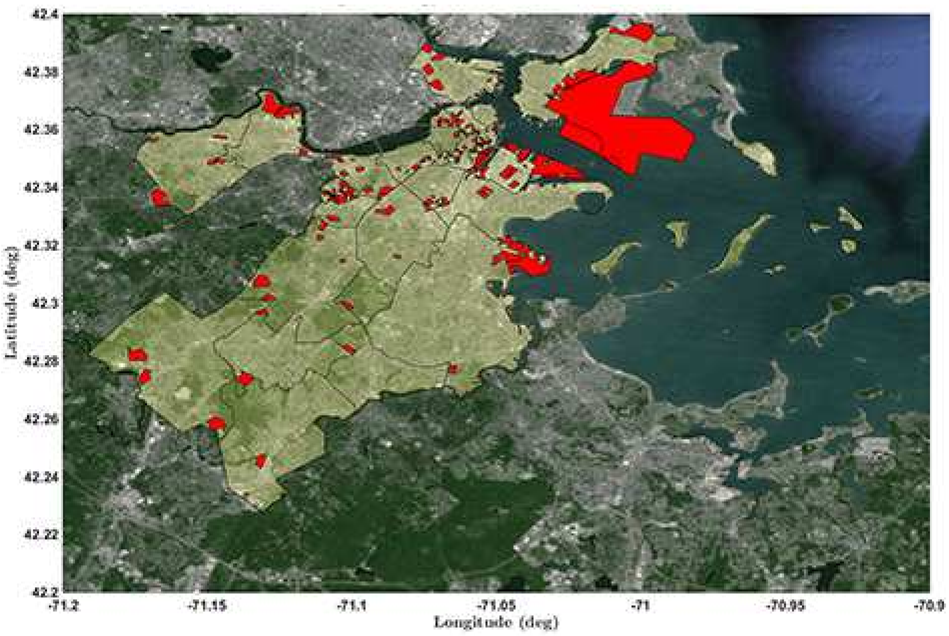
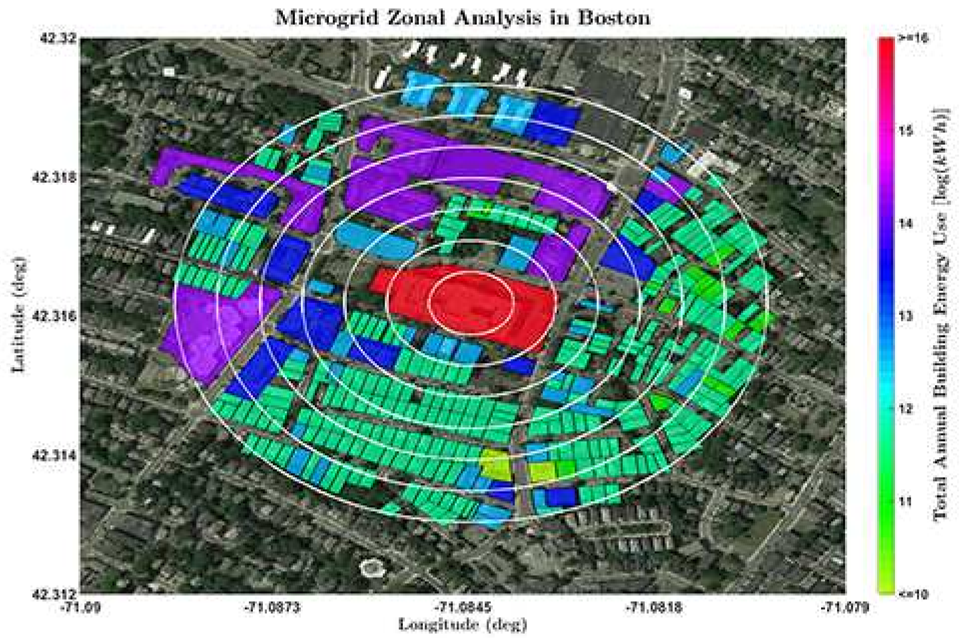
http://www.ll.mit.edu/news/MITLL-studies-microgrid-design-for-Boston.html

MIT Lincoln Laboratory investigates the potential for a microgrid design for Boston



A study conducted with the Boston Redevelopment Authority explores options for improving the resiliency of the city's power distribution system.

by Jacob Solomon | Technical Communications Group



In 2012, New York City sustained $19 billion in damages attributed to Hurricane Sandy. Much of this pricetag went to repairs to the city's energy infrastructure, but loss of power resulting from the damages to the energy distribution system led to consequent costs, such as lost business and productivity, increased demand for emergency social services, and ruined food and pharmaceuticals. Because the areas that were most successful in retaining power were those supported by energy microgrids, many states have begun to look at microgrid strategies to improve the resilience of their energy distribution systems to large-scale disasters.

