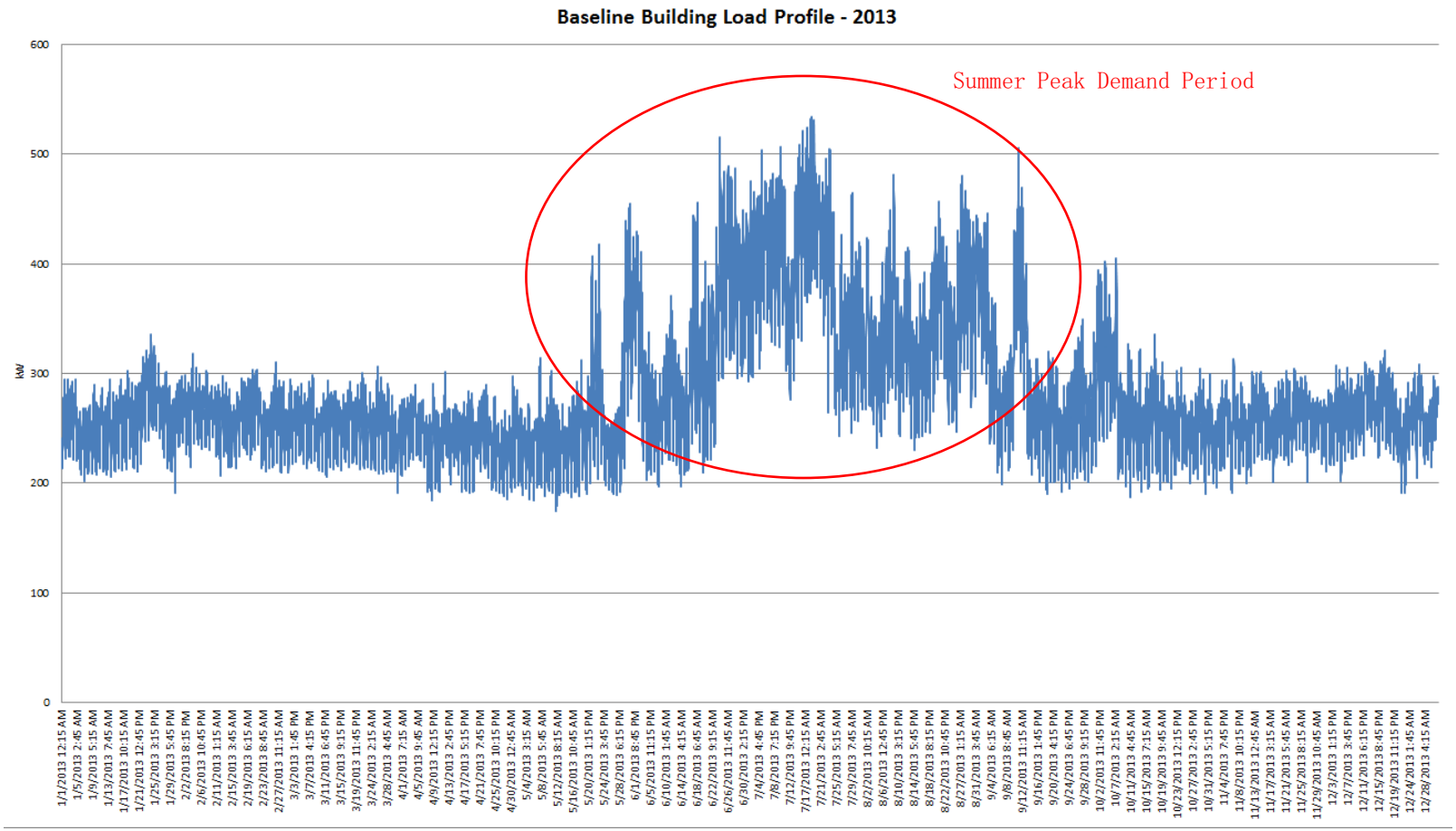


Resilient Solar Project
Via Verde

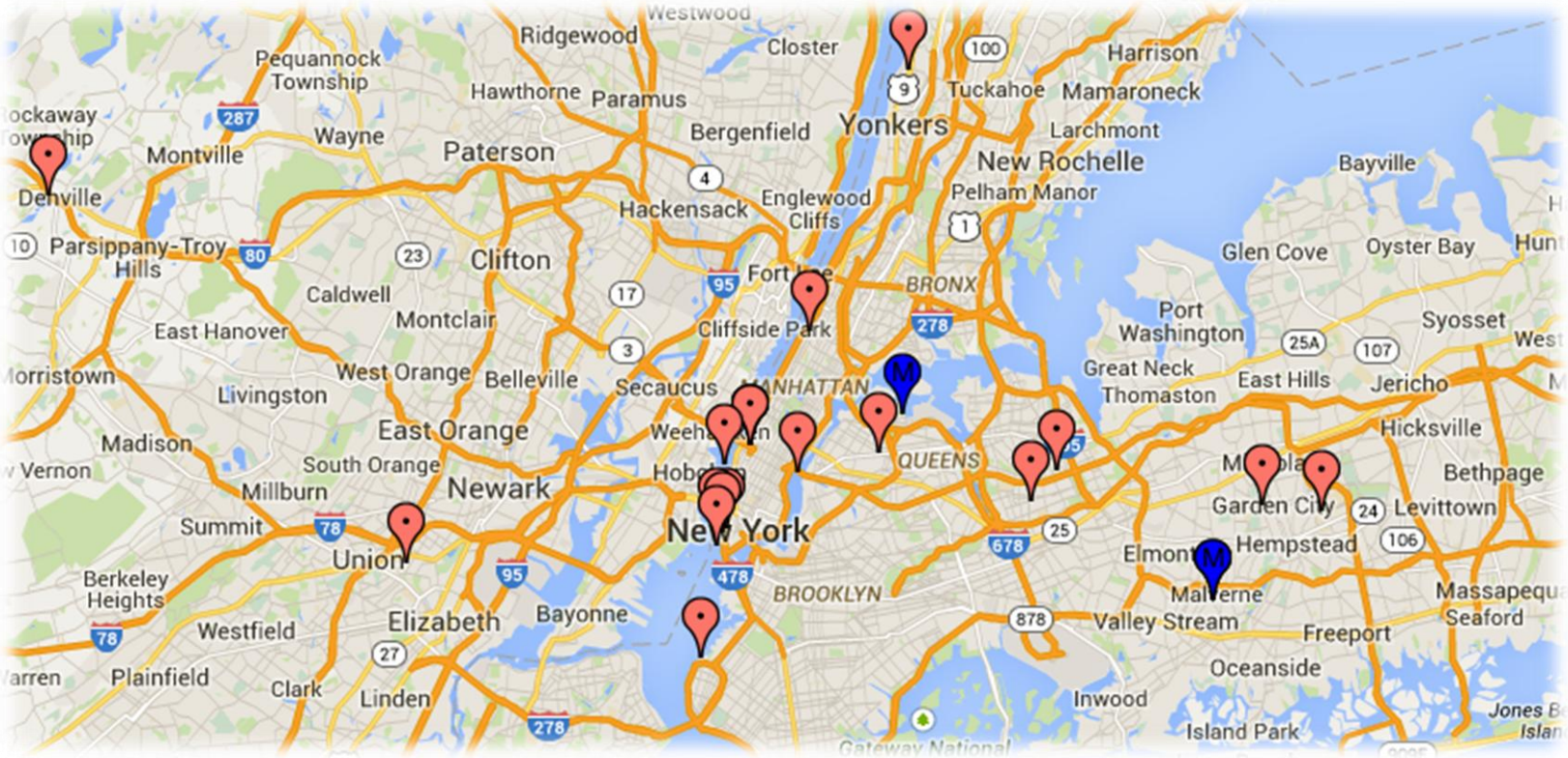
- **66 kW Solar PV Array, built in 2012**
- **No energy storage**
- **Emergency Generator on site**

CODA Core™ Tower (left),

Princeton Power 30 kW Inverter (middle),

Cummins Automatic Transfer Switch (right)

