Regional Energy Challenges

Connecticut Power & Energy Society

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What is the Question?

New England needs infrastructure

- *Resource vulnerabilities, state policy*

Infrastructure costs money

- *Consumers will pay*

But which consumers should pay…

- *…for what, and how?*

Regional Energy Challenges

The challenge

- Starting from today, how might/should New England's power system evolve to maintain reliability, given the following key factors:
  - Negative winter demand growth, modest summer growth
  - Tightening winter fuel supply conditions
  - Potential retirements (coal, oil, nuclear)
  - Rapid growth in distributed resources (energy efficiency, solar)
  - Multiple resource options, grid-level and distributed, gas and non-gas

What is the context?

- Starting point – wholesale market outcomes: *enable competition, minimize long-run costs and risks to electricity consumers*
  - Including recent major changes to ensure reliability, *in the face of fuel delivery challenges*
- Market corrections – state policy goals:
  - achieve carbon reduction and energy/economic policy goals (to extent not already reflected)
- Key driver – fully integrated assessment of ratepayer costs and risks, considering policy goals and market impacts

A Rude Awakening?

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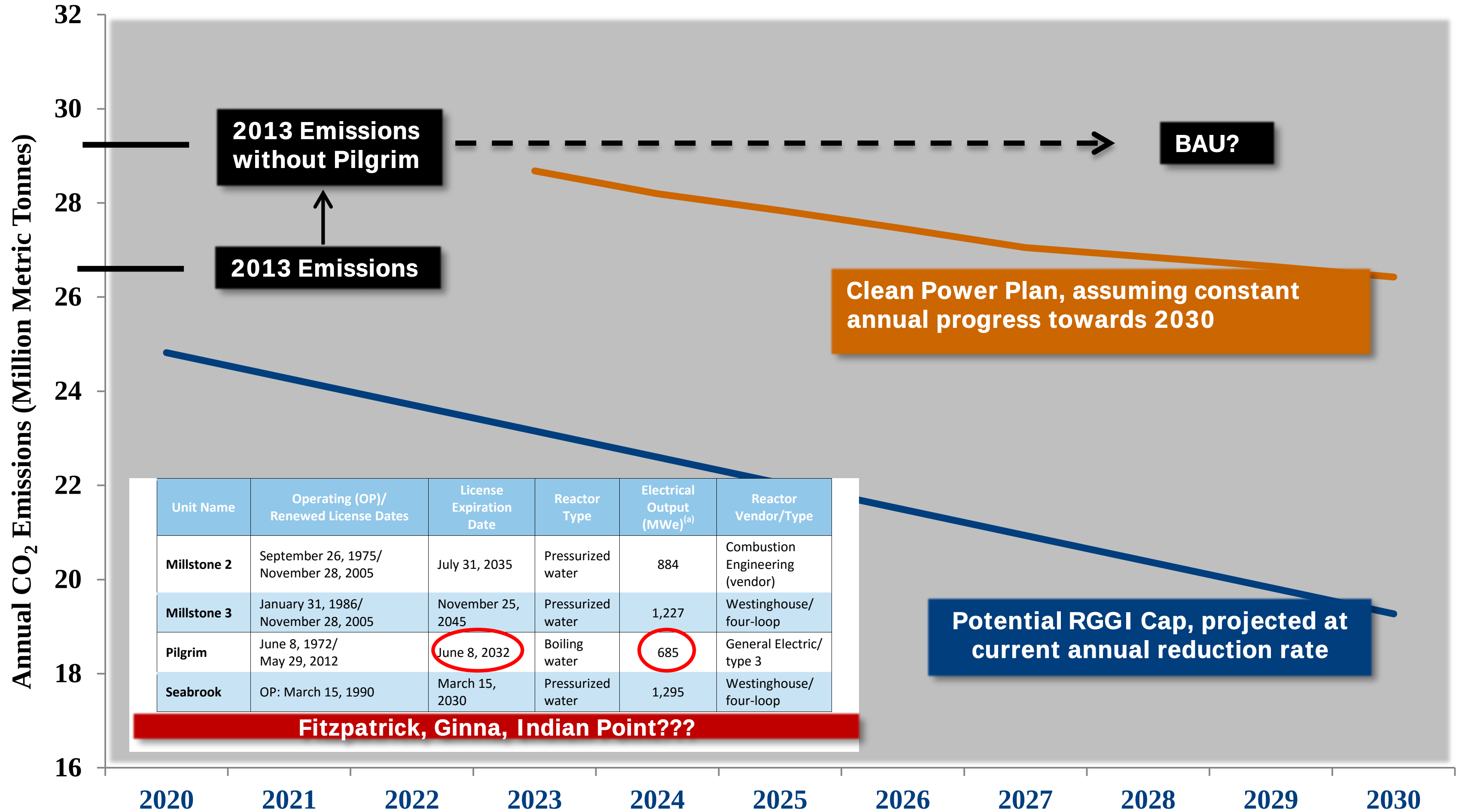
ECONOMIC, FINANCIAL and STRATEGY CONSULTANTS

