E2Tech
Security, Reliability, & Integration – Analyzing the Regional Energy Grid

The Point is, We’re Missing the Point

Benji Borowski, Preti Flaherty
March 29, 2018
50+ Reports on NG Pipeline Constraints, dating back to 2001

**Government / Quasi-Gov’t**

- 2001-04: ISO-NE, by Levitan, 7 studies/updates
- 2003: ISO-NE white paper
- 2003: FERC Staff report
- 2004: Massachusetts Task Force on Electric Reliability
- 2005: Connecticut Attorney General
- 2012: ISO-NE white paper
- 2012-13: NESCOE, by Black & Veatch, 3 studies
- 2012-16: ISO-NE, by ICF, 7+ studies/updates
- 2013-15: Eastern Interconnection Planning Collaborative, by Levitan, 4 studies
- 2014: Maine PUC, by Sussex
- 2014: Maine OPA, by Brattle Group
- 2014: EIPSC/NARUC, by ICF
- 2015: Massachusetts DOER, by Synapse
- 2015: Maine PUC, by London Economics
- 2015: Maine OPA, by Brattle Group
- 2015: MA Attorney General, Analysis Group
- 2016: Maine PUC, by London Economics, 2 studies
- 2016: Maine PUC, by Navigant
- 2017: ISO-NE/NEPOOL
- 2018: ISO-NE, Operational Fuel Security Analysis

**Industry / Non-Profit**

- 2012: Spectra, by Concentric
- 2013-15 IECG/CLEC, by Competitive Energy Services, 6 studies
- 2014: NEPGA, by Energyzt
- 2015: Eversource/Spectra, by ICF
- 2015: New England Coalition for Affordable Energy, by La Capra
- 2015: CLF, by Skipping Stone
- 2015: GDF Suez, by Energyzt
- 2015: Kinder Morgan, by ICF
- 2015: Eversource, by ICF
- 2017: Connecticut Fund for the Environment et al., by Synapse
- 2017: Environmental Defense Fund
- 2018: Eversource, by Levitan

**Still no action ...**
ISO-NE Operational Fuel-Security Analysis

*Upshot* – “Fuel security is the greatest challenge to continued power system reliability ... Taking action will be costly; inaction will also come at a cost.” (ISO-NE State of the Grid 2018)

**How much fuel security risk will we tolerate?**

- **Who is “we”?**
  - FERC (just & reasonable, reliable for all)
  - ISO-NE (New England electric reliability)
  - New England region (???)
  - State policymakers (their constituents)
  - State regulators (their utilities and ratepayers)
- **Pay for Performance?**
  - “[W]holesale markets are unlikely to drive ... collective investment in shared infrastructure, particularly ... natural gas pipeline.” (ISO-NE REO 2018)
- **Report contains no solutions yet, but with regional cooperation ......**
Regional Cooperation?

Cold snap makes New England the world’s priciest gas market

Our Russian ‘pipeline,’ and its ugly toll

By the Editorial Board, February 13, 2018

We’re not absolutists, we’re realists

Arrival of Russian gas stirs Ukrainian community

Pipeline debate gets testy on Twitter

When it comes to Russian gas, just say nyet

Mass. turned to oil and coal during the cold snap. Here’s what went wrong

Healey unveils new renewable energy targets

Gas-by-train? Beacon Hill opens the door

Beware the Coalition for Sustainable Energy
Natural Gas: Bridge to Nowhere vs. Foundation for Sustainable Carbon Cuts?

**Increased Natural Gas Pipeline Capacity:**
- Almost all studies show economic benefit
- Many studies demonstrate electric reliability benefit

**No studies comprehensively analyze:**
1. Near-term emissions
2. Feasible and viable integration of (lots of) renewable energy
3. Long-term electrification of heating and transportation
Missing the Point on Near-Term Emissions

Why has no NG opponent proven that more LNG and oil (and coal) is a better climate alternative to NG in the short-term?

Saying “no” to NG without serious analysis misses the point.
3 Peer-Reviewed Studies that are On-Point: a springboard for decisive action?


1. Burden of proof: A comprehensive review of the feasibility of 100% renewable-electricity systems

- Critically assesses feasibility (not viability) of 24 “100% renewable energy” studies using four reasonable, defensible criteria.