Microgrids, which are localized power grids with the ability to disconnect from the larger energy grid, offer improved resilience to disruptions and have the potential for increasing efficiency by exploiting combined heat and power (CHP) systems that reuse heat produced by the power generation process. Recently, MIT Lincoln Laboratory staff collaborated with the Boston Redevelopment Authority (BRA) to complete the Boston Community Energy Study, a starting point for an investigation into a potential resilient power system design for Boston.

Map of anchor buildings in BostonAn early step in determining feasible locations for microgrids is discovering the areas in which energy usage is highest. The goal at this stage is to identify an "anchor building" for a microgrid. The anchor building is one that demands enough energy to justify the investment in local infrastructure upgrades for establishing a microgrid. The areas in red above are the top 2% of Boston land parcels (about 500 parcels) in terms of total annual energy use.

This figure shows a sample potential microgrid zone, with the anchor building situated in the center. Concentric rings, indicating high to lower energy usage by the shading from red to light green, emanate out from the center point at increments of 50 meters. The buildings that fall within the rings are considered for analysis as opportunities for utilizing CHP systems.

"There are myriad benefits that stem from integrating microgrids into Boston," said Eric Morgan, a member of the Laboratory's Energy Systems Group who utilized his previous experience with microgrid analysis in his role as technical lead of this energy study. "First, microgrids can decouple from the larger utility grid and operate autonomously, making them more resilient to large weather events. Second, when electricity generation and consumption are co-located, as with many microgrids, there is an opportunity to utilize the waste heat (i.e., the byproduct of energy generation) within neighboring buildings for hot water, heating, or even cooling." A CHP system that makes use of waste heat produces two energy products from a single fuel source, effectively doubling fuel efficiency.

While assessing new resilience strategies, the BRA identified a gap in the data on the energy usage of small buildings, and even some commercial buildings, in Boston. To address this deficit, the BRA asked the MIT Sustainable Design Lab (SDL) to generate a map of simulated energy usage for each building during every hour of the year. The SDL used datasets about building age and type, provided by the City of Boston, to produce thermal and electrical use estimates of 85,000 buildings. The resulting dataset from SDL was the first of its kind, including temporal resolution and data on the types of energy being used. "The SDL data was leveraged extensively for this study," said Morgan.

Using the simulated data from SDL, Morgan developed an algorithm that could determine feasible sites for microgrids. The study team considered social welfare factors in evaluating sites for the microgrids; these important factors were handled by Cheryl Blomberg: "I took into account places that are deemed critical to keep functioning in the event that the energy infrastructure did go down, such as hospitals, grocery stores, gas stations, and places of refuge, and made microgrids that stemmed from there."

Ultimately, the team identified 22 potential microgrid sites, split between three distinct types: ten multiuser microgrids to deliver power to mixed-use buildings from an anchor building; ten energy justice microgrids to service affordable housing buildings; and two emergency microgrids to supply power to places that would provide food, warmth, and water during disaster events. Some of the sites are now being further investigated at a more granular level in order to better analyze where and how microgrids should be built out.

Map of 22 proposed sites for microgrids in Boston The map shows 22 sites that were studied as possible locations for microgrids, color-coded for the three types of microgrids the study team determined would provide for the needed services in the event of a serious disruption to the main electric grid. (Click on image for larger view.)

Stephen Valentine and Victoria Dydek drew upon Morgan's data analysis and location assessments to ascertain the technology needs (e.g., heating and cooling systems, control systems, computers), the financial costs, and the CO2 savings for each microgrid site.

To develop these site assessments, Valentine and Dydek used the Distributed Energy Resources Customer Adoption Model (DER-CAM), a decision support tool for distributed energy systems. Designed by Lawrence Berkeley National Laboratory and adapted by Valentine for this specific case, DER-CAM uses three types of input data: energy usage statistics, economic constraints (e.g., energy pricing, site construction costs, operation and maintenance costs), and environmental factors (e.g., outside air temperature, solar effects) to recommend an optimal site selection and the dispatch of available energy-generation technologies. "DER-CAM is programmed to make site recommendations that minimize cost and/or greenhouse gas emissions," said Valentine.

As program manager for the study, Erik Limpaecher, assistant leader of the Energy Systems Group, connected Lincoln Laboratory with not only the BRA but also the agencies and people with a strong interest in Boston's energy resilience. According to Morgan, "The study brought together many different stakeholders, including the City of Boston, the gas and electric utilities, policymakers, and the public, in order to foster energy infrastructure innovation within the region." This first-ever city-scale study of microgrids estimated that the 22 potential microgrids could realize $1 billion in financial and environmental savings over the next two decades. That estimate is a definite encouragement for future investigations into microgrids, and not just in Boston.

