E2Tech

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

The Point is, We're Missing the Point

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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 ???

Resource Retirements

LNG Availability

Renewable Resources

Imported Electricity

Oil Tank Inventories

Regional Cooperation?

Metro

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

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Storage, not new pipelines, is the answer

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Pipeline debate gets testy on Twitter

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EDITORIAL

When it comes to Russian gas, just say nyet

Editorials

EDITORIAL

Arrival of Russian gas stirs Ukrainian community

Our Russian 'pipeline,' and its ugly toll

By the Editorial Board,
February 13, 2018

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EDITORIAL

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

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We're not absolutists, we're realists

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Healey unveils new renewable energy targets

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EDITORIAL

Gas-by-train? Beacon Hill opens the door

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Beware the Coalition for Sustainable Energy

Natural Gas: Bridge to Nowhere vs. Foundation for Sustainable Carbon Cuts?

Increased Natural Gas Pipeline Capacity:

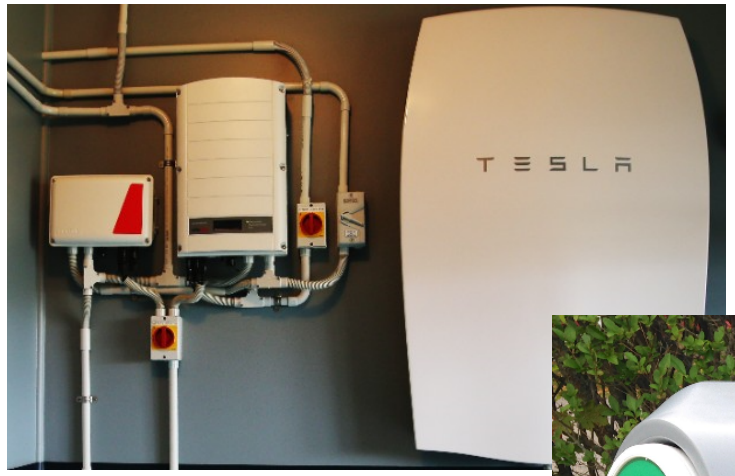
- Almost all studies show economic benefit
- Many studies demonstrate electric reliability benefit

No studies comprehensively analyze:

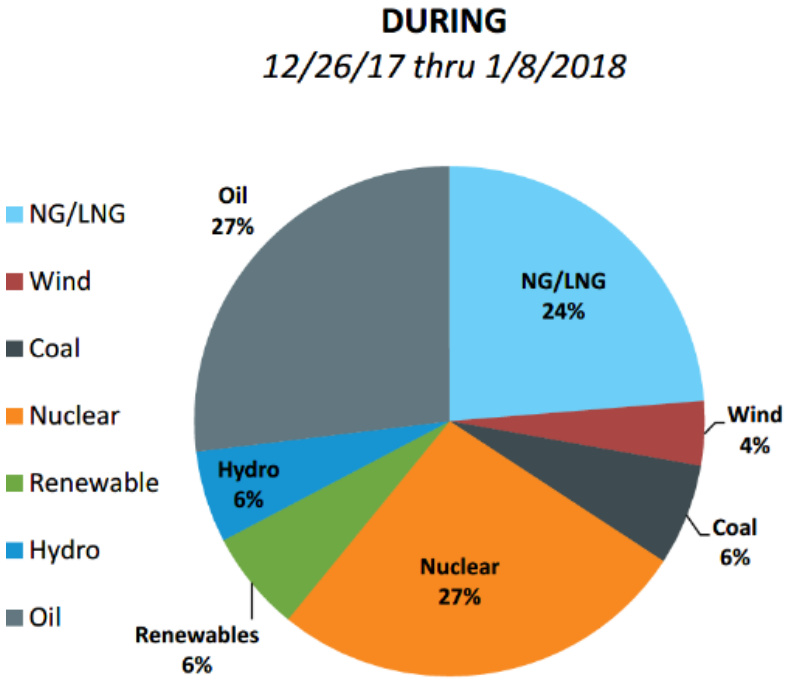
(1) Near-term emissions

(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



Oil –

- likely fracked (methane leaks)
- probably not in U.S
- more $$$
- less reliable in N.E.
- more emissions to transport
- more emissions when burned
- less efficient

LNG –

- likely fracked
- from "bad" places
- more $$$
- opportunistic
- less reliable
- more emissions to liquefy, transport, re-gasify

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. B.P. Heard et al., "*Burden of proof: A comprehensive review of the feasibility of 100% renewable-electricity systems*," RENEWABLE AND SUSTAINABLE ENERGY REVIEWS 76 (2017)

2. Brick, et. al., "*Renewables and decarbonization: Studies of California, Wisconsin and Germany*," THE ELECTRICITY JOURNAL 29 (2016)

3. Mac Kinnon, et. al., U.C. Irvine, "*The role of natural gas and its infrastructure in mitigating greenhouse gas emissions, improving regional air quality, and renewable resource integration*," PROGRESS IN ENERGY AND COMBUSTION SCIENCE 64 (2018)

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."