Grid-Tied Battery Projects in New York City



DOE GLOBAL ENERGY STORAGE DATABASE

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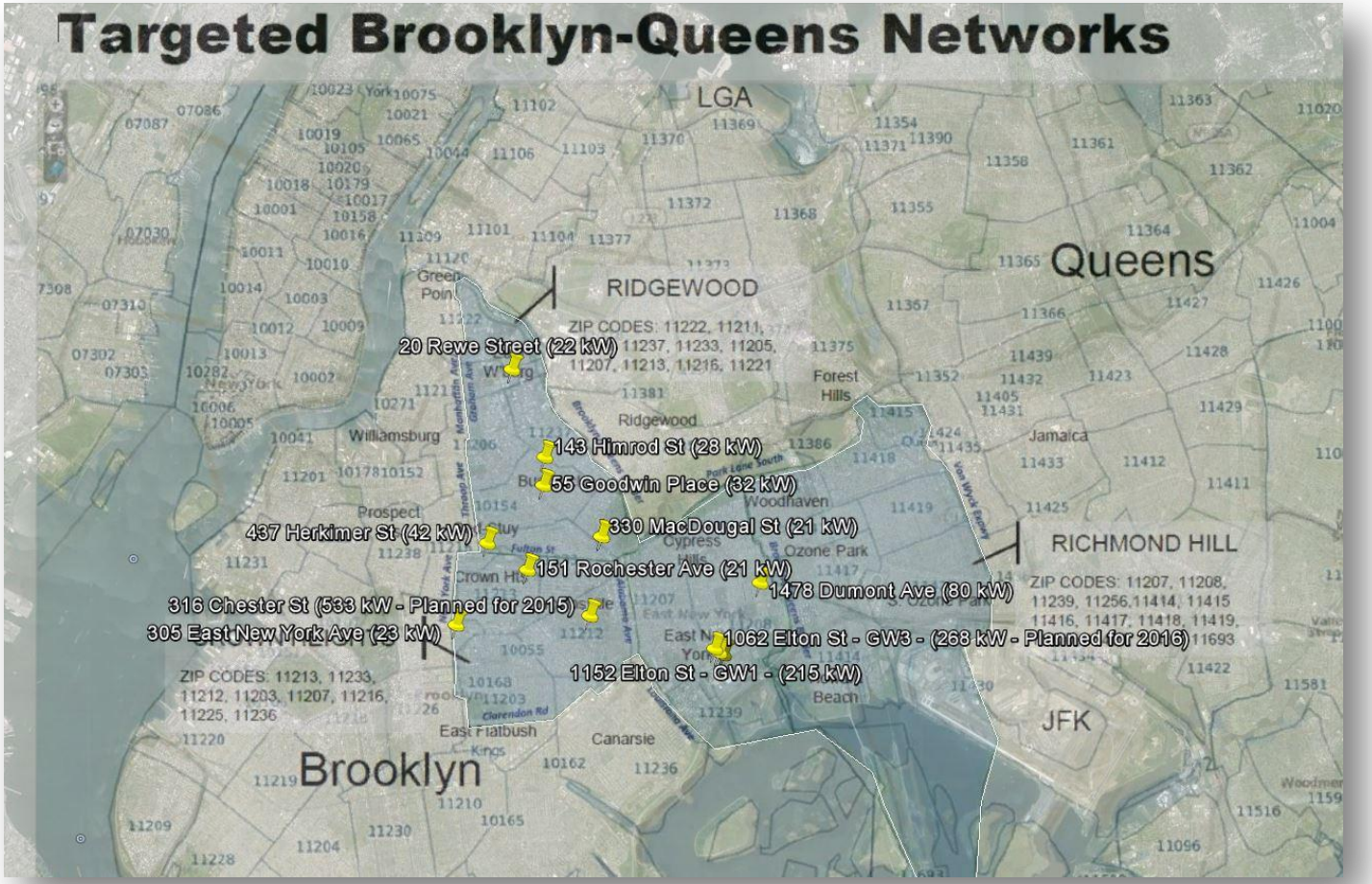
Reforming the Energy Vision (REV)
BQDM Overload Relief



Creating Resilient Communities

- Bringing together stakeholders
  - Building Owners
  - Utilities / Government
  - Project Developers
- Enabling Technology
  - Resiliency
  - Savings
  - Integrated
  - Smart

State Microgrid and Resiliency Programs

- Connecticut Department of Energy and Environmental Protection (CTDEEP) – Microgrids Program – 11 project grants, $23 million awarded
- California Energy Commission (CEC) – Demonstrating Secure, Reliable Microgrids and Grid-linked Electric Vehicles to Build Resilient, Low-Carbon Facilities and Communities – 10 project grants, $27 million awarded
- Maryland Energy Administration – Game Changer Awards – Konterra Solar + Storage Microgrid – $250,000 awarded (total project cost of $2.5 million)
- New York State Energy Research and Development Authority (NYSERDA) – NY Prize Community Grid Competition – Up to $40 million available
- New Jersey Energy Resilience Bank (ERB) – Up to $200 million available

The Massachusetts Perspective
Climate Preparedness: Top EEA Priority

"We need to do more to address the extreme threats from climate change…We must properly assess the risks and vulnerabilities, plan for them and ensure our emergency services have the ability to keep our residents safe. And we must take action to protect our natural habitats to maintain healthy communities."

