



Constructing an HEPG Agenda

Electricity/Energy Markets in Transition
Addressing the Climate Challenge But Preserving
Affordable Rates and Reliability

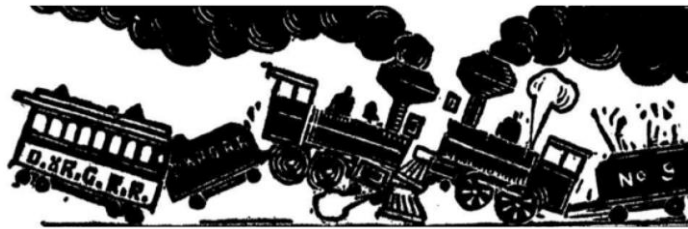
Abram W Klein

14 October 2022

Harvard Electricity Policy Group

Dueling Train Wrecks

Impending Climate Catastrophe vs. Reliability/Market/J&R Collapse from "Speeding"



Humanity has a 'brief and rapidly closing window' to avoid a hotter, deadly future, U.N. climate report says

The latest United Nations IPCC report details the escalating toll of climate change — but top scientists say the world still can choose a less catastrophic path.

By Sarah Kaplan February 28, 2022 at 6:00 AM EST

Climate & Environment

'Uncertainty is not our friend': Scientists are still struggling to understand the sea level risks posed by Antarctica

A pair of scientific studies find we can still probably avert extreme sea level rise — but also show how little scientists still understand about the biggest threat, Antarctica.

By Chris Mooney May 05, 2021 at 11:02 AM EDT

Climate & Environment

2021 brought a wave of extreme weather disasters. Scientists say worse lies ahead.

Studies presented at the world's largest climate science conference offered an unsettling message: Climate change is fundamentally altering what kind of weather is possible.

By Sarah Kaplan December 17, 2021 at 1:18 PM EST

Climate & Environment Climate Solutions Hurricane season Global warming World impacts Global emissions Extreme heat Biden's actions

Greenland ice sheet set to raise sea levels by nearly a foot, study finds

New research suggests the massive ice sheet is already set to lose more than 3 percent of its mass, even if the world stopped emitting greenhouse gases today.

By Chris Mooney August 29, 2022 at 10:00 a.m. EDT

BUSINESS

California scrambles to avoid blackouts as it pursues a green energy future

The state's power grid, at the forefront of America's energy transition, is under threat from an unprecedented September heat wave.

By Evan Halper and Erica Werner

Updated September 7, 2022 at 9:19 p.m. EDT | Published September 7, 2022 at 12:14 p.m. EDT

Five days in Texas as millions went without power amid a record cold snap

Blackouts left many unable to heat their homes, cook meals, work remotely or even sleep.

Capital Weather Gang

Analysis | Deadly Texas blackout shows our vulnerability to coming climate extremes

The event provides a glimpse of a "hellscape" future if we don't build resilience.

By Meryl Kornfield, Karly Domb Sadof

February 20, 2021 at 1:25 PM EST

Business

The fight over who will pay for Texas blackouts gears up

A high-stakes struggle is taking place in federal bankruptcy courts, in state courts and in the Texas legislature.

By Will Englund April 14, 2021 at 7:00 AM EDT

World

The E.U. is preparing for blackouts this winter, amid an energy crisis

The European Union is shoring up its resources as temperatures drop and energy supplies remain tight because of the Ukraine war.

