

Not All Microgrids Are Created Equal: Northeastern University's Blueprint for Resiliency

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AMERESCO 
Green • Clean • Sustainable

Northeastern University

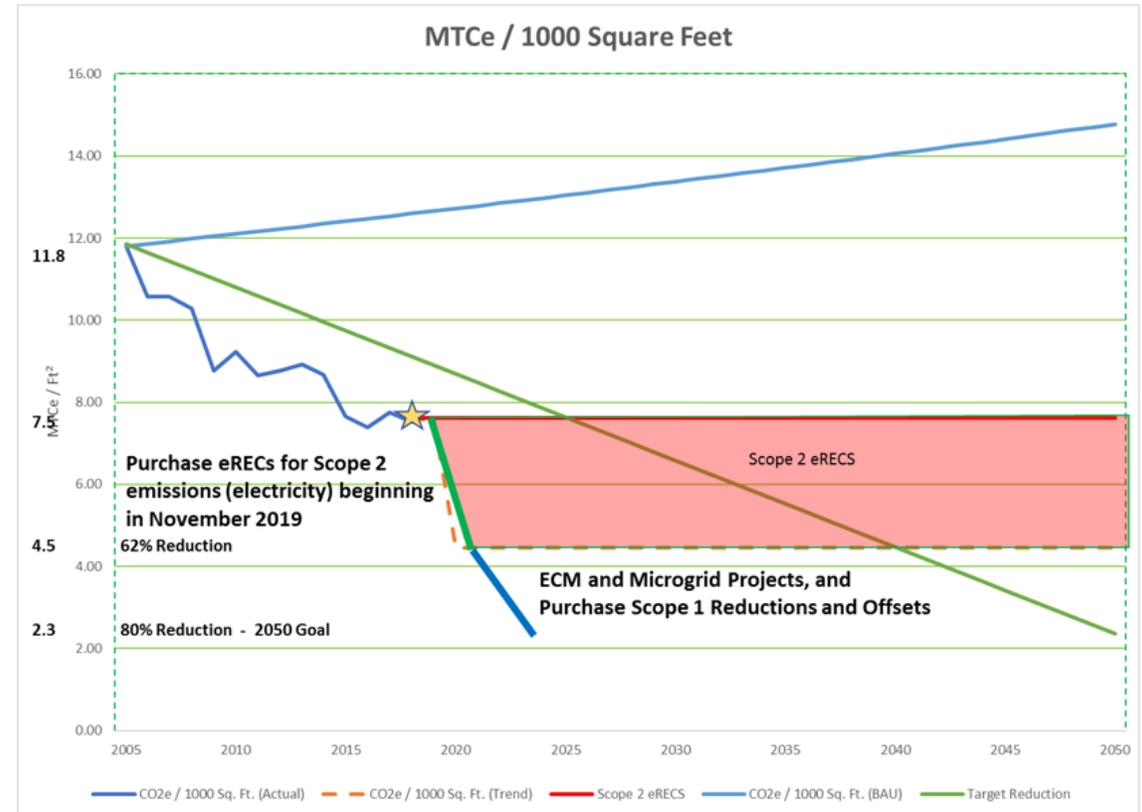
About Us:

- Urban 70+ acre campus 8M GSF and growing
- Over 36,000 students across undergrad/graduate and growing
- Learning in action: Uniquely offering Experiential Learning
- Nearly \$180M in external research funding and growing

Northeastern's Energy and Resiliency Vision for the Future:

- Reduce 2005 carbon footprint by 80% by 2050 (More Sooner)
- Improve resiliency related energy supply interruptions
- Reduce operating costs and improve cash flow
- Research partnerships and student engagement
- Maintain or improve the University's financial strength & integrity

Carbon Reduction Roadmap:

