Valuing Nuclear in Long-term Energy Models

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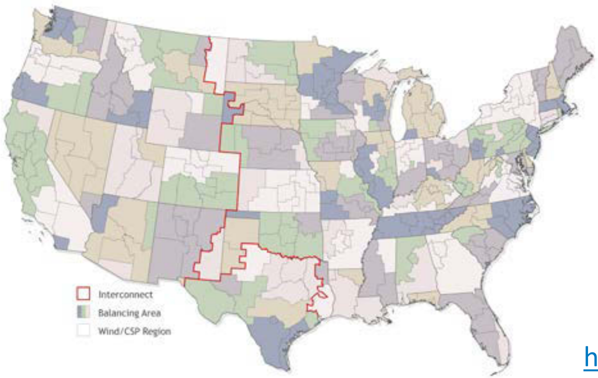
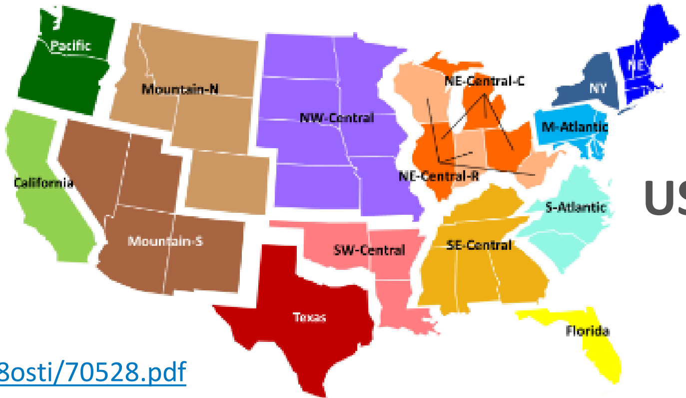
What Are Long-term Energy Models?

EPA's IPM

EIA's NEMS



NREL's ReEDS

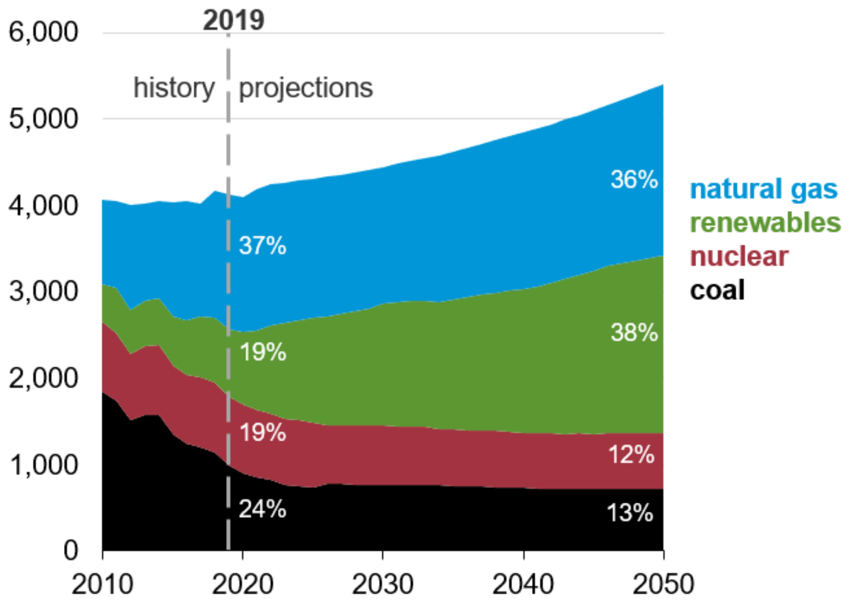


EPRI's US-REGEN

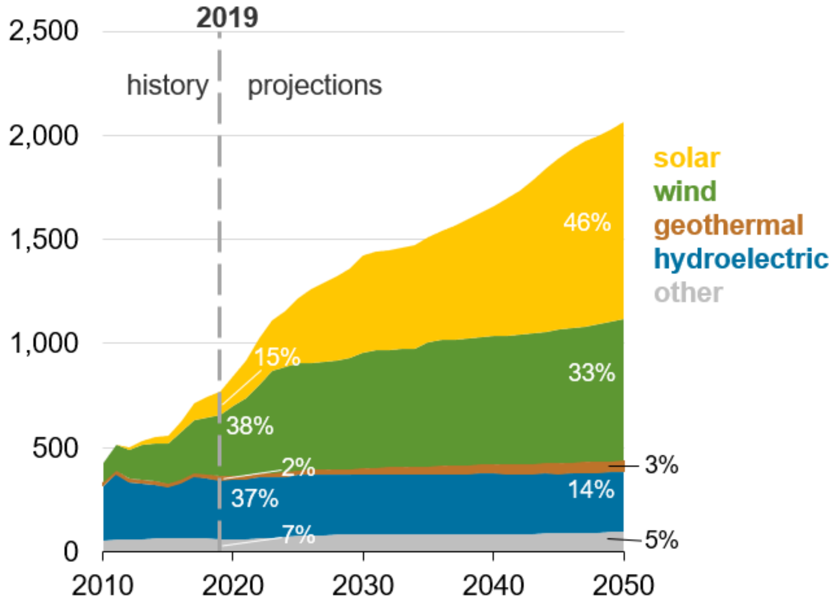
https://www.nrel.gov/docs/fy18osti/70528.pdf