New England Emissions vs. RGGI and Clean Power Plan Emission Goals



Unit Name	Operating (OP)/ Renewed License Dates	License Expiration Date	Reactor Type	Electrical Output (MWe)[a]	Reactor Vendor/Type
Millstone 2	September 26, 1975/ November 28, 2005	July 31, 2035	Pressurized water	884	Combustion Engineering (vendor)
Millstone 3	January 31, 1986/ November 28, 2005	November 25, 2045	Pressurized water	1,227	Westinghouse/ four-loop
Pilgrim	June 8, 1972/ May 29, 2012	June 8, 2032	Boiling water	685	General Electric/ type 3
Seabrook	OP: March 15, 1990	March 15, 2030	Pressurized water	1,295	Westinghouse/ four-loop

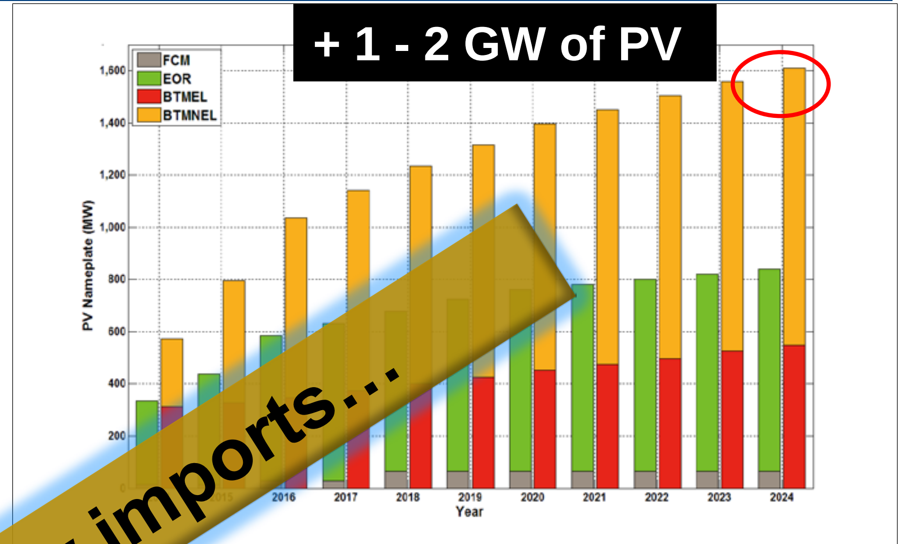
Pilgrim replacement assumes 2014 Pilgrim output (5.8 TWh) at New England marginal emission rate (941 lb/MWh). Table from ISONE

Changing Resource Mix

State	Annual Energy Savings (GWh)			Summer Peak Demand Reductions (MW)			Winter Peak Demand Reductions (MW)		
	2015	2024	CAGR[a]	2015	2024	CAGR[a]	2015	2024	CAGR[a]
CT	2,554	4,655	6.9	420	732	6.4	412	673	5.6
ME	1,025	2,012	7.8	157	264	5.9	155	283	6.9
MA	4,382	12,018	11.9	760	1,904	10.7	752	1,782	10.1
NH	508	936	7.0	84	155	7.0	82	126	4.8
RI	720	1,860	11.1	139	315	9.5	138	306	9.2
VT	791	1,486	7.3	124	210	6	123	198	5.4
ISO	9,980	22,967	9.7	1,685	3,579	8.7	1,663	3,370	8.2