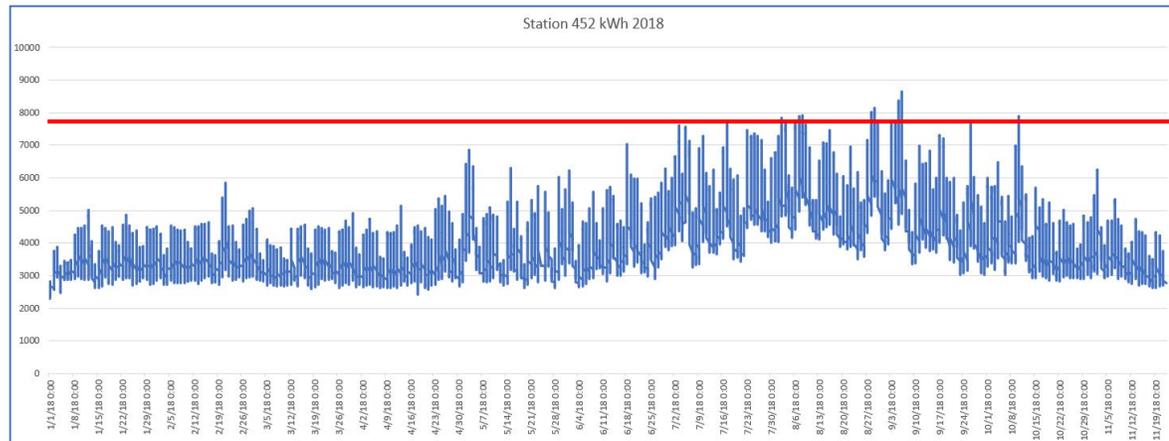


Energy Challenges

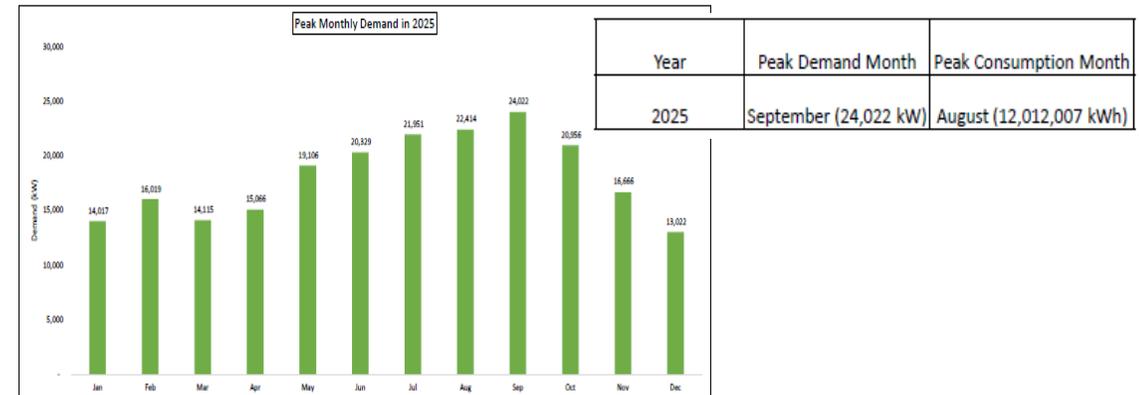
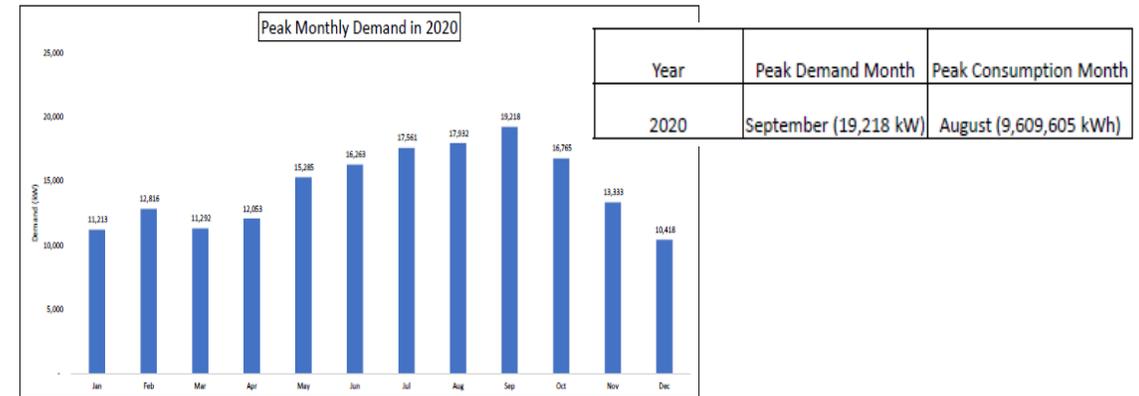
Electric Substation Capacity Issue