Electricity generation from natural gas and renewables increases as a result of lower natural gas prices and declining costs of solar and wind renewable capacity, making these fuels increasingly competitive

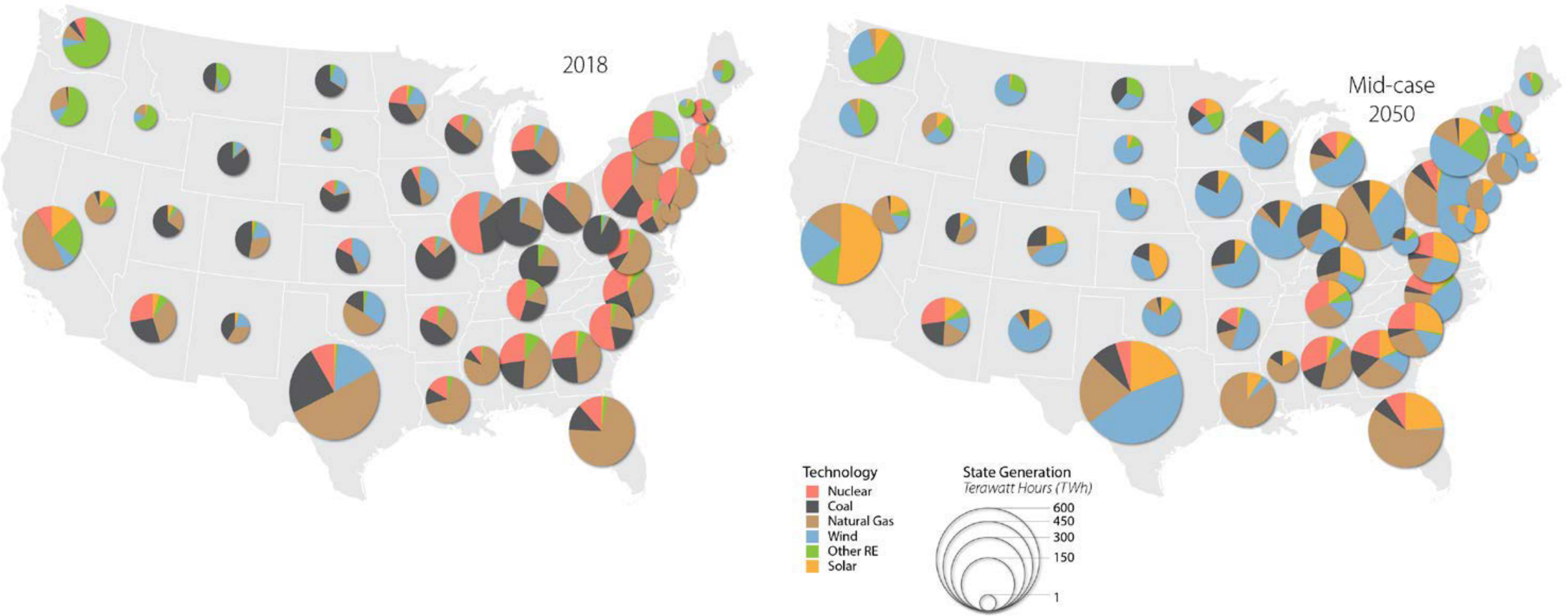
Electricity generation from selected fuels (AEO2020 Reference case)
billion kilowatthours



Renewable electricity generation, including end use (AEO2020 Reference case)
billion kilowatthours