+ 3 - 4 GW of EE

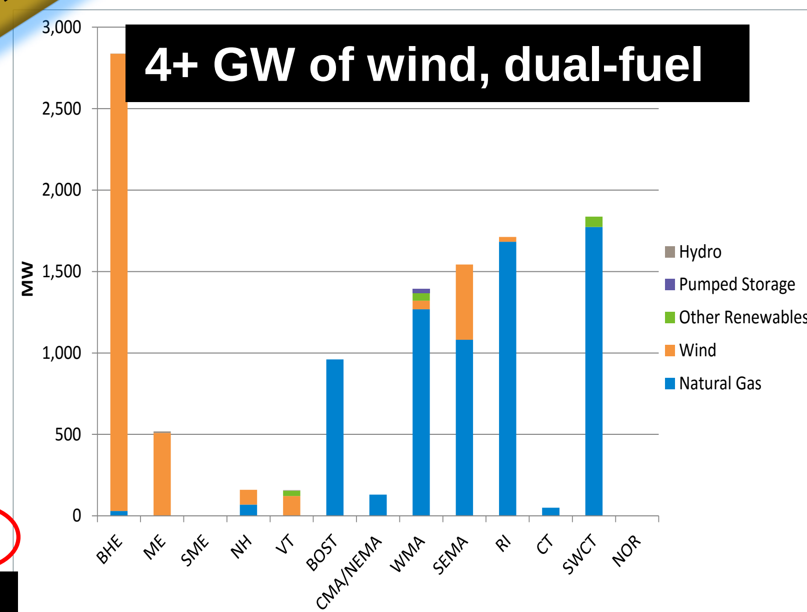
+ 1 - 2 GW of PV



+ 1 – 3 GW of new imports…

Area	Energy (1,000 MWh)			Summer Peak Loads (MW)					Winter Peak Loads (MW)				
				50/50 Load		90/10 Load			50/50 Load		90/10 Load		
	2015	2024	CAGR	2015	2024	2015	2024	CAGR	2015/16	[illegible]	2015/16	2024/25	CAGR
CT	31,729	32,327	0.2	6,998	7,276	7,683	8,016	0.5	5,358	5,347	5,528	5,517	0
ME	11,531	11,434	−0.1	1,987	2,056	2,127	[illegible]	0.5	1,820	1,752	1,875	1,812	−0.4
MA	59,120	58,229	−0.2	12,287	12,933	13,317	14,093	0.6	9,648	9,438	9,943	9,733	−0.2
NH	11,777	12,614	0.8	2,523	2,827	2,728	3,082	1.4	1,983	2,104	2,063	2,184	0.6
RI	8,151	7,588	−0.8	1,825	1,881	2,070	2,166	0.5	1,297	1,194	1,342	1,239	−0.9
VT	5,871	5,497	−0.7	950	898	995	953	−0.5	967	967	982	982	0
ISO	128,173	127,698	0	26,565	27,875	28,915	30,525	0.6	21,077	20,805	21,737	21,465	−0.1