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top of page

http://boston.maps.arcgis.com/apps/MapSeries/index.html?appid=33c30cb10c294edabf30da51141893cf

The foundational data for this Study are simulated energy demand for every structure in Boston. These data had to be created via simulation, as customer-level energy use data cannot legally be shared for each property in the City. MIT Sustainable Design Lab created energy use data for each building including hourly demand data for lighting, plug loads, heating, cooling, and hot water. Some parcels were exclude due to missing property data.

Click the map to see the annual energy use data.

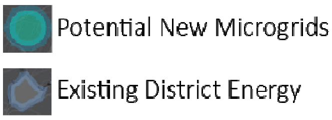
Watch the video produced by MIT Sustainable Design Lab to learn more about the simulation process.

Visit the Website to learn more about the Study | Sign up to receive updates on the forthcoming **Report and Webinar!**

Potential for Local Generation, District Energy and Microgrids

The map shows potential new areas for local generation, district energy and microgrids in Boston. Click to see the simulated, baseline cost of energy for all buildings in a district. [Download the report to learn more.]

New and Existing Districts



Interactions between Potential and Existing District Energy and Microgrids

For Districts that overlap with existing district energy systems: These potential districts can take advantage of the existing Veolia Steam system. Technologies that may compliment the steam system include district cooling infrastructure, large scale absorption cooling, thermal and electric storage, and renewable energy supply.

For Districts that are adjacent to existing district energy assets: Hypothetical districts near the Longwood Medical Area and near Boston Medical Center are adjacent to existing district energy systems . There may be opportunities to expand adjacent district energy infrastructure into the districts identified here.

For Districts that are isolated from existing district energy systems: Hypothetical districts in most neighborhoods of Boston that are isolated from existing district energy systems . These districts would be starting from scratch and require building retrofits, road excavation, and a central plant for local generation and energy storage technologies. Since these zones do not abut existing district energy assets, a deeper analysis would be required to understand building retrofit costs and available land.

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Community Solar Potential

Community Solar is defined as a solar-electric system that is owned, invested in, or benefits an entire community. This map identifies districts that are suitable for Community Solar projects based on a high density of rooftop solar potential. Boston building owners can already explore online maps to identify rooftop solar potential; however, few solar maps identify Community Solar potential. This analysis examines potential for large-scale solar projects with a minimum 500 kW of solar production potential.

To learn more about the emerging trend of community solar - visit the [US. Department of Energy website for Community and Shared Solar](#).

Critical Facilities

These districts center around concentrations of critical facilities. These facilities include health and shelter facilities, grocery stores and food warehouses, and critical infrastructure such as cell phone towers and gas stations.

The districts in blue were selected by an analysis of the most dense clusters of critical facilities, supported by the Homeland Security Infrastructure Program Gold Database. [link](#)

Boston’s hospitals are already equipped with resilient power systems, and Emergency Microgrids aim to identify similar energy security opportunities in Boston’s neighborhoods.

Critical Facilities within the Emergency Microgrids :

Buildings that include affordable housing, 88
Emergency Shelters, 16
Gas/Electric assets (substations, gas stations), 24
Pharmacies, 30
Supermarkets, 14
Boston Center for Youth and Families facilities, 9
Hotels / Motels, 8
Libraries,14
Malls, 1
Museums, 2
Public Schools, 3
Public good Shelters (homeless shelters, etc), 14

Optimized for Cost Savings

The map shows potential new areas for district energy and microgrids in Boston. Click the districts to see the engineering results for district energy and microgrids that are optimized to minimize energy costs.

The districts in pink were selected based on a concentration of high energy use buildings that demonstrate a balance of electric and thermal loads.

The districts in green were selected based on a concentration of affordable housing.

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All data is simulated, not actual.

This mapping analysis was generously contributed by the [Google Project Sunroof](#) team.

Boston Solar Catching Potential by census block

kW Solar Installation Potential:

> 1,173 to 1,661

> 918 to 1,173

> 739 to 918

> 635 to 739

> 563 to 635

500 to 563

The map shows potential new areas for district energy and microgrids in Boston. Click the districts to see the engineering results for district energy and microgrids that are optimized to minimize greenhouse gas emissions.

The districts in pink were selected based on a concentration of high energy use buildings that demonstrate a balance of electric and thermal loads.

The districts in green were selected based on a concentration of affordable housing.