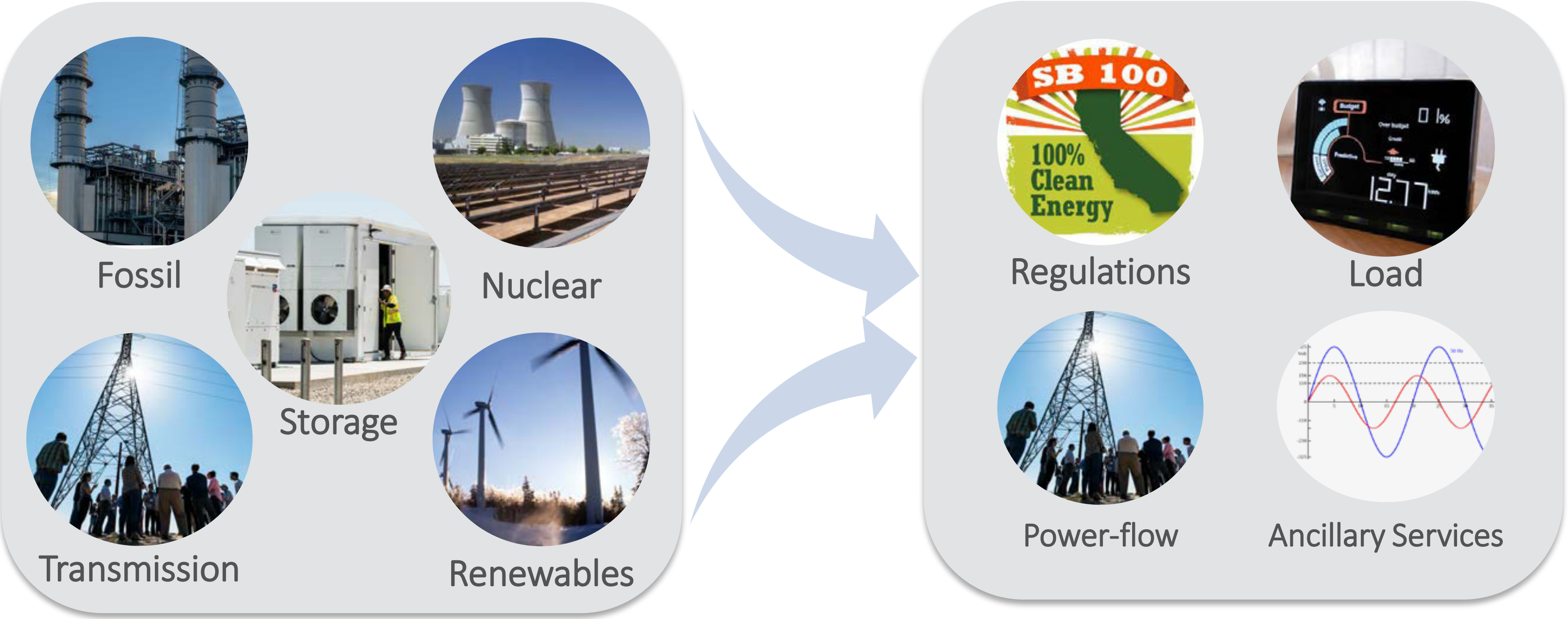


NREL Standard Scenarios: System Evolution by State in the Mid-case

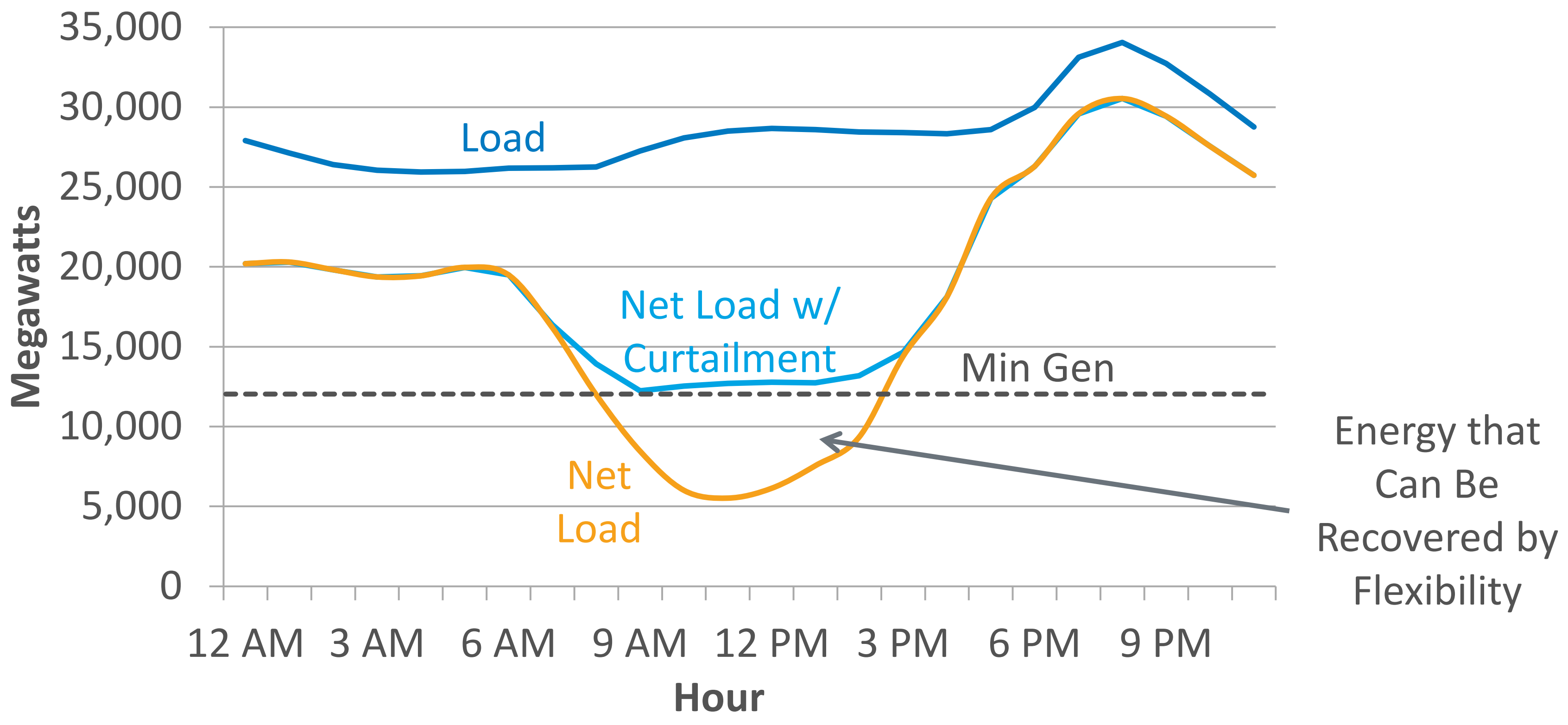


https://www.nrel.gov/docs/fy20osti/74110.pdf

Evaluate Cost and Value of Resources to Determine Optimal Mix (i.e., not LCOE)