4+ GW of wind, dual-fuel

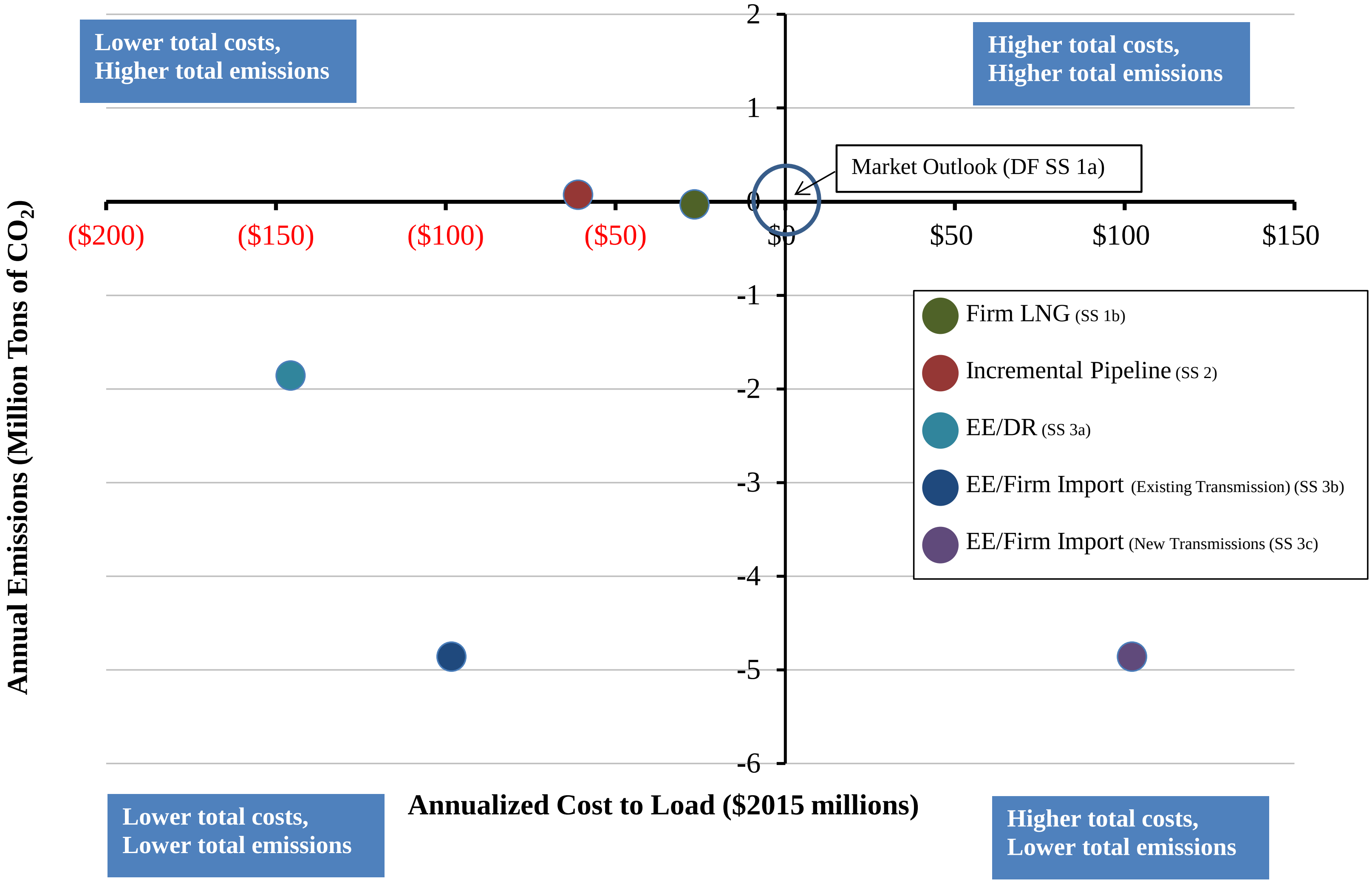


Anemic/negative growth

Dependence on Natural Gas

- **Winter fuel delivery problem is important, and could get worse**
  - Not a problem for heating & commercial/industrial process needs (Gas LDCs obligated to meet needs, backed where needed by federal siting authority)
  - Changing system will continue region's electric system need for gas and oil
  - Fundamental disconnects exist between electricity and gas markets, industries, and law/regulation
- **Additional gas-fired capacity will be added to replace legacy units; "nimble" capacity needed to facilitate renewable integration**
- **ISONE has taken steps within its purview – focused on market solutions to deliver low-cost, efficient outcomes**
  - Incentives for investments for fuel assurance and performance when needed – FCM PI, 7-year lock-in, sloping demand curve
  - Reserve levels and pricing; energy market timing and flexibility
  - Performance auditing, increased vision into gas system conditions
- **Left to market, solutions would emerge**
  - …but most likely ***not*** involve major natural gas pipeline capacity additions (for electricity generation) – too expensive

Integrated Assessment



Note: Pipeline solutions include an estimate for incremental in-region GHG emissions from fugitive methane leaks.

Other Considerations

Many tradeoffs

- Markets versus state approach
- Up-front investment versus adjustable annual costs
- Shades on levels of reliability
- Siting/permitting
- Installation/ramping challenges
- Out-of-region GHG implications

Solution Set	Other Considerations
Market Driven Outcomes	
SS 1a: Dual-fuel Capacity ("Status Quo")	• No up-front investment and requires no action on the part of legislatures or regulators • Dual-fuel upgrade costs may not be passed on to consumers (unless upgrade cost affects marginal capacity market prices), costs borne by producers represent a reduction in profits • Relying on oil during winter peak periods has only limited impact on winter gas prices; when oil prices are low, economic oil-fired generation can reduce on-site inventories leading into stressed winter conditions • Air quality permits often restrict total hours of oil-fired operation, though restrictions generally allow more hours of operation than needed to address winter peak reliability needs • Operation time at units will be limited by the quantity and size of oil storage tanks, ability to switch from gas to oil, and ability to replenish supplies, which can be challenging during extreme cold periods
SS 1b: Firm LNG Capacity	• No up-front costs to consumers; implementation costs reflected in energy market prices on as-needed basis • LNG use targeted to deficiency may have only limited impact on winter delivered gas prices • Creates flexibility with respect to intra-annual operations and allows for 5 year lead time for renegotiation or pursuit of alternative solution sets if needed • Contract prices and terms are untested at this point; firm commitments remain dependent on contract language and financial penalties; imports constrained by global price risk, global supply production risk • Prices ultimately would be set by few suppliers with limited competition
Incremental Pipeline Capacity	
SS 2: Incremental Pipeline:	• Major up-front investment creates long-term ratepayer cost obligation; obligation remains even if use or value of assets diminish or is limited for any reason (e.g., evolution of GHG reduction goals/obligations) • Increased certainty of solution set once approved; known in-service date allows for accountability and tracking of progress made by a single entity • Mechanism to guarantee firm transportation for electricity generation at winter peak is unknown • Increased capacity reduces or eliminates the value of existing capacity release benefits, which may lead to a net loss for gas ratepayers, LDC shareholders, and portfolio managers • Increased in-region flows may be used to serve other markets or LNG exports, potentially increasing pipeline utilization and reducing or eliminating price suppression benefits • Faces significant siting and regulatory challenges, potential local property value impacts and non-GHG environmental impacts • May increase GHG outside New England, and an associated increase in natural gas production and consumption would also increase non-GHG environmental impacts
Energy Efficiency, Demand Response, and Renewable Energy	
SS 3a: Energy Efficiency and Demand Response	• Up-front investment is annual, and can be adapted on an annual basis in consideration of actual need and changes in technology, policy and cost factors; actual technologies/programs relied on could adjust in response to technology and cost breakthroughs • Requires a sustained commitment by states for investment, likely over many years; absent a commitment the EE/DR solution cannot be counted on to meet deficiency in later years • Realization could be limited by ability to ramp up resources and providers; full suite of benefits are not immediately available • Requires robust monitoring and verification to ensure expected winter peak impacts are being realized • Annual costs are not certain – could either grow or decline in later years
SS 3b/c: Energy Efficiency and Firm Imports (existing and new transmission)	• (See above in SS 3a regarding EE) • Major up-front investment creates long-term ratepayer cost obligations; ratepayer obligation remains even if use or value of assets diminish or is limited for any reason • Must guarantee and price firm winter/year-round capacity; otherwise, cannot be counted on to address deficiency; availability and cost of a firm winter deliverable product is unknown

Wrap up

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- Incredibly complicated economic, policy, and environmental challenge for the region
- Markets will preserve reliability, but will not necessarily produce outcomes consistent with policy maker objectives
  - Yet interference with market outcomes has its own risks
- State-driven efficiency, pipeline, and transmission approaches all produce market price benefits
- Efficiency, renewable paths are the only ones consistent with long-term climate objectives