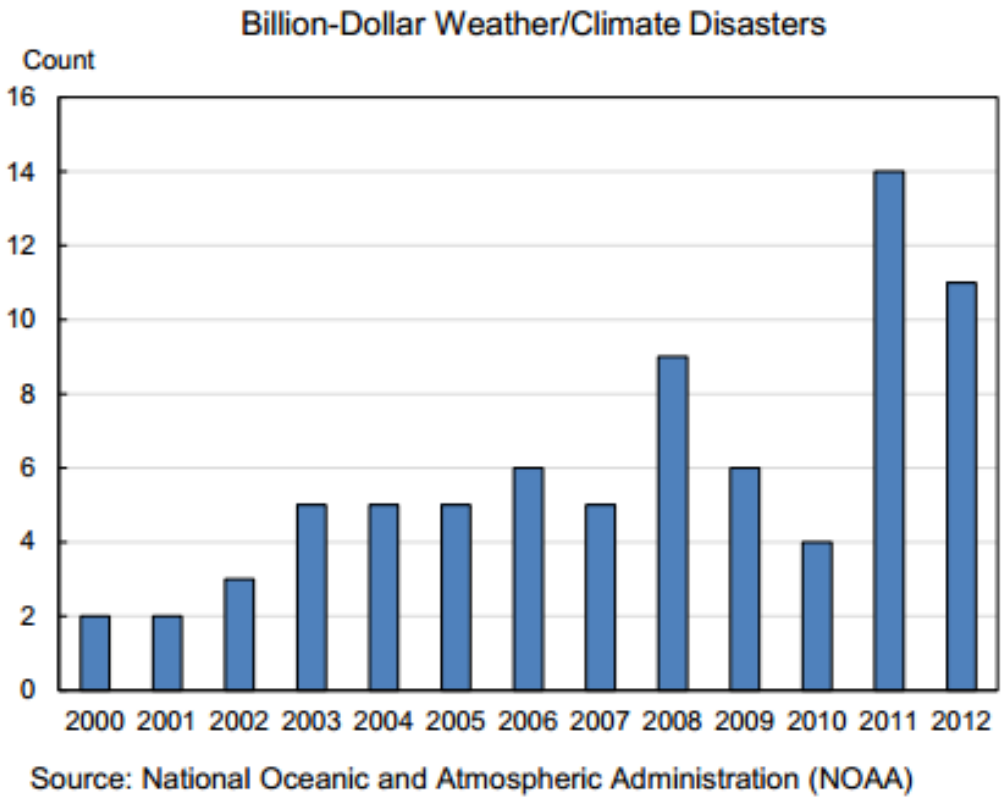
Governor Deval Patrick

July 24th, 2013

(Photo: Eric Haynes/Governor's Office)

A Multi-Dimensional Strategy

- **The Goal**: Prepare for climate change and the increasing incidence of severe and costly weather events
- **The Approach**: Invest in new technologies to increase energy infrastructure resiliency and reliability
- **The Climate Preparedness Initiatives**: $52M in climate change initiatives announced in January 2014



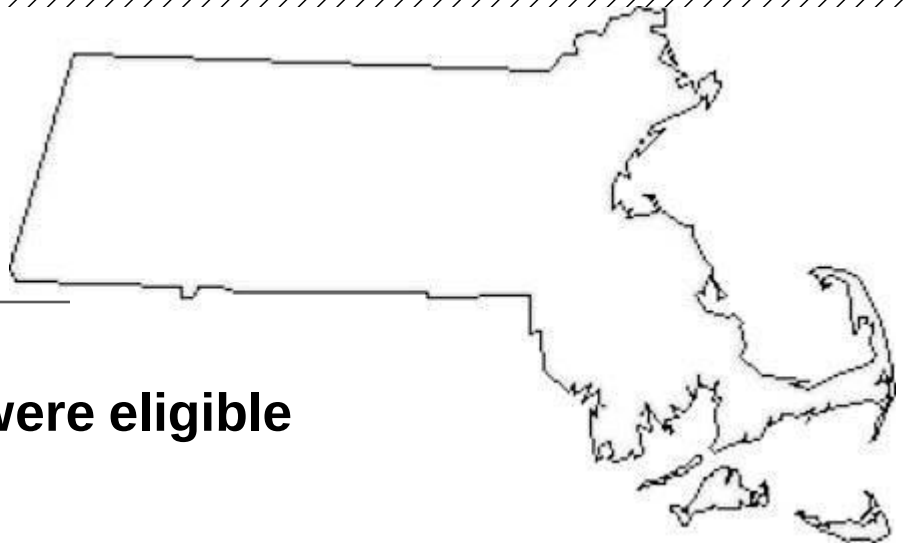
Coordinated Climate Preparedness Initiatives