Value of Daily Flexibility

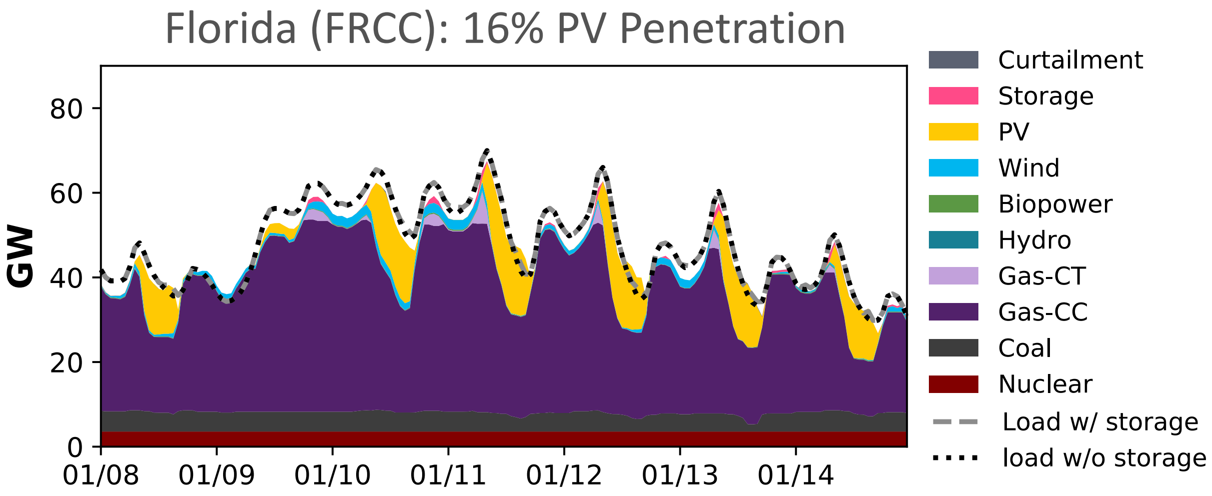


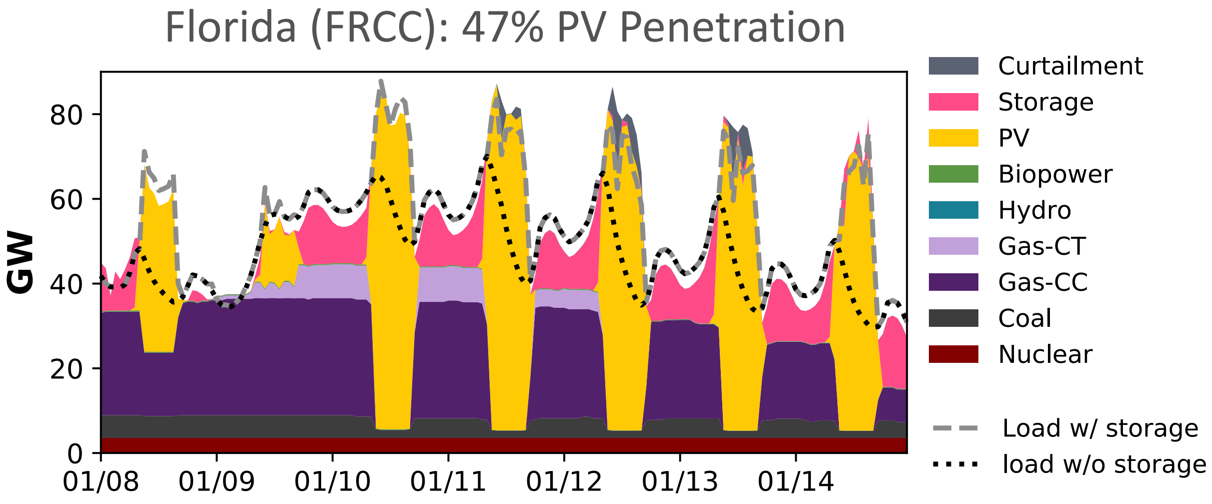
Source: Denholm et al., Overgeneration from Solar Energy in California: A