Study	Coverage	Criterion				Total
		I (Demand)	II (Reliability)	III (Transmission)	IV (Ancillary)	
Mason et al. [9,104]	New Zealand	1	2	1	0	4
Australian Energy Market Operator (1) [8]	Australia (NEM–only)	1	1	1	0.5	3.5
Australian Energy Market Operator (2) [8]	Australia (NEM–only)	1	1	1	0.5	3.5
Jacobson et al. [112]	Contiguous USA	0	3	0	0	3
Wright and Hearps [60]	Australia (total)	0	2	1	0	3
Fthenakis et al. [133]	USA	0	2	0	0	2
Allen et al. [27]	Britain	0	2	0	0	2
Connolly et al. [19]	Ireland	1	1	0	0	2
Fernandes and Ferreira [119]	Portugal	1	1	0	0	2
Krajacic et al. [20]	Portugal	1	1	0	0	2
Esteban et al. [17]	Japan	1	1	0	0	2
Budischak et al. [118]	PJM Interconnection	1	1	0	0	2
Elliston et al. [22]	Australia (NEM–only)	0	1	0	0.5	1.5
Lund and Mathiesen [16]	Denmark	0	1	0	0	1
Cosic et al. [11]	Macedonia	0	1	0	0	1
Elliston et al. [75]	Australia (NEM–only)	0	1	0	0	1
Jacobsen et al. [18]	New York State	1	0	0	0	1
Price Waterhouse Coopers [10]	Europe and North Africa	1	0	0	0	1
European Renewable Energy Council [26]	European Union 27	1	0	0	0	1
ClimateWorks [116]	Australia	1	0	0	0	1
World Wildlife Fund [108]	Global	0	0	0	0	0
Jacobsen and Delucchi [24,25]	Global	0	0	0	0	0
Jacobson et al. [113]	California	0	0	0	0	0
Greenpeace (Teske et al.) [15]	Global	0	0	0	0	0

- **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.

+ biomass,
+ nuclear,
+ biogas, etc.?

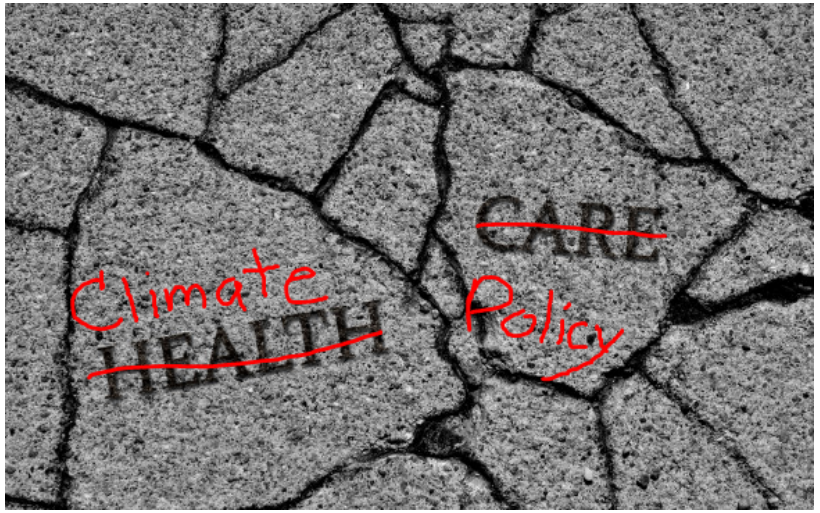
+

=

(x 10 billion)

2. Renewables and decarbonization: Studies of California, Wisconsin and Germany

- [C]limate policy has been pursued by proxy in diverse, fragmented measures ... rather than a system-based, comprehensive approach to achieving long-term emission reductions.
- [T]he 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.
- [S]tudies 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.

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

Renewables and decarbonization: Key Findings - COST

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

Table 2
System costs under multiple scenarios for California, Germany, and Wisconsin.

Cost	EIA ($/MWH)	OR/PN ($/MWH)
CA default	52	52
CA 50 RPS	96	61
CA 80 RPS	140	78
CA balanced	93	98
CA 195 RPS	324	128
WI default	52	52
WI 50 RPS	147	85
WI 80 RPS	202	106
WI balanced	128	112
WI 172 RPS	413	189
Germany default	73	73
Germany 50 RPS	126	83
Germany 80 RPS	194	109
Germany balanced	84	88
Germany 154 RPS	377	190

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
CO_2 emissions and costs under multiple scenarios for California, Germany, and Wisconsin.

	% CO_2 reduction	EIA ($/ton CO_2 reduced)	OR/PN ($/ton CO_2 reduced)
CA 50 RPS	50	280	42
CA 80 RPS	70	393	91
CA balanced	87	150	128
CA 195 RPS	87	775	300
WI 50 RPS	48	633	174
WI 80 RPS	67	729	210
WI balanced	81	303	192
WI 172 RPS	81	1168	440
Germany 50 RPS	50	348	103
Germany 80 RPS	69	553	184
Germany balanced	86	207	88
Germany 154 RPS	86	877	335

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.

Gas System Composition

	100% Natural Gas	Natural Gas/Renewable Gas Blend	100% Renewable Gas
	Near-Term	Mid-term	Long-term
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.

<u>Example in</u>:

PLUGGING IN / ENERGY / ENVIRONMENT / OPINION

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! +

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