Substation Load Analysis: Eversource firm capacity limitation is being exceeded on one main campus feed – Forsythe

| Growth | | 1% | | NORTHEASTERN UNIVERSITY CAMPUS FEEDS STATION 452 | | | | | | | | | | | | | | | | | | | | | | |
|--------------|--------|------|------------|--|------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|-------|
| 2018 | | 2018 | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | | | |
| SMinute Data | Max KW | 8643 | Station | 452 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | | |
| 9/6/18 14:00 | % | 112% | Feeder | 1340/1401 | 15kV Cable | AMPS | 8729 | 8817 | 8905 | 8994 | 9084 | 9175 | 9266 | 9359 | 9453 | 9547 | 9643 | 9739 | 9836 | 9935 | 10034 | 10134 | 10236 | 10338 | 10442 | 10546 |
| | | | Cable Size | 700KCMIL | 113% | 114% | 115% | 116% | 117% | 118% | 120% | 121% | 122% | 123% | 125% | 126% | 127% | 128% | 130% | 131% | 132% | 133% | 135% | 136% | | |



Electric Peak Projections – 2020 and 2025



Advanced Energy Solutions Developed for Resiliency

Energy Efficiency

- Comprehensive energy conservation measures
- Reduces energy demand/use on campus

Onsite Energy Generation

- Solar PV system
- Turbine-based combined heat and power (CHP)

Battery Energy Storage

- Consumption of onsite generation
- Backup power/microgrid support

Microgrid

- Ties all elements together
- Enables stored power supply when the local grid goes down

Microgrid Project – Needs and Benefits

- Implements part of the Carbon Reduction Roadmap
- Increases the electrical capacity and reliability of the campus infrastructure
- Reduces annual utility operating costs
- Addresses electric and steam deferred maintenance needs
- Improves the resiliency of the University's utility infrastructure
- Frees valuable campus real estate



Microgrid Project – Description

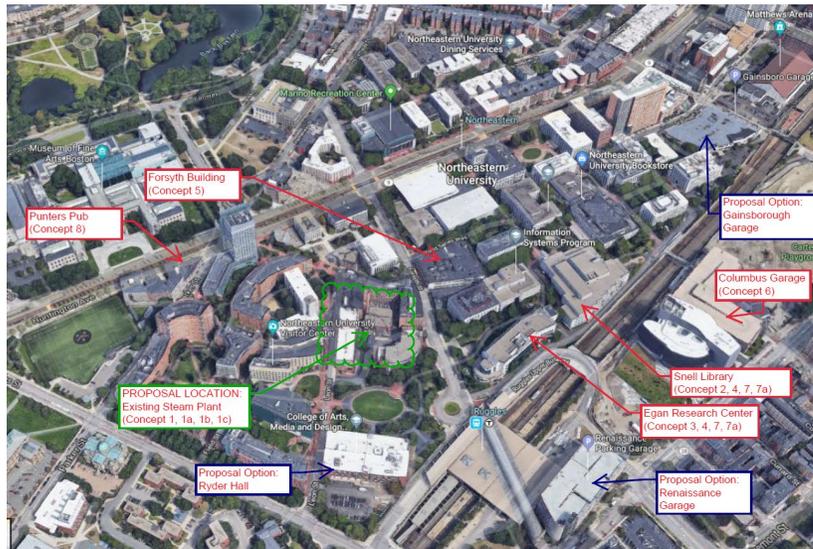
- Two (2) 4.6 MW Cogeneration Gas Turbines
 - ISO Dispatch/Ancillary Services
 - Island Mode Capable
- 32,000 Lb/Hr Heat Recovery Steam Generator
- Electrical Substation Upgrades Throughout Campus
- New Boilers and Steam Improvements
- 2MW/3MWh Battery System and Resiliency Improvements
- ~2MWdc solar PV
- Living Learning Lab



Location Analysis

Multiple Tasks, Many Skill Sets

- Matrix of Locations (12+ Sites over 12+ months)
- Structural Analysis
- Proximity to Fuel
- Campus Steam Infrastructure
- Campus Electric Infrastructure