Field Guide to the Duck Chart (2015)

System Operation during a High-stress Period

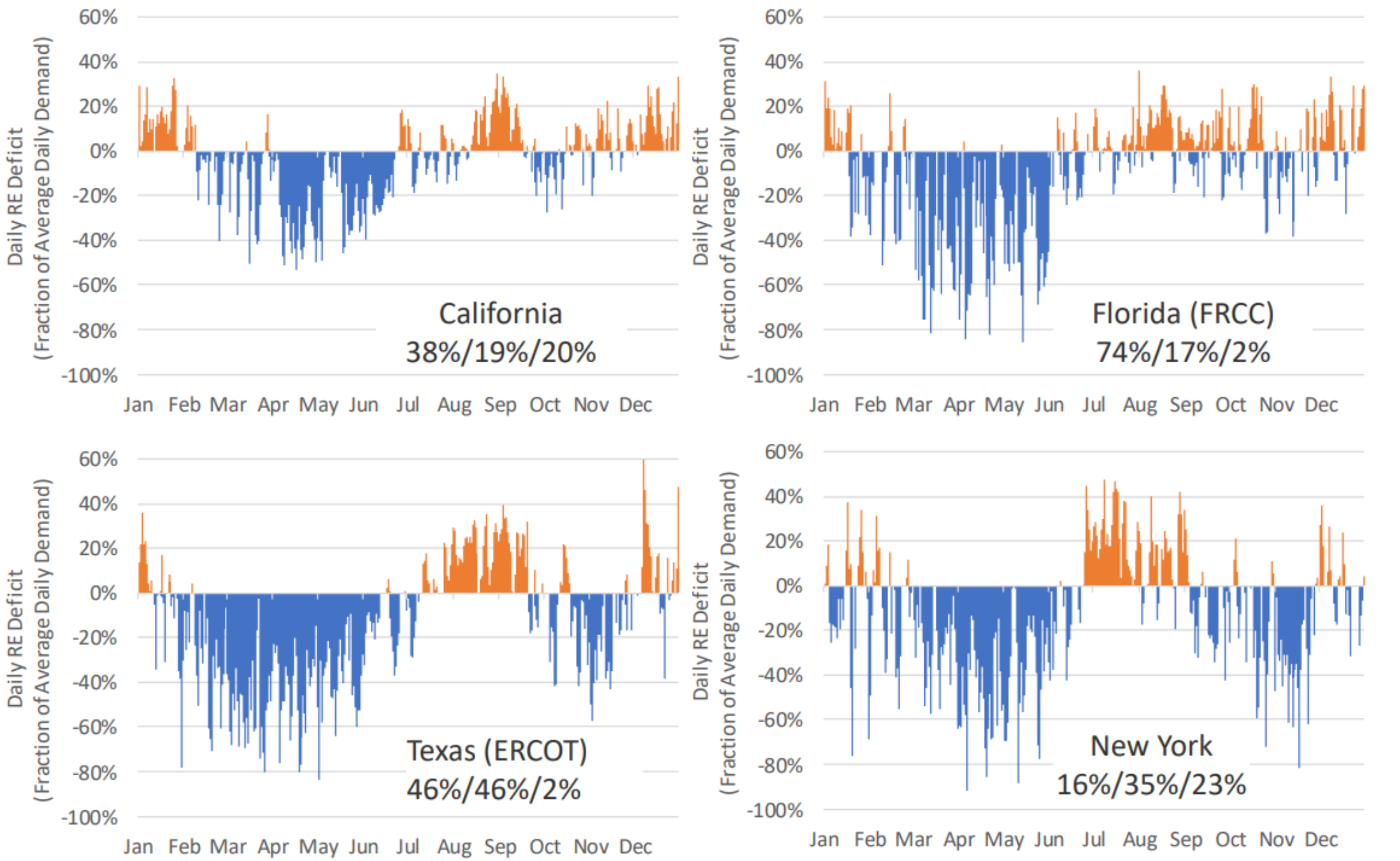
(January 2-13, 2010, coldest 12-day period in Florida since 1940)