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DOOSAN

Fuel Cells: The Clean Energy You Count On

CT Power and Energy Society

March 9, 2016

DOOSAN FUEL CELL

ABOUT US

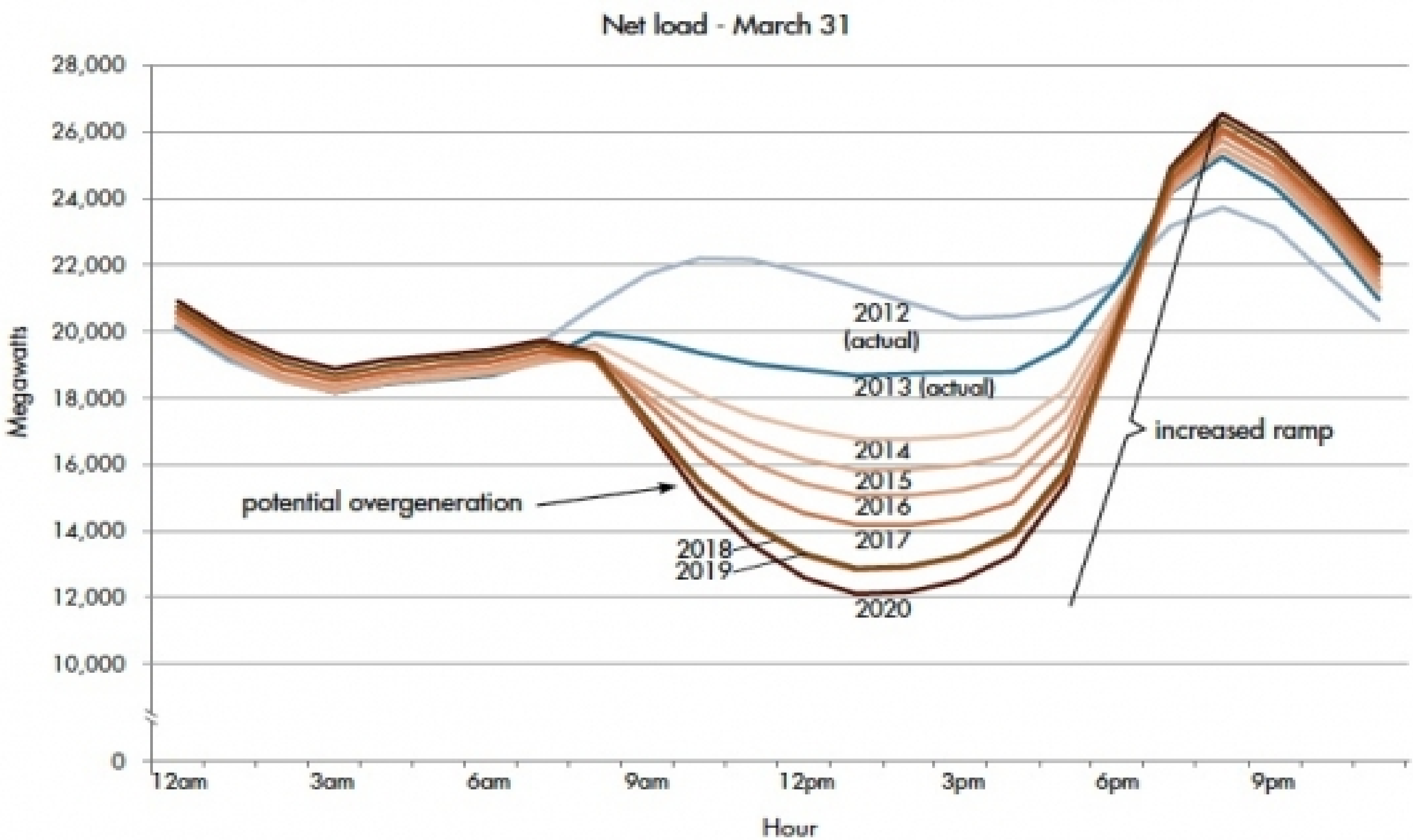
- Focused on being the #1 global leader in fuel cells
- Headquarters and operations in South Windsor, CT
- Leading-edge R&D staff with broad patent portfolio
- Made in the U.S.A. with automated production line
- Expert global service team with 24/7 support

50 years of fuel cell experience	300+ innovative employees	110 megawatts installed	12 million fleet hours	10 year cell stack life

DOOSAN

THE CALIFORNIA DUCK CURVE

Intermittent renewables are challenging grid resources



DOOSAN FUEL CELL

PureCell® Model 400

440 kW fuel cell combined heat and power system fueled by natural gas

RELIABLE

- Continuous power operation
- 95+% capacity factor
- Grid-independent emergency power
- 10 year fuel cell life