Did you know?

Iceland is the only 100% renewable large-scale system due to its: “unique endowment of shallow geothermal aquifers, abundant hydropower, and a population of only 0.3 million people.”
Burden of Proof: Results

“Based on our criteria, none of the 100% renewable-electricity studies we examined provided a convincing demonstration of feasibility.”

<table>
<thead>
<tr>
<th>Study</th>
<th>Coverage</th>
<th>Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mason et al. [9,104]</td>
<td>New Zealand</td>
<td>I (Demand)</td>
</tr>
<tr>
<td>Australian Energy Market Operator (1) [8]</td>
<td>Australia (NEM-only)</td>
<td>II (Reliability)</td>
</tr>
<tr>
<td>Australian Energy Market Operator (2) [8]</td>
<td>Australia (NEM-only)</td>
<td>III (Transmission)</td>
</tr>
<tr>
<td>Jacobson et al. [112]</td>
<td>Contiguous USA</td>
<td>IV (Ancillary)</td>
</tr>
<tr>
<td>Wright and Hearpe [60]</td>
<td>Australia (total)</td>
<td>Total</td>
</tr>
<tr>
<td>Phemikis et al. [133]</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Allen et al. [27]</td>
<td>Britain</td>
<td></td>
</tr>
<tr>
<td>Connolly et al. [19]</td>
<td>Ireland</td>
<td></td>
</tr>
<tr>
<td>Fernandes and Ferreira [119]</td>
<td>Portugal</td>
<td></td>
</tr>
<tr>
<td>Krajacic et al. [20]</td>
<td>Portugal</td>
<td></td>
</tr>
<tr>
<td>Estevez et al. [17]</td>
<td>Japan</td>
<td></td>
</tr>
<tr>
<td>Bodischak et al. [118]</td>
<td>PJM Interconnection</td>
<td></td>
</tr>
<tr>
<td>Elliston et al. [93]</td>
<td>Australia (NEM-only)</td>
<td></td>
</tr>
<tr>
<td>Lund and Mathiesen [16]</td>
<td>Denmark</td>
<td></td>
</tr>
<tr>
<td>Elliston et al. [75]</td>
<td>Australia (NEM-only)</td>
<td></td>
</tr>
<tr>
<td>Jacobsen et al. [18]</td>
<td>New York State</td>
<td></td>
</tr>
<tr>
<td>Price Waterhouse Cooper [10]</td>
<td>Europe and North Africa</td>
<td></td>
</tr>
<tr>
<td>European Renewable Energy Council [26]</td>
<td>European Union 27</td>
<td></td>
</tr>
<tr>
<td>ClimateWorks [116]</td>
<td>Australia</td>
<td></td>
</tr>
<tr>
<td>Jacobson et al. [113]</td>
<td>California</td>
<td></td>
</tr>
</tbody>
</table>

• Max score of 7
• Four studies scored 0
• Eight didn’t do integrated simulation to verify reliability
• Twelve relied on unrealistic energy-demand scenarios
• Only four articulated necessary transmission requirements
• Only two partially addressed ancillary services
• Zero studies addressed distribution infrastructure required for distributed generation
Burden of Proof: Recommendations

- It would be irresponsible to restrict our options to renewable energy technologies alone. The reality is that 100% renewable electricity systems do not satisfy many of the characteristics of an urgent response to climate change:
  - highest certainty and lowest risk-of-failure pathways,
  - safeguarding human development outcomes,
  - having the potential for high consensus and low resistance, and
  - giving the most benefit at the lowest cost.

- It behooves all governments and institutions to seek optimized blends of all available low-carbon technologies, with each technology rationally exploited for its respective strengths to pursue clean, low-carbon electricity-generation systems that are scalable to the demands of 10 billion people or more.

\[
\text{+ biomass,} \quad \text{+ nuclear,} \quad \text{+ biogas, etc.} \quad + \quad \text{(x 10 billion)}
\]

\[
\text{=}
\]
2. Renewables and decarbonization: Studies of California, Wisconsin and Germany

• Climate policy has been pursued by proxy in diverse, fragmented measures ... rather than a system-based, comprehensive approach to achieving long-term emission reductions.