Source: Cole et al., *Applied Energy*, 2020 https://www.sciencedirect.com/science/article/pii/S0306261920312782





Seasonal Flexibility

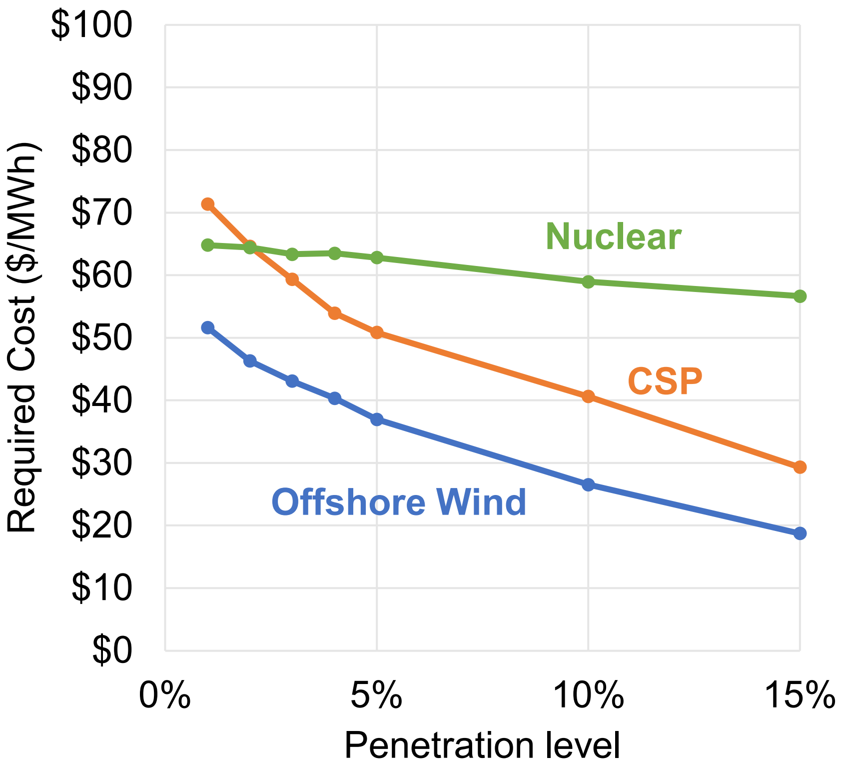


Each region meets 95% of demand with renewable energy

Percent values are wind/PV/Other RE

Source: Denholm, "The Last 10%", ESIG Fall Workshop October 1, 2020

Examining Breakeven Cost



- Nuclear can maintain value with penetration better than variable renewable energy generators

Source: Mai, Cole, and Reimers, *Applied Energy*, 2019, https://www.sciencedirect.com/science/article/pii/S0306261919308542