Criteria & Constraints

- Economics
- Campus and Academic Disruption
- Operations and Maintenance
- Campus Resiliency

| Northeastern University CHP Plant Location Decision Matrix | | | | | | | | | | | | | |
|---|-------------------|-----------|------------|------------|------------|-----------|-----------|-----------|-----------|-----------|-----------|------------|-----------|
| Factors | Importance (0-10) | Concept 1 | Concept 1a | Concept 1b | Concept 1c | Concept 2 | Concept 3 | Concept 4 | Concept 5 | Concept 6 | Concept 7 | Concept 7a | Concept 8 |
| Isoperformance | 10 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 |
| Educational Programs and Opportunities | 10 | 2 | 3 | 2 | 3 | 1 | 1 | 1 | 3 | 2 | 1 | 1 | 1 |
| Carbon Impact | 10 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Site access for plant O&M (working dock, freight elevators, etc.) | 10 | 3 | 3 | 2 | 1 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 1 |
| Access to underground oil's storage area | 10 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 |
| Sufficient space for central plant equipment and fire suppression | 10 | 1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 1 | 1 | 1 |
| Structural feasibility of concept | 10 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| Site access to existing steam/condensate distribution system | 10 | 3 | 3 | 2 | 3 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 1 |
| Site access to existing central plant natural gas service | 10 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 1 |
| Site access to existing electrical distribution system | 10 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 1 |
| Potential building academic disruption during project construction | 10 | 3 | 3 | 1 | 2 | 1 | 1 | 1 | 1 | 3 | 2 | 2 | 3 |
| Disruption to existing central plant operations during construction | 10 | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 |
| Improved Resiliency to Campus Steam System | 10 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 |
| Improved Resiliency to Campus Electrical System | 10 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Energy and Cost Savings | 10 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Cost of Implementation | 10 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | | 428 | 488 | 388 | 378 | 280 | 280 | 280 | 340 | 320 | 280 | 280 | 260 |



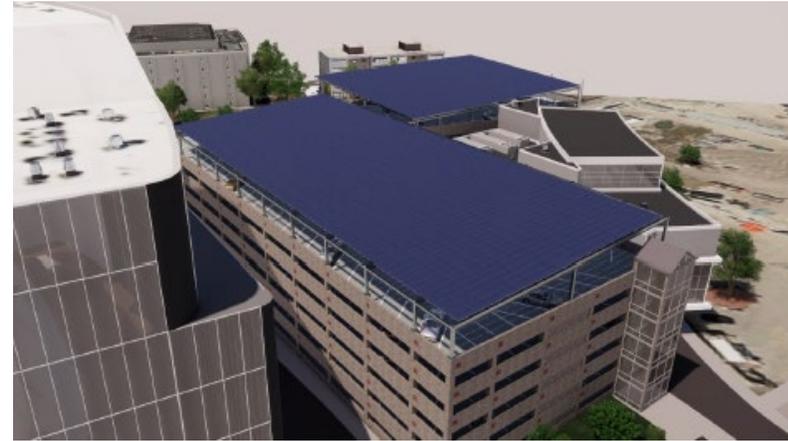
Solar PV Opportunities

Review of on-site PV potential ongoing

- Primary opportunities: Columbus Garage and Curry Student Center
- Additional considerations: Cabot Center & Barletta Natatorium, Snell Library, and Marino Center

| Site | DC Capacity (kW) | kWh/Year | System Type |
|----------------------|------------------|------------------|----------------|
| Curry Student Center | 136.1 | 171,951 | Rooftop |
| Cabot/Barletta | 750.0 | 881,111 | Rooftop |
| Snell Library | 189.2 | 229,784 | Rooftop |
| Marino Center | 243.4 | 295,695 | Rooftop |
| Columbus Garage | 625.0 | 735,625 | Carport Canopy |
| All Sites | 1,943.7 | 2,314,166 | |

Solar PV Opportunities – Columbus Renderings



Research and Education Partnerships

- Leverage partnerships to implement a research and development program that leverages EMS with the integrated distributed energy systems
- Vision to build a simulation platform to allow students and faculty to simulate, analyze and research a wide variety of use cases in the distributed energy management domain

Three Pillars of Research Partnerships

1

Microgrid Energy Solution – Grid Operation Research Platform
A Research Platform for Integrated Smart Distribution Grid Operation

2

University as a Living Learning Lab – Smart City Research Platform
Smart Campus Energy Management with Clean Technology & Electric Economy

3

Engineering & Training Program Enhancements
Certification Program Development – Work Force Training on GE Technologies

Questions?



Thank You!



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