By Annabelle Timsit

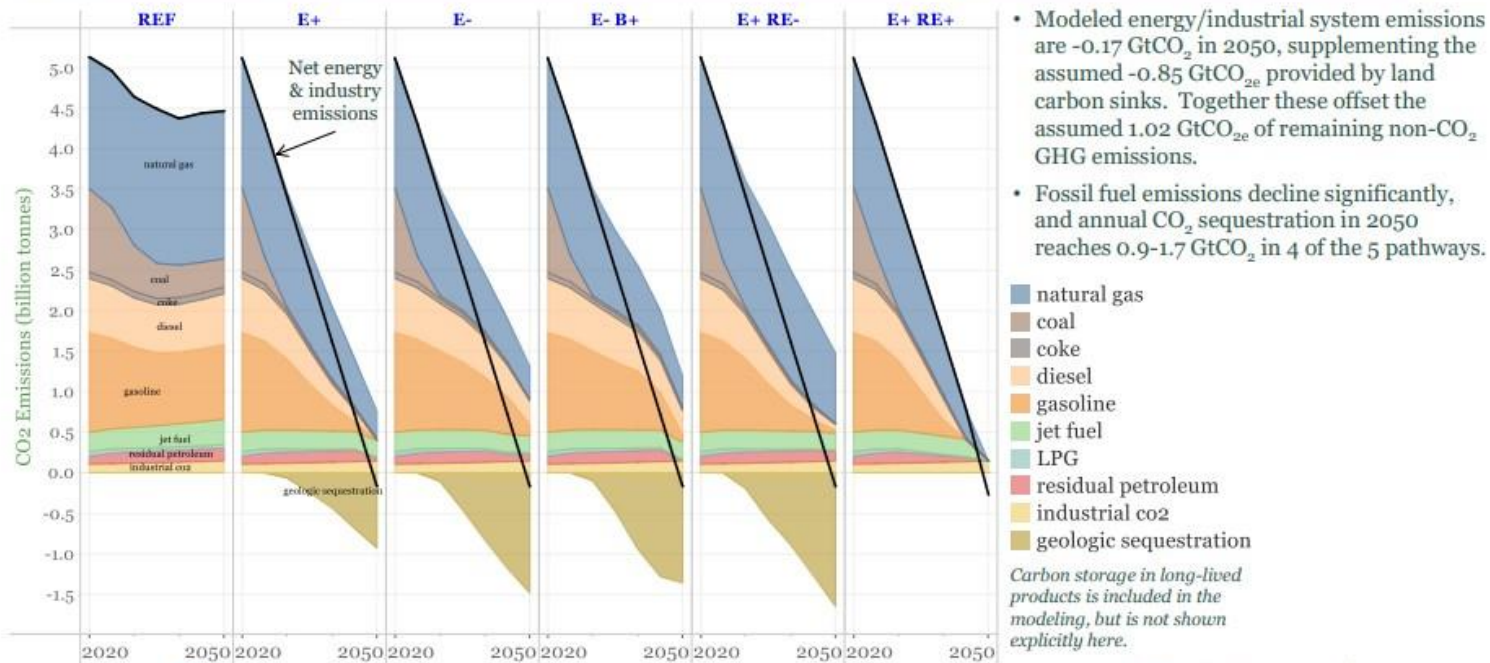
October 05, 2022 at 9:30 AM EDT



Working Backward from Net-Zero by 2050

Implications of “carbon free / electrify everything” strategy (see Princeton Net-Zero America)

Energy and industrial CO₂ emissions are net negative by 2050 to deliver net-zero emissions for the full economy



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High Meadows
Environmental
Institute

Carbon
Mitigation
Initiative



Working Backward from Net-Zero by 2050

"Carbon free / electrify everything" is....really massive (see Princeton Net-Zero America)