- **EEA with NEPGA** – Identifying resiliency efforts at generation facilities
- **DPU** – Grid modernization
- **CZM, $10M** – Coastal infrastructure projects
- **DCR with MassDOT, $2M** – Assessing transportation vulnerability
- **DOER with Governor's Military Task Force** – Evaluating clean energy opportunities at military bases
- **DOER, $40M** – Community Clean Energy Resiliency Initiative

Community Clean Energy Resiliency Initiative

- $40 million municipal grant program
- Energy resiliency at critical facilities using clean energy technology
- Round 1 awards were available for Technical Assistance or Project Implementation
- Round 2 awards were available for Project Implementation

Eligible Applicants



All Massachusetts municipalities were eligible

- Single municipality
- Joint applications by multiple municipalities
- Regional Planning Agencies
- Regional districts (water, wastewater, school, etc)
- Public/private partnerships

Eligible Critical Facilities

Critical facilities = *"buildings or structures where loss of electrical service would result in disruption of a critical public safety life sustaining function"*

Critical facilities could include:

1. Life safety resources
2. Lifeline resources
3. Community resources

Eligible Clean Energy Technologies

- Projects including:
  - Clean energy generation
  - Energy storage
  - Energy management systems
  - Technology used for DG operation in island mode
- Single building facilities or microgrids

Application Types: Technical Assistance

An overview:

- Available at no cost to awarded applicants
- Provided by a consulting team – The Cadmus Group with MCFA and HOMER Energy
- Awarded applicants had the opportunity to use the resulting plan to apply for a follow-up round of project implementation funding

By the numbers:

- 27 applications received, July 15, 2014
- 27 awards made, July – August 2014
- All 4 regions of the Commonwealth supported
- 43 stand-alone facilities analyzed
- 5 microgrid configurations analyzed
- 27 Technical Assistance reports completed October 2014

Technical Assistance Awards

Applicant	Facility	Technology
ABRSD	High School - Shelter	Biomass heating/ CHP/PV/Storage
ABRSD	RJ Grey Junior High School - Shelter	Biomass heating/ CHP/PV/Storage
Acton	Public safety building	PV/Battery
Acton	Department of Public Works	PV/Battery
Amherst/UMass	Microgrid: Wastewater treeatment plant, Fire Station, Champion Center	CHP/PV/Battery
Andover	Water treatment plant	NG Turbines
Andover	Senior Center - Shelter	CHP/Absorption Chiller
Barnstable	Middle School - Shelter	CHP
Beverly-MAPC	Regional emergency supply cache site	PV/Battery
Boston	Microgrid: Boston Medical Center	CHP
Boston	Madison Park High School - Shelter	CHP/PV/Battery
Cambridge	Sulivan water treatment plant	PV/Battery
Cambridge	Cambridge Rindge & Latin School	CHP/PV/Battery
Chicopee	Safety Complex	CHP/PV/Battery
Chicopee	Wastewater treeatment plant	CHP/PV/Battery
CVEC	High School - Shelter	PV/Battery
Falmouth	High School - Shelter	PV/Wind/Battery/CHP
Greenfield	Wastewater treeatment plant	AD/CHP or Gas Turbine
Greenfield	High School - Shelter	PV/Battery
Holyoke	Dean School - Shelter	PV/Battery
Holyoke	Fire Station	PV/Battery
Holyoke	Mt. Tom Tower	PV/Battery/Wind
Lawrence	Water treatment plant	PV/Battery
Leverett	Public safety building	PV/Battery