• The debate over how to reduce GHGs ... has become a drama of confused ends and means, where political and intellectual support for solar and wind power have distracted policymakers’ attention from the larger goal of cost effective decarbonization.

• Studies run the risk of treating renewables as a societal end in itself, instead of just one among a suite of technologies that could be used to achieve the combined goals of environmental protection, cost containment, and electric system reliability.

This study reports on three studies that have answered:

(1) What do systems highly reliant on intermittent renewables (IR), such as wind and solar, look like?

(2) How do they compare to other possible system configurations in terms of cost, size, emissions?
Renewables and decarbonization: Key Findings - SIZE

- IR-heavy systems are significantly larger than conventional counterparts.
- IR like wind and PV have low capacity factors; to generate the same amount of output, a larger system is needed.

Table 1
System size under multiple scenarios for California, Germany, and Wisconsin.

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Total size (MW)</th>
<th>NGCC</th>
<th>Wind</th>
<th>Solar</th>
<th>Nuclear</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA default</td>
<td>53,633</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA 50 RPS</td>
<td>90,534</td>
<td>39,433</td>
<td>19,449</td>
<td>23,609</td>
<td>0</td>
</tr>
<tr>
<td>CA 80 RPS</td>
<td>123,589</td>
<td>38,926</td>
<td>34,614</td>
<td>42,017</td>
<td>0</td>
</tr>
<tr>
<td>CA balanced</td>
<td>63,662</td>
<td>22,925</td>
<td>6868</td>
<td>8337</td>
<td>17,500</td>
</tr>
<tr>
<td>CA 195 RPS</td>
<td>251,734</td>
<td>36,923</td>
<td>93,400</td>
<td>113,379</td>
<td></td>
</tr>
<tr>
<td>WI default</td>
<td>811</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WI 50 RPS</td>
<td>1799</td>
<td>765</td>
<td>324</td>
<td>710</td>
<td>0</td>
</tr>
<tr>
<td>WI 80 RPS</td>
<td>2383</td>
<td>756</td>
<td>540</td>
<td>1087</td>
<td>0</td>
</tr>
<tr>
<td>WI balanced</td>
<td>1265</td>
<td>508</td>
<td>162</td>
<td>355</td>
<td>240</td>
</tr>
<tr>
<td>WI 172 RPS</td>
<td>4383</td>
<td>727</td>
<td>1026</td>
<td>2630</td>
<td></td>
</tr>
<tr>
<td>Germany default</td>
<td>67,028</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany 50 RPS</td>
<td>150,111</td>
<td>56,030</td>
<td>45,038</td>
<td>41,531</td>
<td>0</td>
</tr>
<tr>
<td>Germany 80 RPS</td>
<td>233,185</td>
<td>55,721</td>
<td>88,274</td>
<td>81,401</td>
<td>0</td>
</tr>
<tr>
<td>Germany balanced</td>
<td>79,859</td>
<td>34,556</td>
<td>9308</td>
<td>8583</td>
<td>20,000</td>
</tr>
<tr>
<td>Germany 154 RPS</td>
<td>437,600</td>
<td>54,956</td>
<td>195,163</td>
<td>179,969</td>
<td></td>
</tr>
</tbody>
</table>
Renewables and decarbonization: Key Findings - COST

- Using EIA assumptions for technology costs, IR-heavy systems are more expensive ($/MWh)

<table>
<thead>
<tr>
<th></th>
<th>EIA ($/MWH)</th>
<th>OR/PN ($/MWH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA default</td>
<td>52</td>
<td>52</td>
</tr>
<tr>
<td>CA 50 RPS</td>
<td>96</td>
<td>61</td>
</tr>
<tr>
<td>CA 80 RPS</td>
<td>140</td>
<td>78</td>
</tr>
<tr>
<td>CA balanced</td>
<td>93</td>
<td>98</td>
</tr>
<tr>
<td>CA 195 RPS</td>
<td>324</td>
<td>128</td>
</tr>
<tr>
<td>WI default</td>
<td>52</td>
<td>52</td>
</tr>
<tr>
<td>WI 50 RPS</td>
<td>147</td>
<td>85</td>
</tr>
<tr>
<td>WI 80 RPS</td>
<td>202</td>
<td>106</td>
</tr>
<tr>
<td>WI balanced</td>
<td>128</td>
<td>112</td>
</tr>
<tr>
<td>WI 172 RPS</td>
<td>413</td>
<td>189</td>
</tr>
<tr>
<td>Germany default</td>
<td>73</td>
<td>73</td>
</tr>
<tr>
<td>Germany 50 RPS</td>
<td>126</td>
<td>83</td>
</tr>
<tr>
<td>Germany 80 RPS</td>
<td>194</td>
<td>109</td>
</tr>
<tr>
<td>Germany balanced</td>
<td>84</td>
<td>88</td>
</tr>
<tr>
<td>Germany 154 RPS</td>
<td>377</td>
<td>190</td>
</tr>
</tbody>
</table>
Renewables and decarbonization: Key Findings - EMISSIONS