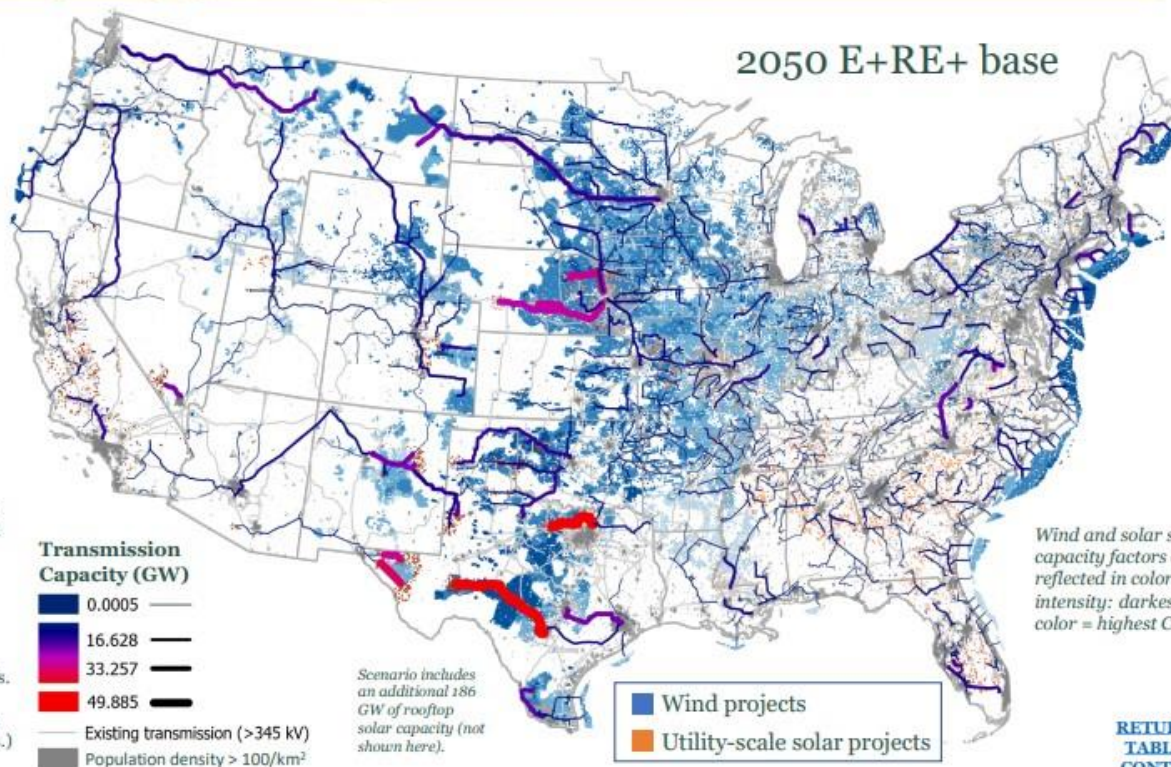
E+ RE+: 5.9 TW of wind and solar capacity operating in 2050;
transmission capacity grows to 5.1x the 2020 level.



2050		
	Wind	Solar
Capacity installed (TW)		
	3.07	2.75
Land used (1000 km²)		
Total	1,003	61.2
Direct	10.0	55.7
Capital invested (Billion \$₂₀₁₈)*		
Solar	-	2,684
Onshore wind	3,010	-
Offshore wind	594	-
Transmission added vs. 2020**		
Capacity (GW-km)	1,309,000	
Increase over 2020	409%	
Capital in serv (B\$ ₂₀₁₈)	3,560	

* Excludes investments associated with 2020 pre-existing capacity. Capital is for additional capacity required to meet total modeled wind & solar generation levels.

** Transmission expansion is mapped to follow existing rights of way (>160 kV); paths are indicative not definitive. Spur lines from solar and wind projects to substations are not shown, but are included in GW-km and investment totals. Capital in service includes capital for transmission expansions and "sustaining capital" (for end-of-life line replacements.)



