Why distributed?
Thinking about incentives for solar (and storage)

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SOLAR IS INTEGRAL TO NEW ENGLAND’S CLIMATE GOALS
Historical data from “2016 ISO New England Electric Generation Air Emissions Report,” January 2018. Deep decarbonization trajectories span three scenarios: 90% reductions from 2016 by 2050; 100% reductions by 2050, and 90% reductions by 2045 and net negative emissions equal to 10% of 2016 emissions levels by 2050. Trajectories are illustrative of electricity sector reductions needed to reach economy-wide carbon reductions of approximately 80%.
THE EASY PART IS OVER

Percent of Total Electric Energy Production by Fuel Type
(2000 vs. 2017)

Graphic source: Williams et al., “Deep Decarbonization in the Northeastern United States and Expanded Coordination with Hydro Quebec,” April 2018
WHY DISTRIBUTED?
WHY DISTRIBUTED?

• RPS solar carve-out I & II and SRECs: less than 6 MW-dc
• Net metering: advantages smaller systems earning retail rate; highest tariff for residential installations
• SMART program tariffs: less than 5 MW-ac; steadily increasing tariff as project size decreases
• Behind-the-meter storage “adder” in SMART
• Etc.
A: LOCATIONAL VALUE

1. Transmission & distribution losses
2. Network constraints & upgrades
3. Network reliability & disruptions
4. ‘Land sparing’
Variation in locational transmission-level energy value of solar PV due to variation in wholesale LMPs

Source: Patrick Brown, MIT Energy Initiative, from forthcoming work; image blurred until publication
Calculations based on a distribution feeder with 9% average annual losses and using ISO New England average system load profile and solar PV production profiles for a roof mounted system in Newtown, MA from PVWatts. Marginal loss reduction value will differ by feeder and location depending on combination of line resistance, line loading, and alignment of solar and demand profiles.
What about resilience?
Locational value premium for distributed solar PV relative to utility-scale PV at bulk transmission level

$6 – Highest spread in 2016 ISONE values from P. Brown

$2 – Boston vs. Western Mass. Spread in 2016 ISONE values from P. Brown

Presenters calculations. Assumptions and methods available upon request: jesse_jenkins@hks.harvard.edu
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RANGE OF LOCATIONAL VALUES FOR NEW ENGLAND

Locational value premium for distributed solar PV relative to utility-scale PV at bulk transmission level

- $3 – 10 mi, 230 kV spur line to existing transmission network
- $21 – 100 mi, 345 KV line (e.g. Springfield to Boston)
- $41 – 200 mi, 345 KV line or HVDC similar to NECEC / Northern Pass

Levelized $ per MWh

Transmission: energy value
Transmission: network capacity value
Distribution: energy value
Distribution: network capacity value
Presenters calculations. Assumptions and methods available upon request: jesse_jenkins@hks.harvard.edu

$1 – Feeder with 4% average losses, 20% of annual demand met by existing PV

$6 – Feeder with 9% average losses, minimal PV penetration

Range of locational values for New England

Locational value premium for distributed solar PV relative to utility-scale PV at bulk transmission level

Levelized $ per MWh:

- Transmission: energy value
- Transmission: network capacity value
- Distribution: energy value
- Distribution: network capacity value
Vast majority of distribution feeders have no opportunity for solar to defer upgrade (e.g. ~55 of 2100+ feeders in National Grid New York territory face load-driven upgrade in next 10 years) $0 – $60/kW-yr deferral value, highest distribution network value found in Cohen, Kauzmann & Callaway (2016)

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Locational value premium for distributed solar PV relative to utility-scale PV at bulk transmission level
NOT ALL SOURCES OF VALUE ARE LOCATIONAL

1. Firm generating capacity
2. System “flexibility”
3. Operating reserves & regulation
4. Carbon dioxide reductions
Solar PV Economies of Unit Scale
(Massachusetts H1 2018 levelized cost per MWh)

Data source: 50 MW cost from Lazard (2018)
Others are median prices from NREL Q4 2017/Q1 2018 Solar Industry Update

- Incremental cost relative to 50 MW scale

Utility-scale
~50 MW*

100-500 kW

2.5-10 kW

0.5-5 MW

10-100 kW

*Transmission expansion costs not included
Li-ion Economies of Unit Scale
(U.S. 2018 costs per kWh of capacity)

Data source: Lazard Levelized Cost of Storage 4.0 (2014), 4 hour storage duration

- Incremental cost relative to 100-500 MWh scale

$369

+38%

+49%

+103%

100-500 MWh

100-500 kWh

1-10 MWh

1-10 kWh
The key tradeoff

Locational Value

Economies of Scale
Are we getting net value? ($ per MWh)

Net cost gap

6

Net cost gap

96

192

Incremental costs vs 50 MW-scale solar

Total Locational Value (Low Range Example)

Sum of lowest values from Slide 16

0.5-5 MW

2.5-10 kW
Are we getting net value?

($ per MWh)

Net cost gap

96

6

102

Incremental costs vs 50 MW-scale solar

Total Locational Value (High Range Example)

Sum of highest values from Slide 16

0.5-5 MW

2.5-10 kW
## Policy & rate design scorecard

<table>
<thead>
<tr>
<th></th>
<th>Locational values</th>
<th>Non-locational values</th>
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<tbody>
<tr>
<td></td>
<td>Transmission</td>
<td>Distribution</td>
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<tr>
<td></td>
<td>Energy value</td>
<td>Energy value</td>
</tr>
<tr>
<td>Flat Retail Rate / Net Metering</td>
<td>Yes</td>
<td>Yes*</td>
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<tr>
<td>TVR (fixed blocks)</td>
<td>(possible)</td>
<td>(possible)</td>
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<tr>
<td>Dynamic Rate (hourly)</td>
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<td>RGGI</td>
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<td>Mass. CES (&amp; RPS)</td>
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<td>Mass. SREC I &amp; II</td>
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<td>Mass. SMART</td>
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<tr>
<td>New York VDER*</td>
<td>Yes* zonal</td>
<td>Yes*</td>
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<tr>
<td>*only exported KWh</td>
<td>*first steps</td>
<td>*first steps</td>
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</tbody>
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Final Thoughts

Policy & regulation should be about value (ends), not technology (means)

1. Value clean = Clean Energy Standard + RGGI

2. Value distributed = time and location-based mass-market rates
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