• Under ordinary cost assumptions, 80% RPS scenarios yield about a 70% reduction in CO2 emissions; balanced generation systems produce reductions between 80 and 87%.

• To achieve CO2 reductions on par with balanced portfolios, IR systems must be built much larger, to between 154 and 195% RPS levels.

Table 3
CO₂ emissions and costs under multiple scenarios for California, Germany, and Wisconsin.

<table>
<thead>
<tr>
<th></th>
<th>% CO₂ reduction</th>
<th>EIA ($/ton CO₂ reduced)</th>
<th>OR/PN ($/ton CO₂ reduced)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA 50 RPS</td>
<td>50</td>
<td>280</td>
<td>42</td>
</tr>
<tr>
<td>CA 80 RPS</td>
<td>70</td>
<td>393</td>
<td>91</td>
</tr>
<tr>
<td><strong>CA balanced</strong></td>
<td><strong>87</strong></td>
<td><strong>150</strong></td>
<td><strong>128</strong></td>
</tr>
<tr>
<td>CA 195 RPS</td>
<td>87</td>
<td>775</td>
<td>300</td>
</tr>
<tr>
<td>WI 50 RPS</td>
<td>48</td>
<td>633</td>
<td>174</td>
</tr>
<tr>
<td>WI 80 RPS</td>
<td>67</td>
<td>729</td>
<td>210</td>
</tr>
<tr>
<td><strong>WI balanced</strong></td>
<td><strong>81</strong></td>
<td><strong>303</strong></td>
<td><strong>192</strong></td>
</tr>
<tr>
<td>WI 172 RPS</td>
<td>81</td>
<td>1168</td>
<td>440</td>
</tr>
<tr>
<td>Germany 50 RPS</td>
<td>50</td>
<td>348</td>
<td>103</td>
</tr>
<tr>
<td>Germany 80 RPS</td>
<td>69</td>
<td>553</td>
<td>184</td>
</tr>
<tr>
<td><strong>Germany balanced</strong></td>
<td><strong>86</strong></td>
<td><strong>207</strong></td>
<td><strong>88</strong></td>
</tr>
<tr>
<td>Germany 154 RPS</td>
<td>86</td>
<td>877</td>
<td>335</td>
</tr>
</tbody>
</table>
Renewables and decarbonization: Key Findings - STORAGE

• Battery storage technologies may have a role in managing shorter-term imbalances but are unlikely to solve the very large seasonal swings in generation.

• Pumped hydroelectric storage (PSH) is the only available technology applicable to longer-term storage; however, storing the large seasonal surpluses produced in these scenarios would require much more PSH than could be reasonably installed.

• While some long-term storage may be feasible, wasted surplus is unavoidable in high-IR systems, and backup conventional generation remains necessary.
Renewables and decarbonization: Key Findings - CONCLUSIONS

• [C]ompare alternate pathways that could perform well in multiple dimensions—that is, policies that could most cost-effectively reduce CO2 emissions significantly over time while maintaining the affordability and reliability of the electric system and minimizing other environmental harms.

• [F]or many, the presumptive answer has been almost self-evident ... : Renewables are the technology of choice, and the only question considered is how to deploy them. This is a dangerous confusion of ends and means.

• Rather than building a system that is much larger and more expensive than necessary, we should rigorously seek to ascertain the most cost-effective way to maintain reliability and cut carbon emissions. ... Electricity, as an input to most every single good and service in the world, should be as inexpensive as possible, and not a vehicle for pursuit of tangential social goals.