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Working Backward from Net-Zero by 2050

“Carbon free / electrify everything” is....really massive
(see Princeton Net-Zero America)

Rapid expansion is needed, 2020 – 2050, across all six pillars to achieve net-zero emissions. 2050 goals for each pillar include:



1. Efficiency & Electrification

Consumer energy investment and use behaviors change

- Light-duty EVs: 210 million (E-) to 330 million (E+)
- Residential heat pump heaters: 80 million (E-) to 120 million (E+)

Industrial efficiency gains

- Energy intensity declines 1.9%/yr.
- Steel making evolves to all EAF and direct (H₂) reduced iron

4. CO₂ capture & storage

Geologic storage of 0.9 – 1.7 GtCO₂/y

- Capture at ~1,000+ facilities
- 21,000 to 25,000 km interstate CO₂ trunk pipeline network
- 85,000 km of spur pipelines delivering CO₂ to trunk lines
- Thousands of injection wells

2. Clean Electricity

Wind and solar

- 1.3 to 5.9 GW of solar and wind installed, up from 0.2 GW in 2020
- 2x to 5x today's transmission

Nuclear

- In RE- scenario site up to 250 new 1-GW reactors (or 3,800 SMRs).
- Spent fuel disposal.

NGCC-CCS

- In RE-, 300+ plants (@750 MW)

Flexible resources

- Combustion turbines w/high H₂
- Large flexible loads: electrolysis, electric boilers, direct air capture
- 50 - 180 GW of 6-hour batteries

5. Non-CO₂ Emissions

Methane, N₂O, Fluorocarbons

- 20% below 2020 emissions (CO_{2e}) by 2050 (30% below 2050 REF).

3. Zero-Carbon Fuels

Major bioenergy industry

- 100s of new conversion facilities
- 620 million t/y biomass feedstock production (1.2 Bt/y in E- B+)

H₂ and synfuels industries

- 8-19 EJ H₂ from biomass with CCS (BECCS), electrolysis, and/or methane reforming with CCS
- Largest H₂ use is for fuels synthesis in most scenarios

6. Enhanced land sinks

Forest management

- Potential sink of 0.5 to 1 GtCO_{2e}/y, impacting 1/2 or more of all US forest area (≥ 130 Mha).

Agricultural practices

- Potential sink ~0.20 GtCO_{2e}/y if conservation measures adopted across 1 – 2 million farms.



HEPG Agenda

More than a ZECSY Role for Nuclear in Net-Zero 2050? Why are there 22 operators?

OPERATOR NAME	MW
Constellation Nuclear LLC	23,803
Duke	11,415
Tennessee Valley Authority	8,957
Dominion Energy	7,279
Entergy	6,201
Southern Nuclear Operations Co LLC	6,102
FirstEnergy	4,306
Arizona Public Service Co	3,980
Florida Power & Light Co	3,880
PSEG Nuclear LLC	3,758
Nextera	3,463
STP Nuclear Operating Co	2,746
Susquehanna Nuclear LLC	2,688
Luminant	2,540
Indiana Michigan Power Co	2,427
Pacific Gas & Electric Co	2,323
Northern States Power Co (Minnesota)	1,871
System Energy Resources Inc	1,574
Wolf Creek Nuclear Operations Corp	1,291
Energy Northwest	1,271
Ameren Missouri	1,240
DTE Electric Co	1,236



Four years after San Onofre shutdown, questions remain about flawed project

BY JEFF MCDONALD
JAN. 30, 2016 9 AM PT



Oct 15, 2021
by Aaron Larson

IN THIS ISSUE
ier 15, 2021

Oct 22, 2021

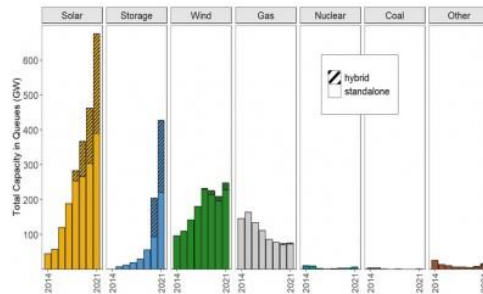
Nuclear

Former SCANA CEO Will Land in Prison as Result of V.C. Summer Nuclear Project



Working Forward from 2022

The Makings of the Alternate "Train Wreck" Scenario



Capacity in interconnection queues as of the end of 2021. *Hybrid storage capacity is estimated in some cases using storage: generator ratios from projects that provide separate capacity data. Storage capacity in hybrids was not estimated for years prior to 2020.