DISPATCHABLE

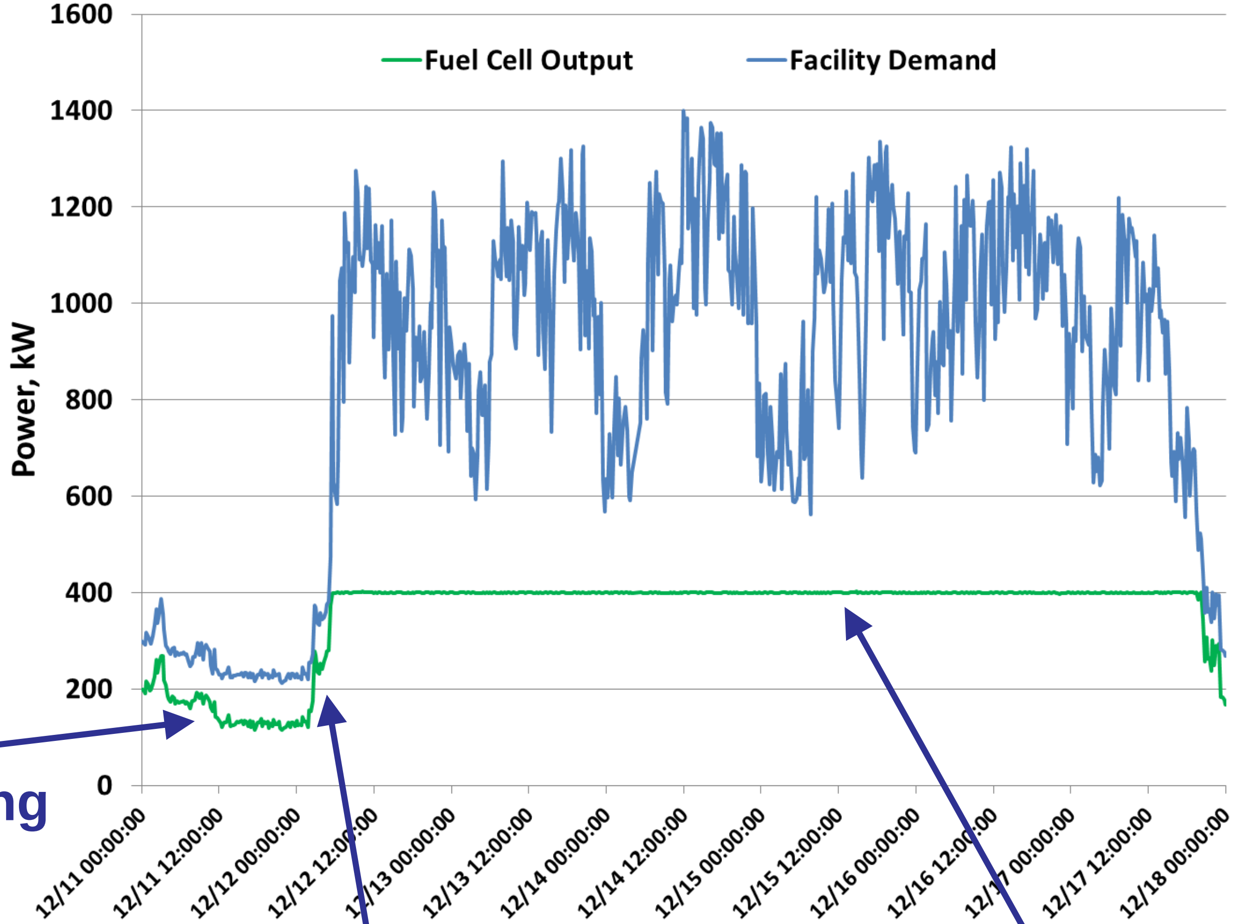
- 0 – 100% power set-point
- 10 kW/sec ramp rate
- Multi-MW scalable
- Small footprint