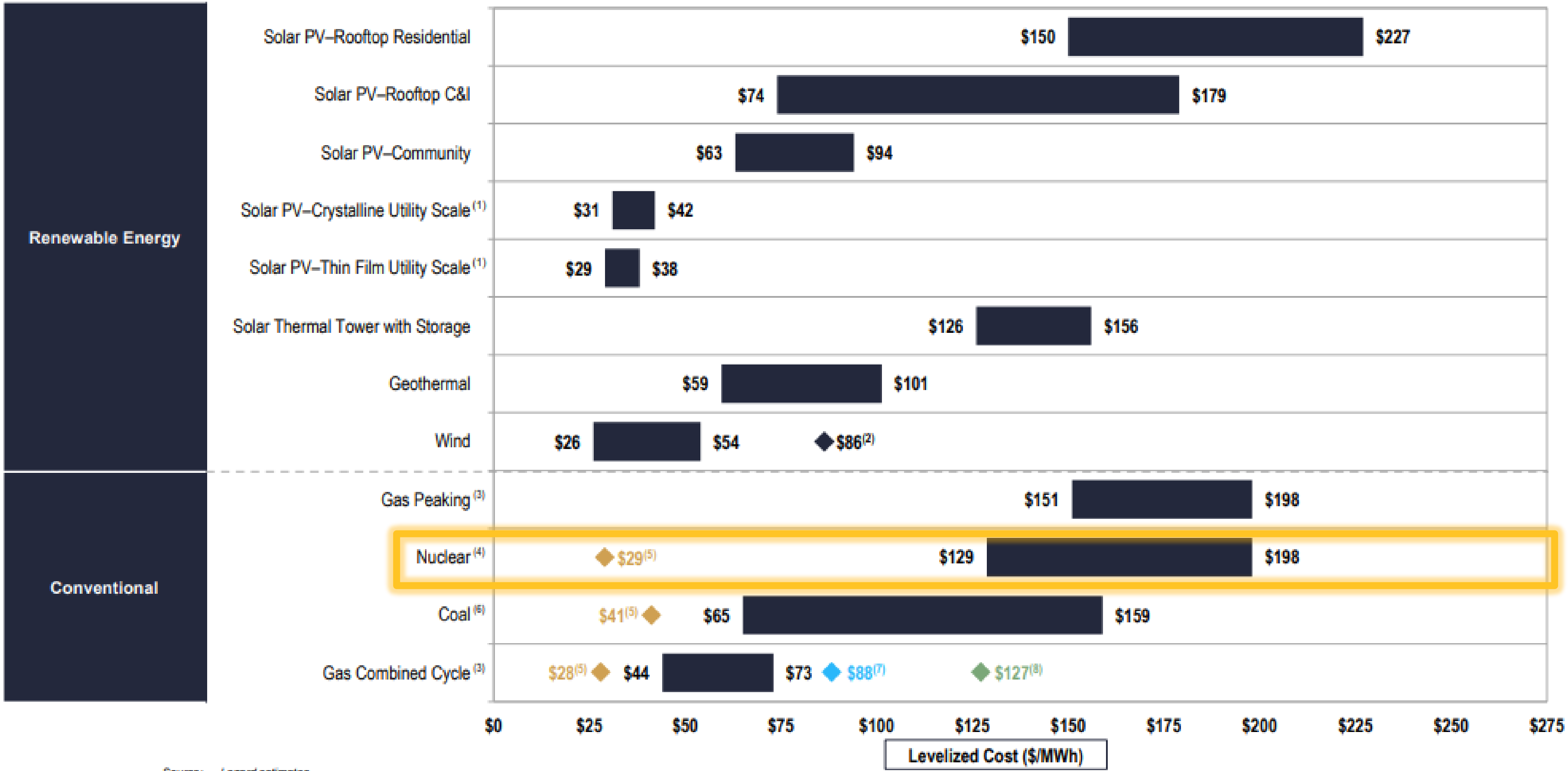
Challenge to Nuclear Power in Long-term Models

Source: Lazard, LCOE Analysis, 2020, slide 18

	Units	Gas Peaking		Nuclear (New Build)		Coal (New Build)		Gas Combined Cycle (New Build)	
		Low Case	High Case	Low Case	High Case	Low Case	High Case[3]	Low Case	High Case
Net Facility Output	MW	240	50	2,200	2,200	600	600	550	550
EPC Cost	$/kW	$675	$875	$6,025	$9,800	$2,350	$4,925	$650	$1,150
Capital Cost During Construction	$/kW	$25	$50	$1,650	$2,700	$550	$1,300	$50	$100
Total Capital Cost[1]	$/kW	$700	$925	$7,675	$12,500	$2,900	$6,225	$700	$1,250
Fixed O&M	$/kW-yr	$7.25	$22.75	$119.00	$133.25	$39.75	$83.00	$14.50	$18.50
Variable O&M	$/MWh	$4.25	$5.75	$3.75	$4.25	$2.75	$5.00	$2.75	$5.00
Heat Rate	Btu/kWh	9,800	8,000	10,450	10,450	8,750	12,000	6,150	6,900
Capacity Factor	%	10%	10%	92%	89%	83%	63%	70%	50%
Fuel Price	$/MMBtu	$3.45	$3.45	$0.85	$0.85	$1.45	$1.45	$3.45	$3.45
Construction Time	Months	12	18	69	69	60	66	24	24
Facility Life	Years	20	20	40	40	40	40	20	20
CO_2 Emissions[2]	lb/MWh	1,147	936	—	—	1,839	252[3]	720	807
Levelized Cost of Energy	$/MWh	$151	$198	$129	$198	$65	$159	$44	$73