JesseJenkins
@JesseJenkins

Northern Pass would import enough electricity to meet about 7% of New England's electricity needs, more than enough to replace the Pilgrim nuclear power station (about 4% of NE electricity) set to close in 2019.

4:11 PM · Feb 1, 2018 · Twitter Web Client



FERC Issues Transmission NOPR Addressing Planning, Cost Allocation

April 21, 2022



Docket No. [RM21-17](#)
[Item E-1](#) | [Presentation](#)

"...For these reasons, I respectfully dissent."
-Commissioner Danly

FERC Proposes Interconnection Reforms to Address Queue Backlogs

June 16, 2022



Docket No. [RM22-14](#)
[Items E-1](#) | [Staff Presentation](#)



Federal Energy Regulatory Commission posted a video to playlist FERC 10/6 Tech Conference.
2d ·

FERC Transmission Planning & Cost Management Technical Conference
October 6, 2022.
Docket No. AD22-8-000

Panel 3: Local Transmission Facility Cost Management Practices... S
more

DEEP DIVE

Why the energy transition broke the U.S. interconnection system

The same processes that created the U.S. power system may now be preventing its transition to clean generation.

Published Aug. 22, 2022

DIVE BRIEF

Republicans oppose 'sweeping' transmission reforms, force Manchin to withdraw energy permitting bill

Published Sept. 28, 2022



Working Forward from 2020

ISO/RTOs Cope with Increasing Penetration of Variable Renewable Energy

- What will the future market regulatory structure look like?

- ✓ Status Quo with minor incremental changes?
- ✓ Substantial changes required for markets to function given the evolving resource mix?
- ✓ Return to central planning / cost-of-service

NEWS RELEASES

FERC Seeks Information on Organized Markets' Changing System Needs, Plans

April 21, 2022



Docket No. [AD21-10](#)

Item E-2

Today FERC took the next step toward modernizing wholesale electricity market design by directing the operators of six regional organized electric power markets to provide information regarding their changing system needs and plans for potential reforms. The California Independent System Operator Corp., ISO New England, Inc., Midcontinent Independent System Operator, Inc., New York Independent System Operator, Inc., PJM Interconnection, L.L.C., and Southwest Power Pool, Inc. have 180 days to file reports in response to the order.

Today's order follows a staff whitepaper and four technical conferences conducted in 2021 that explored the changing nature of the organized markets and their operations. The Commission

Contact Information

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Email: MediaDL@ferc.gov

[Latest News](#)



Working Forward from 2022

ISO/RTOs Cope with Increasing Penetration of Variable Renewable Energy

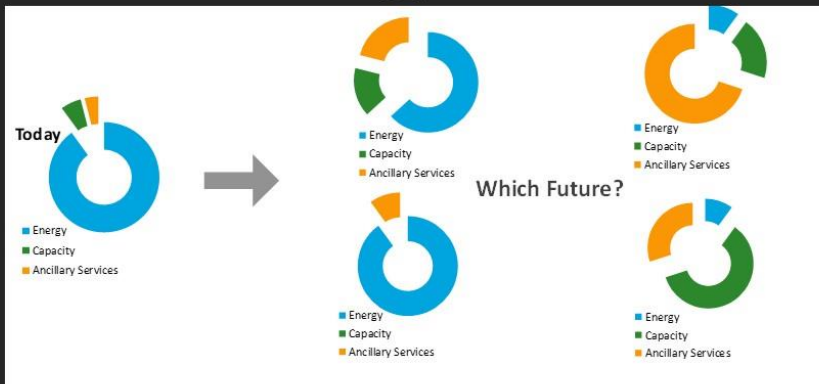
- Implications for Market Design, Operations, Price Formation, Reliability and Technology
 - ✓ Policy responses to increasing penetration of variable renewables, changing resource mix and new technologies
 - ✓ Will reliability problems become as frequent as bad weather stories?
 - ✓ What is the cost/value and how to incentivize (or mandate) operational attributes and flexibility (i.e. such as “ramp”)?
 - ✓ Are we getting “shortage pricing” design and implementation right?
 - ✓ What will be the role of Demand Response in clearing the market and DR implications for price formation?