CLASS 1 RENEWABLE

- 90% system efficiency
- Ultra-low air emissions
- No water consumption

DISPATCHABLE POWER

Reliable and controllable power for production facility



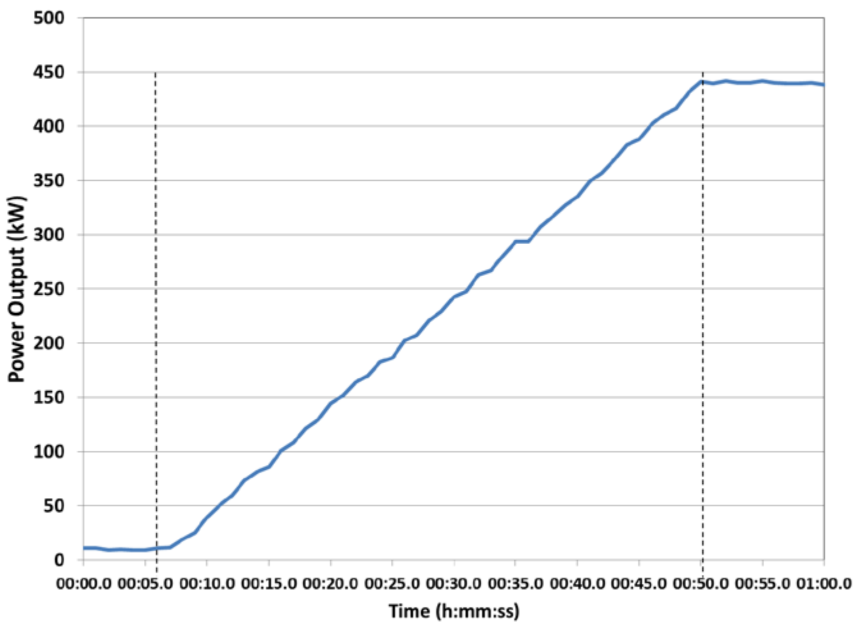
Load-following

Fast ramping

Steady output

FAST RAMPING

Zero to full power in 45 seconds



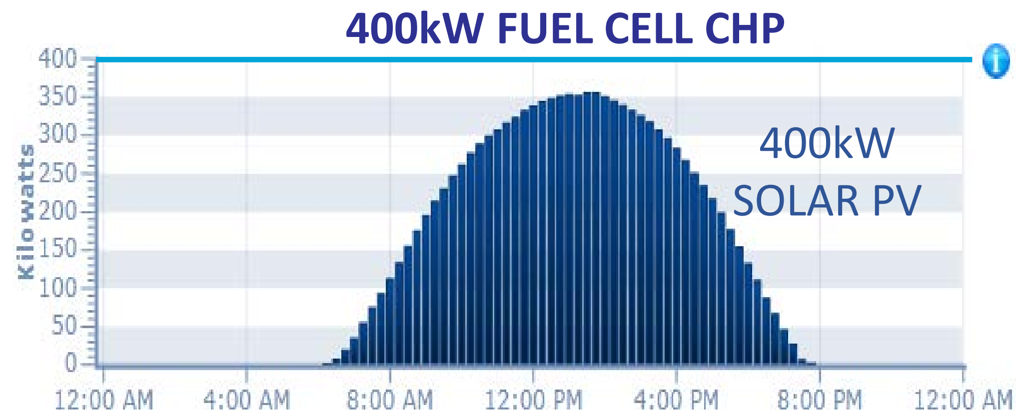
Performance is scalable with # of units

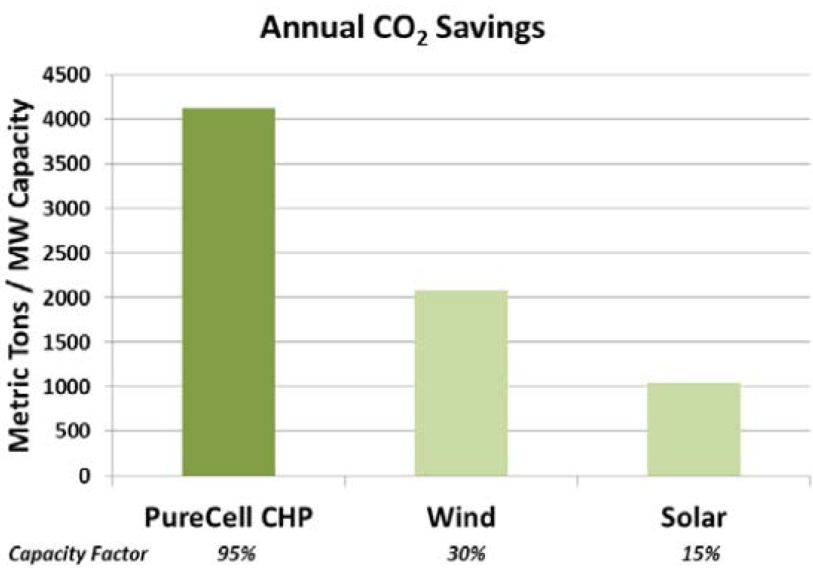
30 MW site can respond in same time period