Applicant	Facility	Technology
Leverett	Elementary School - Shelter	PV/Battery/Biomass CHP
Lincoln-MAPC	Public safety building	PV/Battery
Medford	Medford City Hall	PV/Battery
Medford	Department of Public Works	PV/Battery
Medford	Andrews School - Shelter	PV/Battery
Melrose	Microgrid: City Hall, Main St. Fire Station, Memorial Hall - Shelter	PV/Battery (solar canopy)
New Bedford	High School - Shelter	CHP/PV/Storage
New Bedford	City Yard	Interconnect w/ High School
New Bedford	Hillman Complex	CHP/PV/Storage
Newton	Waban Comms Facility	PV/Storage
Newton	City Hall	PV/Storage
Northampton	Microgrid: High school - shelter, Department of Public Works, Hospital	CHP/PV/Battery
Sandwich	High School - Shelter	CHP/PV/Battery
Sandwich	Emergency Operations Center	PV/Battery
Saugus	Senior Center - shelter	PV/Battery
Saugus	Public safety building	PV/Battery
Scituate	Public safety building	PV/Battery
Shirley	Police Department	Biomass/PV/Battery
Somerville	Public safety building	PV/Battery
Somerville	Early Childhood Center	CHP/PV/Battery
Somerville	Department of Public Works	PV/Battery
Wayland-MAPC	Middle School - shelter	PV/Battery
West Boylston	Microgrid: 3x schools, DPW, Fire Dept., Library	Fuel Cell

Application Types: Project Implementation Round 1

An overview:

- Required to meet specific project threshold criteria
- Projects could be retrofit or new install

By the numbers:

- 9 applications received, July 15, 2014
- 6 awards totaling $7.4m made September 25, 2014
- 4 applications to be reconsidered in the second round
- Deadline – November 10, 2014
- 3 regions of the Commonwealth supported
- 8 stand-alone facilities considered
- 1 microgrid configuration awarded

Round 1 Project Implementation Awards

Applicant	Project Title	Grant Amount	Brief Description	Factility(ies)	Technology(ies)
Berkley and Taunton	**Taunton/Berkley Community Microgrid**	$ 1,455,000	Community microgrid	(1) Middle School - shelter (2) Emergency Services Building - Police and Fire (3) Community School - shelter (4) Municipal fueling station/pump (5) Police/fire radio repeater	- Energy management system - Lithium Ion battery - Solar PV (existing) - Diesel generators (existing)
Boston	**Solar PV with Battery Storage for select Boston Community Centers**	$ 1,320,000	Solar and storage based islandable community shelters	(1) Shelburne Community Center - shelter (2) Roslindale Community Center - shelter (3) Tobin Community Center - shelter (4) Curtis Hall Community Center - shelter	- Solar PV - Battery storage
Greater Lawrence Sanitary District	**Organics to Energy Upgrade Project**	$ 611,000	Islandable and black start capable self-sustaining wastewater treatment facility	(1) Wastewater treatment facility	- Biogas storage - Combined heat and power system - Anaerobic digestion (existing)
Northampton	**Batteries and PV Islanding Capability for Fire HQ**	$ 525,401	Solar and storage based islandable fire station, that incorporates existing backup generation for further resiliency	(1) Northampton Fire Department	- Solar PV - Battery storage - Diesel generators (existing)
South Essex Sewerage District	**Combined Heat and Power Facility**	$ 700,000	Islandable and black start capable combined heat and power facility at wastewater treatment facility	(1) Wastewater treatment facility	- Combined heat and power system
Springfield	**Baystate Health Cogeneration Project**	$ 2,790,099	Islandable and black start capable combined heat and power facility at regional hospital	(1) Baystate Health - hospital	- Combined heat and power system
Total		**$ 7,401,500**			

Application Types: Project Implementation Round 2

An overview:

- Applicants were required to either:
  - have received first round technical assistance ,or
  - be submitting revisions to first round project implementation applications

By the numbers:

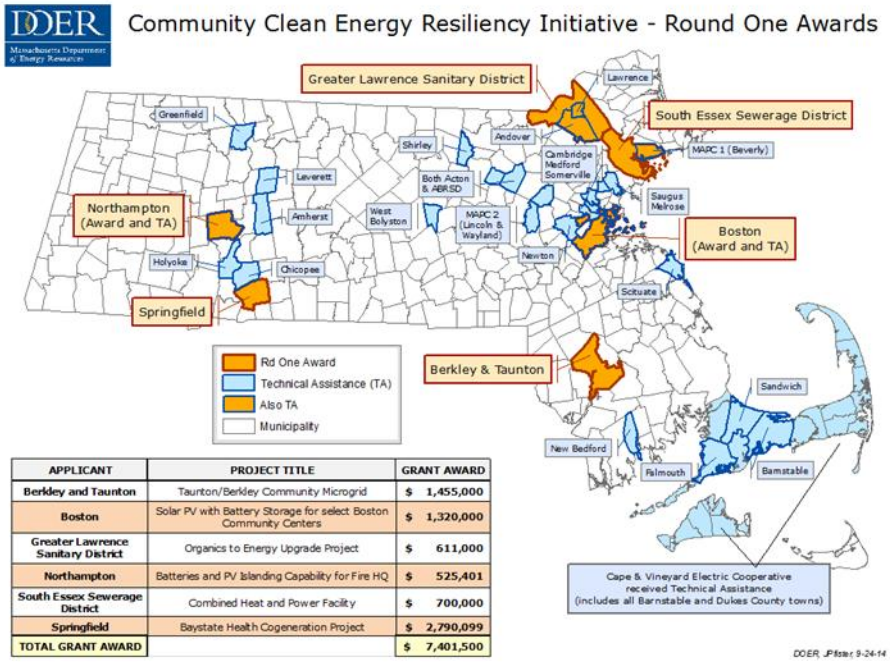
- 13 applications received, November 10, 2014
- 13 awards totaling $18.4m made December 29, 2014
- All 4 regions of the Commonwealth supported
- 13 stand-alone facilities awarded
- 3 microgrid configurations awarded

Round 2 Project Implementation Awards

Applicant	Project Title	Grant Amount	Applicant	Project Title	Grant Amount
Barnstable	Cogeneration Plant at Barnstable Intermediate School	$ 406,000	Holyoke	Resiliency at Holyoke Facilities - Fire HQ, Mt. Tom Tower, Dean School	$ 1,013,794
Boston	BMC Menino Campus CHP Plant Project	$ 3,680,000	MAPC - Beverly	Energy Resiliency at Beverly Regional Cache Site	$ 526,180
Cambridge	Cambridge Water Supply Resilience	$ 851,868	MAPC - Wayland	The MAPC Solar Resiliency Project	$ 264,627
Chelmsford	McCarthy Middle School, Emergency Power Generation	$ 74,941	Medford	Medford Resiliency Project	$ 833,366
Cape & Vineyard Electric Cooperative	Dennis-Yarmouth High School Regional Shelter	$ 1,479,193	Northampton	Micro-grid with island-able PV at Smith Vocational and Agricultural High School, Northampton DPW and Cooley Dickinson Hospital	$ 3,078,960
Greater Lawrence Sanitary District	Organics to Energy	$ 4,389,000	Sterling	Implementing a Resiliency Plan through Clean Storage for a Municipal Microgrid	$ 1,463,194
Greenfield	Greenfield Resiliency Plan for High School	$ 367,310	Total		$ 18,428,433

Program Achievements

- Geographic diversity among applicants
- Wide range of facilities and technologies considered
- Single facility projects and microgrid configurations
- Projects demonstrating daily benefits and ability to island, operate and provide resilient support during an outage



APPLICANT	PROJECT TITLE	GRANT AWARD
Berkley and Taunton	Taunton/Berkley Community Microgrid	$ 1,455,000
Boston	Solar PV with Battery Storage for select Boston Community Centers	$ 1,320,000
Greater Lawrence Sanitary District	Organics to Energy Upgrade Project	$ 611,000
Northampton	Batteries and PV Islanding Capability for Fire HQ	$ 525,401
South Essex Sewerage District	Combined Heat and Power Facility	$ 700,000
Springfield	Baystate Health Cogeneration Project	$ 2,790,099
TOTAL GRANT AWARD		$ 7,401,500

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Lessons Learned

- Learn from and share with as many people as possible
  - Throughout program development and implementation
- Develop clear goals and program design
  - Prioritized critical facilities
  - Clean energy technology
  - Technical assistance support and/or direct project implementation
- Provide as much information as possible to applicants
  - Webinars
  - Extensive Q&A
- Technical assistance where needed
  - Get from interested to ready to apply for funding
- Flexibility in project implementation
  - Phased contract approach
  - Milestone funding disbursements

Speaker Contact Information

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