Working Forward from 2022

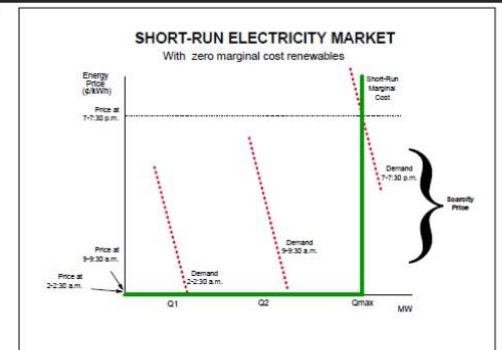
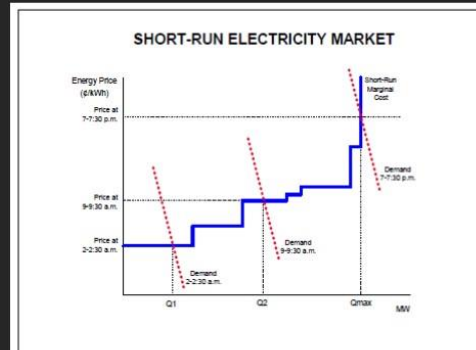
ISO/RTOs Cope with Increasing Penetration of Variable Renewable Energy

What will Energy Prices look like?



- Investment signals, environmental policies outside the energy market
- Resource adequacy structures
- Responsiveness of demand

- Shortage pricing design and allowance
- Renewable locations and correlation
- Cost-effectiveness of enabling technologies



W. Hogan, "Electricity Market Design and the Green Agenda," IEEE PES GM, 2020.

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EPRI

-- Erik Ela, EPRI at
Energy Trading Institute May 2022 Conference



HEPG Agenda continued...

RTO Expansion: Competing Visions



Re: Organized Wholesale Power Markets

Dear Chairman Glick and Commissioners:

As former FERC Commissioners and Chairs, appointed by both Republican and Democratic Presidents over the past three decades, we are united in our strongly held view that organized regional wholesale power markets, known as RTOs and ISOs, provide compelling platforms for renewable energy development and are achieving considerable consumer benefit.

Organized markets do not exist in some regions of the country, and customers in those regions cannot enjoy the benefits they provide. Yet organized markets are more essential than ever as our nation decarbonizes the power sector. As the pace of decarbonizing the grid accelerates, we are convinced that the time for organized market expansion is now. Hence, we are writing to urge the Commission to use the broad authorities and tools available under the Federal Power Act to move toward well-structured organized power markets in all regions of the country.

To prepare the grid for a rapid evolution toward the low carbon future, we urge you to finish the job of setting up organized wholesale power markets and ensure that they flourish in all regions of the country. We know you have a full plate of electricity issues to address; it is our collective opinion that this one is foundational.

Sincerely,

/s/ Nora Mead Brownell
Nora Mead Brownell
Commissioner 2001-2006

/s/ William L. Massey
William L. Massey
Commissioner 1993-2003

/s/ John R. Norris
John R. Norris
Commissioner 2010-2014

/s/ James J. Hoecker
James J. Hoecker
Commissioner 1993-1997, Chairman 1997-2001

/s/ Elizabeth Anne Moler
Elizabeth Anne Moler
Commissioner 1988-1993, Chair 1993-1997

/s/ Robert F. Powelson
Robert F. Powelson
Commissioner 2017-2018

Re: Former Commissioners' Letter

Dear Mr. Chairman and Commissioners,

On June 2, 2021, you received a letter from nine former FERC Commissioners, urging the Commission to use "broad authorities and tools" to establish ubiquitous RTO wholesale markets across the country. We write you to express our concern with this suggestion, for we fear the implication is to encourage FERC to abandon its long-standing policy of providing for voluntary RTO membership for utilities and the states that regulate them.