FUEL CELL COMPARED TO SOLAR

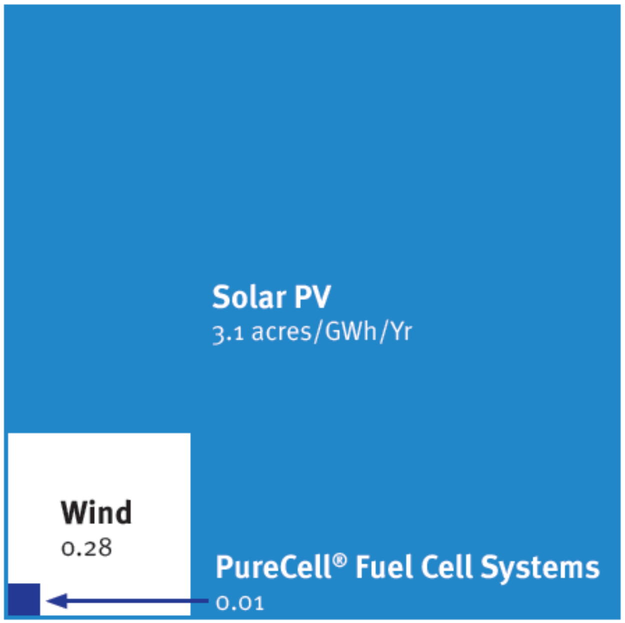
PURECELL SYSTEM

- 6x more energy output
- 4x more CO_2 savings
- 300x less land use



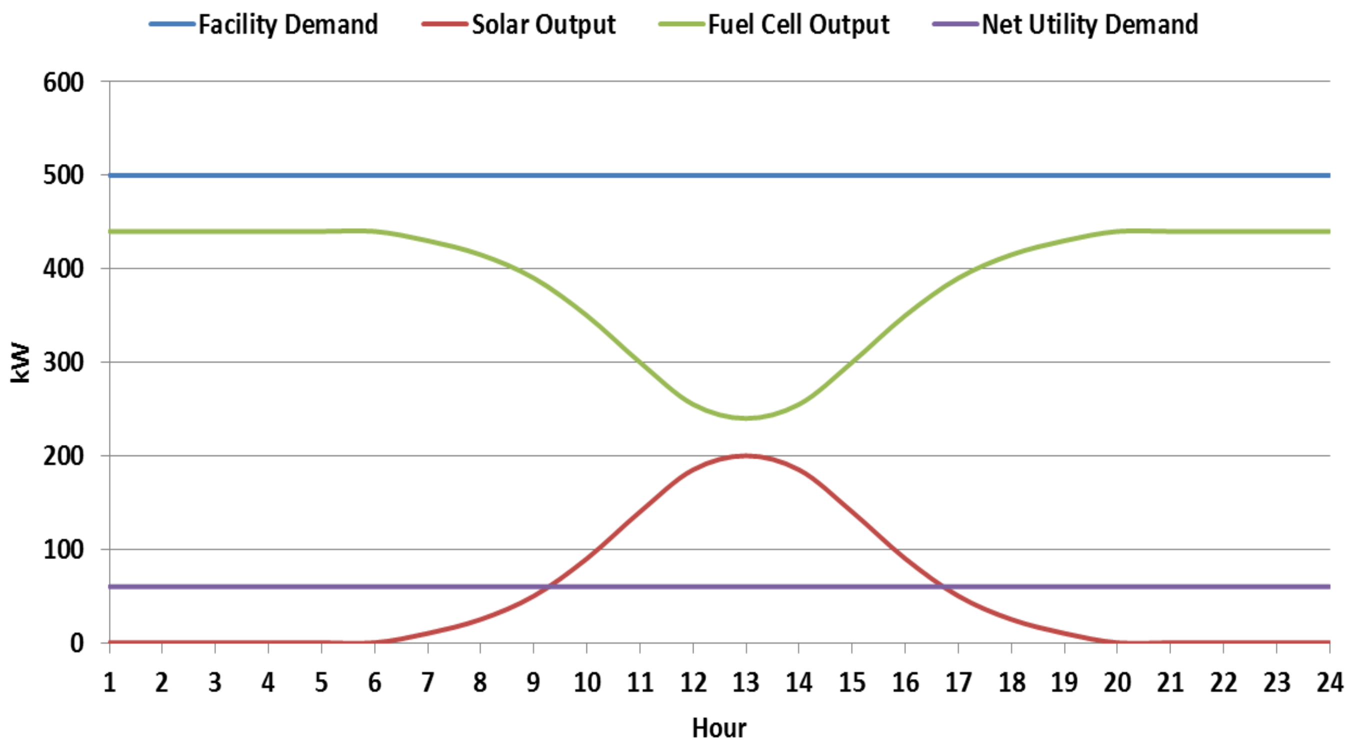


Compared to U.S. average fossil-fueled generation



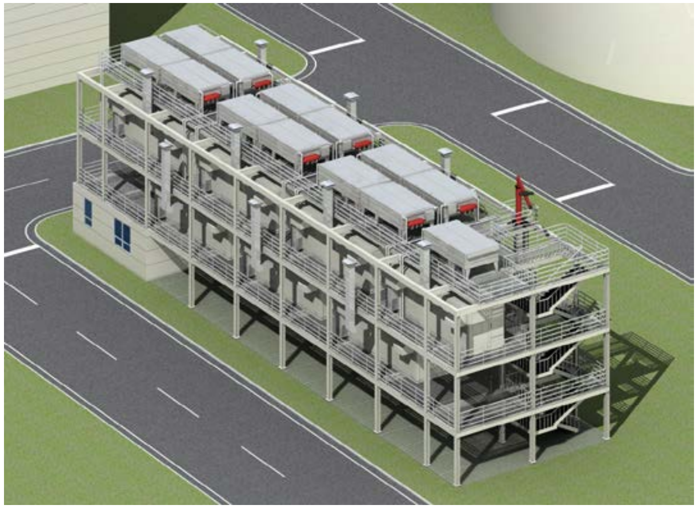
FUEL CELLS WITH SOLAR

Fuel cells and solar can work together to provide level supply/load



UTILITY DISTRIBUTED GENERATION

GS Power 4.8 MW
(operating since 2010)



Korea Southeast Power
5.7 MW on multi-level structure
(in commissioning)

Busan City District Heat Plant
30 MW on multi-level structure
(under construction)