Not your Grandma's Infrastructure

Can a systems-thinking approach inform microgrid deployment in NYC?

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Microgrids are:

- Small local energy systems
- multiple loads (customers) and energy supply sources (that produce electric <u>or</u> both electric and thermal energy)
- can operate connected to the larger central grid or autonomously from it.

(Source: Hyams et al 2010)

Why all the buzz?

- The grid suffers from technology "lock-in"
  - 1-way power flow design
  - DG introduces safety concerns, violates existing engineering design
  - Fixing these problems can be $$
  - Utility cooperation/collaboration can be challenging
- Microgrids offer a gateway to a smarter grid
  - Knowledge of grid status is fundamental
  - Agnostic about power sources, including DG
  - Support customer participation in sophisticated energy management practices (demand response, TOU pricing, "smart" appliances)
- CHP/cogen growing in popularity, creating a foundational opportunity for microgrid development

NYU microgrid in Greenwich Village

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NYU microgrid distributes energy to:

Electricity: 22 buildings
Heat: 37 buildings

Utica NY microgrid

Microgrid trends

- Campus/institutional/military base settings dominate installations (the previous two slides notwithstanding)
- Single system and property owner simplifies regulatory complexity
  - Less likely to run into utility franchise issues
  - Less likely to have extensive regulatory oversight
  - Less management complexity in terms of ownership structure
  - System more likely to be held for a long time, changing perspective on ROI

If NYU can do it, what about the rest of the city?

It depends on what we want our local energy system to look like in 30, 50, or 100 years

Transformative change in the urban energy system

(adapted from F. Geels, 2009)

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Landscape game-changers

- Con Ed steam is sold, buyer want massive system expansion
- Major storm damage to National Grid distribution system
- Indian Point closure
- Failure to site new gas lines into the region
- High elevation fires in skyscrapers
- Innovations in wireless electricity
- NYC takes over the Con Ed grid

Such events change our relationship to energy in very fundamental ways – will they help or hinder microgrids?

Entrepreneurs constantly give us a new vision of what "could be"…but most ideas go nowhere, until the conditions are right

Major technology shifts:

- Breakthrough in advanced generation & load control technology that can manage multiple independent networks across a city
- Breakthrough in wireless electricity

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Typical socio-technical concerns:

- Building owner concerns about loss of system control and impact on real estate value
- Technical integration with the Con Ed system
- Access to high pressure gas lines
- Policies re: net-metering of electricity or steam
- Ability to affect load curves of buildings via different pricing policies, education, smart building systems

These issues are "business as usual" challenges for policymakers and market actors…progress is possible, but it tends to be small and incremental

Channeling Geels: How energy systems change

Stuck with status quo if our vision only focuses on socio-technical system concerns

- Minor (and commonplace) tweaking of policies, technological improvements, etc. continue to deliver incremental change

For microgrids to achieve breakthrough growth, two or three system elements must move in sync. How can we structure our vision to capitalize on these opportunities (and minimize the risk of unhelpful or unforeseen changes in the system?)

Examples:

- **Major push for district energy expansion in outer boroughs**
  - Danish heat law mandating district energy interconnection
- **Growing prominence of CHP drives focus on individual microgrid development**
  - Net-metering allowed; new policies promote competition in distribution
- **Total system reconfiguration via linked microgrids**
  - PSC revisits 1997 Con Ed restructuring agreement; NYC creates muni-led microgrids

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A necessary precursor to change: Data

Microgrid development presumes an understanding of energy demand by different users over different time scales.

But…

- Proprietary data/privacy concerns
- Lack of adequate building-scale interval data

Source: Parshall 2009

It is impossible to articulate and deliver breakthrough energy change without access to good information on how we use energy

Modi Research Group
Columbia University

http://modi.mech.columbia.edu/nycenergy/

Estimated Total Annual Building Energy Consumption at the Block and Lot Level for NYC

About | Map

Estimated BLock Level Annual Energy Consumption

Block ID: 759
Land Area: 13157 m²
Electricity Use: 564 (10³) kWh
Total Fuel Use: 54517 Therms
(1 mÂ² = 10.76 ft² and 1 Therm = 29.30 kWh)

>>Click to see % of Energy End-Use Split

- 1,750 - 2,500
- 1,200 - 1,750
- 900 - 1200
- 600 - 900
- 400 - 600
- 300 - 400
- 200 - 300
- 170 - 200
- 120 - 170
- 90 - 120
- 75 - 90
- 50 - 75
- < = 50
- No Data
- Open Spaces

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Estimated Lot Level Annual Energy Consumptio ✕

Lot Address: 16 WEST 61 STREET
Lot Land Area: 1144 m²
Building Floor Area: 10566 m²
Lot Electricity Use: 1403 (10³) kWh
Lot Total Fuel Use: 61315 Therms
(1 m² = 10.76 ft² and 1 Therm = 29.30 kWh)

Estimated Annual Energy End-Use Split %

Data supports scenario analysis (1)

Goal: satisfy on-site thermal demand using a particular type of technology

- Small gas turbines (<1 MW)
- Absorption chiller (COP=0.7)
- Large **building footprint** required (>2.5K square feet)

Results

- **709 MW** of total capacity identified, of which **96% multi-family**
- **7.9% reduction** in annual building CO_2 emissions

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Source: Parshall 2009

Data supports scenario analysis (2)

Source: Parshall 2009

Parshall's BLOCK SCALE scenario, trying to maximize overall system efficiency

- Generate electricity more efficiently via CHP sited in residential neighborhoods (selling surplus to the grid), and satisfy as much thermal demand as possible
- Relies on larger systems
  - Large gas turbines (~10 MW)
  - Absorption chiller (COP=0.7)
- **8,876 MW** of total capacity
- **72.2% reduction in annual building CO_2 emissions**

Data supports scenario analysis (3)

Howard's BLOCK SCALE scenario maximizes energy use within the block itself, assuming no export potential

- Relies on small (<1 MW) systems
- Only space heat considered
- **1,262 MW** of total capacity
- **7.5% reduction in annual building CO_2 emissions**

Number of Systems	3492
Total Capacity	1262 MW_e
Heat Used	7,400 GWh
Total M sq.ft	2,603
% City Heat Load	10%
% City Elec Load	28%
% City Sq.Ft	49%

Source: Bianca Howard, Columbia Univ. (in progress)

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Does Greener Greater Building law data offer us any insights? Perhaps.

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Source: City of New York 2012

Thermal energy

Thermal energy

Wrapping up…WWGS?
(what would Grandma Rose say?)

- **"Only the Lone Ranger has silver bullets!"**
  - Translation: Microgrids are no silver bullet; they are but one part of a highly complex **energy system**.
- **"My grandson works so hard he'll probably be a Doctor someday"**
  - Translation: Ambition is good…we should establish **visionary goals** for our energy system and then work hard to achieve them.
- **"But oyyy…my Stephen can be such a screw up sometimes! So I told him…"**
  - Translation: Once we've got our plan in place, we need to **monitor our progress** and assess whether **course change** is necessary if we are really to achieve our goals
- **"Don't forget your sweater!"**
  - Translation: Grandma was always thinking ahead, meaning she would encourage us to take actions that would "**future proof**" the energy system, avoiding a new form of lock-in
- **"Your grandfather was a math teacher. Do your math."**
  - Translation: Like Mayor Bloomberg says, "In God We Trust. Everyone else, bring **data**"

Thank you.

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