As former state regulators, we collectively have decades of energy regulatory experience. We hail from different regions of the country. We come from different political parties. We have different experiences with wholesale market structures and we have different views regarding the operations of existing RTOs. Nonetheless, we share a common belief: FERC should continue to allow states and utilities the flexibility to participate in wholesale market structures that work best for their citizens and electricity customers. Any movement to upend this policy risks doing grave damage to the state-federal relationship, putting FERC and the states on a path towards confrontation. This would undermine both the federal-state balance of the Federal Power Act, and the historic comity between state and federal regulators. It also would threaten to impede grid transformation by unilaterally imposing an unexpected new market construct that may work at cross-purpose with clean energy investment decisions states have already made.

RTOs would become a flashpoint in the state-federal relationship. Collectively, the public interest will be better served by state and federal regulators seeking common ground, working towards shared goals, and not fighting each other in the Courts and in Congress. We hope you will agree and maintain FERC's prudent and well-established stance towards voluntary RTO membership.

Sincerely,

Tony Clark
Former NARUC President
Former Chair/Commissioner North Dakota Public Service Commission
Former FERC Commissioner

David Coen
Former NARUC President
Former Member Vermont Public Service Board

Philip Jones
Former NARUC President
Former Commissioner Washington Utilities and Transportation Commission

Jim Sullivan
Former NARUC President
Former President Alabama Public Service Commission



HEPG Agenda continued...

Don't Lose Sight of the Successful Market Design

“Now all organized wholesale markets in the United States are built around the essential elements of bid-based, security-constrained, economic dispatch with locational prices and financial transmission rights. The success and wide adoption of this market design reflects the basics of the underlying electricity system and the requirements of open markets. In short, this successful market design is the only way to organize a short-term electricity market that adheres to the principles of open access and nondiscrimination. [For the Commission,] the most important thing to remember is the critical role of this fundamental market design. There is no other way to organize system operations and adhere to the Commission’s mandate.

Furthermore, the broad policy objectives of the green energy agenda only serve to reinforce this conclusion. The penetration of intermittent resources, such as solar and wind, often located far from load, increases the need for real-time coordination of dispatch across larger regions.”

Comments of William W. Hogan, Docket No. AD17-11, State Policies and Wholesale Markets Operated by ISO New England, Inc., New York Independent System Operator, Inc., and PJM Interconnection, L.L.C. (May 2, 2017).



HEPG Agenda continued...

Demand Response: Has Order 745 Been Helpful?

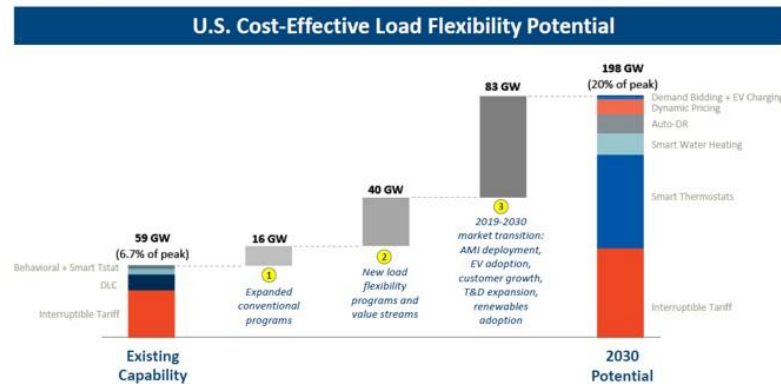
The Potential for Demand Response



- A Brattle Study estimates potential for 200 GW (20% of load) by 2030, worth ~\$15 billion annually...*

The national potential for load flexibility

A portfolio of load flexibility programs could triple existing DR capability, approaching 200 GW (20% of system peak) by 2030



Notes: Existing DR capability does not account for impacts of retail pricing programs, as fewer than 1% of customers are currently enrolled in dynamic pricing rates and the impacts of long-standing TOU rates are already embedded in utility load forecasts. See appendix for summary of key modeling assumptions.