Relative Cost of Nuclear Power

Source: Lazard, LCOE Analysis, 2020, slide 2

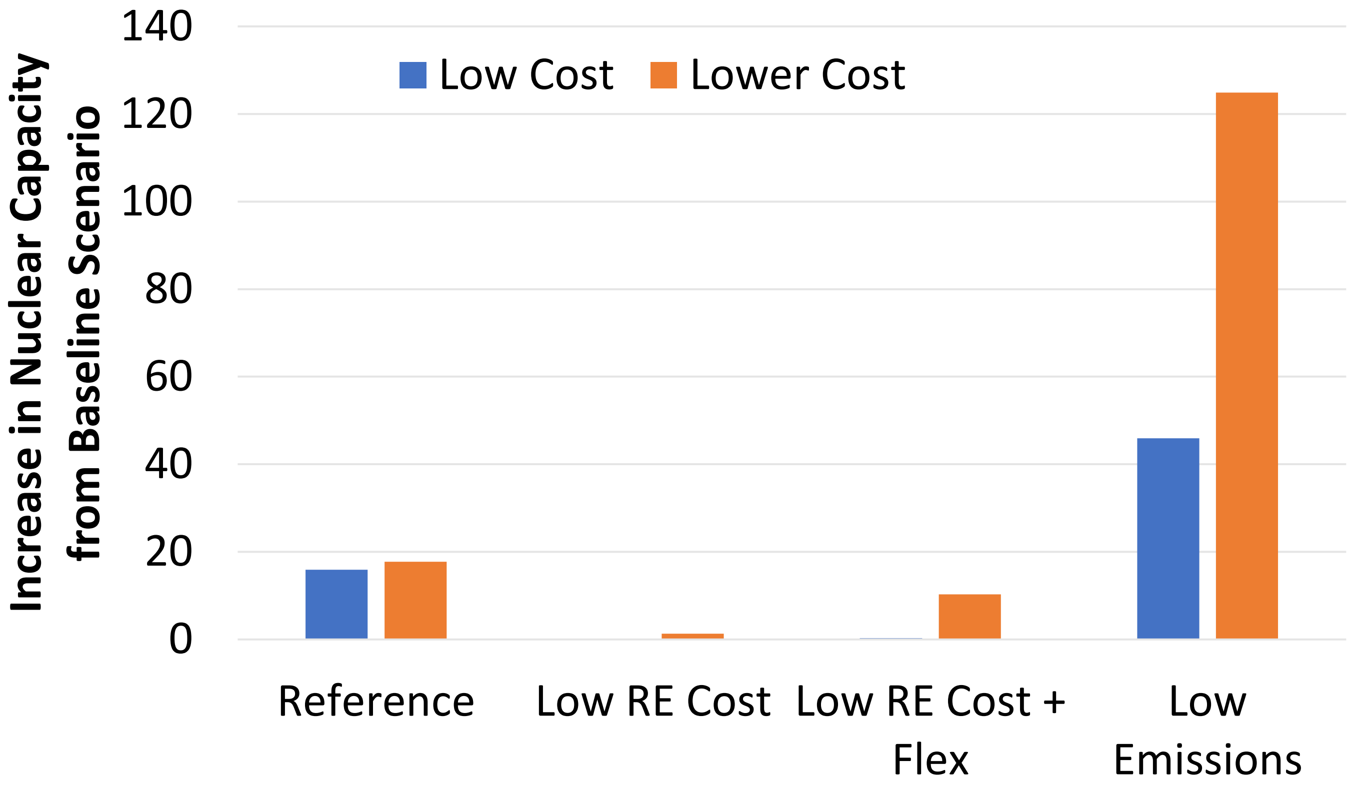


Drivers of New Nuclear Deployment

1. Capital cost
2. Valuing carbon abatement
3. Higher/lower costs of competing technologies
4. Increased operational flexibility

- Additional revenue streams (e.g., hydrogen production)

Drivers of Deployment Example



Source: Flexible Nuclear Energy for Clean Energy Systems, NREL/TP-6A50-77088, 2020

Summary

- Capturing cost and value are important for proper long-term energy modeling
  - Given the increased role of variable renewable energy, this typically requires sophisticated models and large datasets
- Primary barrier of deployment from scenario modeling is capital cost

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