• [I]t is essential to look at systems as systems. Without this, ... we are flying blind—making decisions of enormous social and economic consequence with partial data. We must be realistic about the scope and complexity of this transformation, acknowledge that difficult tradeoffs are involved, and ensure all options are rigorously considered and compared.
3. The role of natural gas and its infrastructure in mitigating greenhouse gas emissions, improving regional air quality, and renewable resource integration

• Examines NG holistically on an electricity systems level as means to sustainably reduce GHG emissions and improve regional air quality, considering:
  • Fuel attributes
  • Generator attributes (e.g., heat rates, ramping, cycling)
  • Comparative life-cycle emissions of various technologies
    • Including methane leakage
  • Renewable energy integration
  • New(er) energy conversion technologies

• Uniquely addresses the role of natural gas pipeline infrastructure
The role of natural gas and its infrastructure – A Conclusion

• Therefore, the natural gas system inherently possesses features that are, and will be, valuable to ultimate sustainability, perhaps offering the only technically feasible option (and certainly one of the most cost effective options) for achieving massive and long-term storage of renewable electricity, and achieving 100% emissions-free energy conversion in all sectors of the economy and especially the challenging sectors (e.g., heavy duty transport and industry).

• Takeaways:
  • Not THE answer, but a holistic system analysis that properly considers renewables as one means to an end
  • Doesn’t just say “no” w/o meeting its burden
  • Doesn’t a priori exclude resources
  • Provides a very useful framework
Authors’ proposed transition to a completely renewable gaseous fuel system that minimizes GHG emissions and air quality impacts using pipeline infrastructure as the backbone.

<table>
<thead>
<tr>
<th>Gas System Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% Natural Gas</td>
</tr>
<tr>
<td>Near-Term</td>
</tr>
</tbody>
</table>

**Energy Conversion Technologies**
- Advanced NGCC
- Gas turbines
- DG and CCHP

- Advanced NGCC
- Fuel Cell Systems
- Fuel Cell Hybrid Systems
- DG and CCHP
- Fuel Cells

**Renewable Complement**
- Advanced NGCC
- Advanced low-emitting peaker plants
- Energy storage

- Fuel Cell and Hybrid Systems
- Advanced Energy Storage
- Smart Grid, Vehicle-to-grid, etc.
- Fuel Cells
- Advanced Energy Storage
- Smart Grid, Vehicle-to-grid, etc.

**Gas Source**
- Natural Gas
- Biogas

- Natural Gas
- Biogas
- Biomass gasification
- Renewable hydrogen
  - P2G, biohydrogen
- Renewable hydrogen
- P2G, biohydrogen, artificial synthesis, algae, etc.
- Biogas
- Biomass gasification
Conclusion: We are Missing the Point

- 50+ studies – “Regional cooperation” → increased costs + emissions + reliability risk.
- Just saying “no” is unacceptable; prove it.

Example in: **We’re not absolutists, we’re realists**

New gas pipelines won’t help us meet our 2050 climate goals

“Construction of new natural gas infrastructure works directly against the necessary conversion of our energy system to renewable fuels. ... By buying into pipeline development, we’d be laying the groundwork for a future energy market that advantages a fuel that we don’t want to use at all. And structuring the long-term market to make fossil fuels more competitive against renewables is antithetical to achieving mandated pollution reduction goals.”

Conclusory, unproven, and ... wrong
Conclusion: We are Missing the Point (cont’d)

• NG opponents can easily defeat regional cooperation at the state level with “no” rhetoric.

What should “we” do instead?

(1) NG proponents and opponents (i.e., 100% renewable proponents) should collaboratively perform a system-level study comparing the viability of feasible alternatives that achieve the “holy grail.” Then decisively act on a feasible, viable option.

(2) Think creatively and critically. New England is so close to doing it right!

• pipeline “dividend” from savings to be used for renewables
• agreement to increase renewable gas and decrease NG usage over time
• pipeline infrastructure as missing long-term “battery” for intermittent renewables
• is a 2% emissions reduction today worth more than a 5% reduction in 10 years? What’s the cost of a near-term increase or “missed” reductions?

+ FIGURE IT OUT! + = 😊