18 | brattle.com

- ...but wholesale and retail price incentives must be aligned and working to reach this



* The Brattle Group. (2019). The National Potential for Load Flexibility. Retrieved from https://brattlefiles.blob.core.windows.net/files/16639_national_potential_for_load_flexibility_final.pdf

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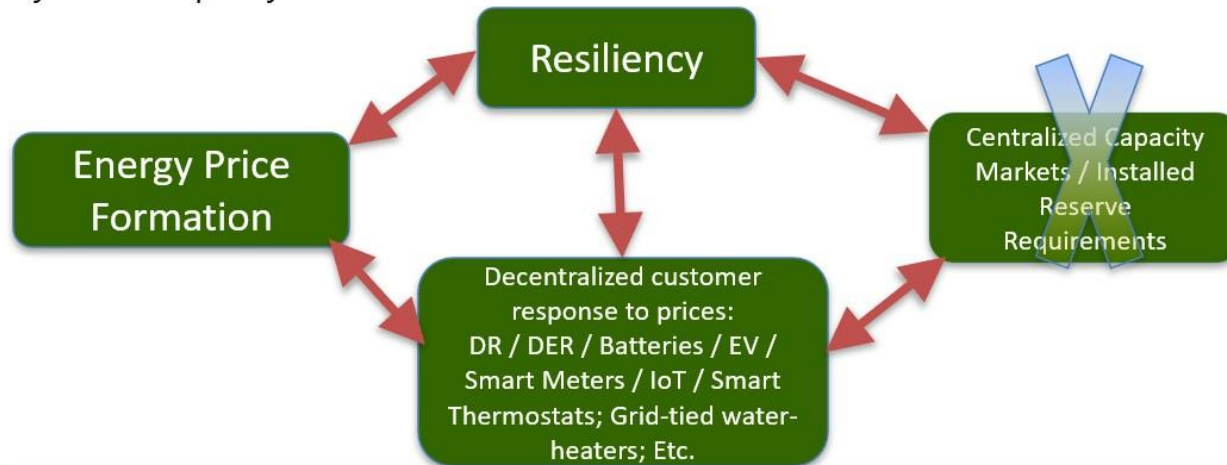


HEPG Agenda continued...

US Courts: FERC has jurisdiction over retail DR pricing

Taking the Demand Side Seriously

Technological innovation and cultural change require that we rethink and transition from our centralized approach to electricity markets. The demand side is key to this transformation, but requires very different policy choices and incentive structures



One of the best investments in "resiliency" is flexible demand integrated into the ISO market processes. Current investments in DR are not well integrated into wholesale price formation. If ISOs could rely on customers responding rationally to price signals, the grid would be more flexible and reliable (and capacity markets would be unnecessary).



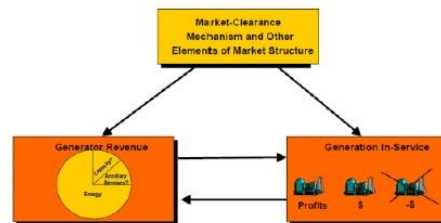
HEPG Agenda continued...

Capacity Markets

Capacity Markets In Perpetual Disrepair



- Fundamentally, capacity markets are at cross purposes with FERC's price formation initiatives
- The choice regarding market clearing mechanisms (energy-only vs. capacity markets) impacts all other aspects of market design and performance



- At some point FERC, state regulators and the ISOs may recognize that the hand-wringing over capacity market design is not worth the trouble, and represents unnecessary \$billions in transfers from consumers, and look to transition to energy-only pricing
- Better price formation and adequate price responsive demand can ensure reserve adequacy, but requires different policy choices and a transition mechanism

