

ESIG Spring Technical Workshop



Tucson, AZ
March 27-30, 2023

Workshop Agenda Overview



Monday, March 27

- Integrated Planning Tutorial and Parallel GPST Session
- Introduction & Keynote Comments - Alice Jackson, Xcel Energy
- Opening Plenary: High VRE Futures – A Way Forward, led by Danielle Merfeld, Qcells
- Board Meeting and Dinner 6:00 pm

Tuesday, March 28

- Session 1: Interregional Transmission
- Session 2: Scaling EVs - Grid Considerations
- Session 3: GFM Requirements and Specifications
- Session 4: Topics in Power Systems Operations
- Awards Ceremony and Networking Reception 6:30 pm

Workshop Agenda Overview



Wednesday, March 29

- Session 5: IBR Studies and Tools
- Session 6: Different Aspects of Resource Adequacy
- Session 7: Planning Implications with Storage and IBRs
- Session 8: Closing Plenary: Flexibility in Sector Coupling

Thursday, March 30

- Working Group and Task Force meetings

Solar and Wind are Complimentary!



Renewable Energy is Very Competitive



- Lazard reports on lowest unsubsidized energy costs at end of 2021 for:

Simple Cycle GT	\$151/MWh
Rooftop residential solar	\$147/MWh
Nuclear	\$131/MWh
Coal	\$65/MWh
Community Solar	\$59/MWh
Combined Cycle GT	\$45/MWh
Utility scale solar	\$28/MWh
Wind energy	\$26/MWh
- Other reports from industry pubs on recent PPA prices:

Utility scale solar	\$15-\$22/MWh
Wind energy	\$11-\$25/MWh

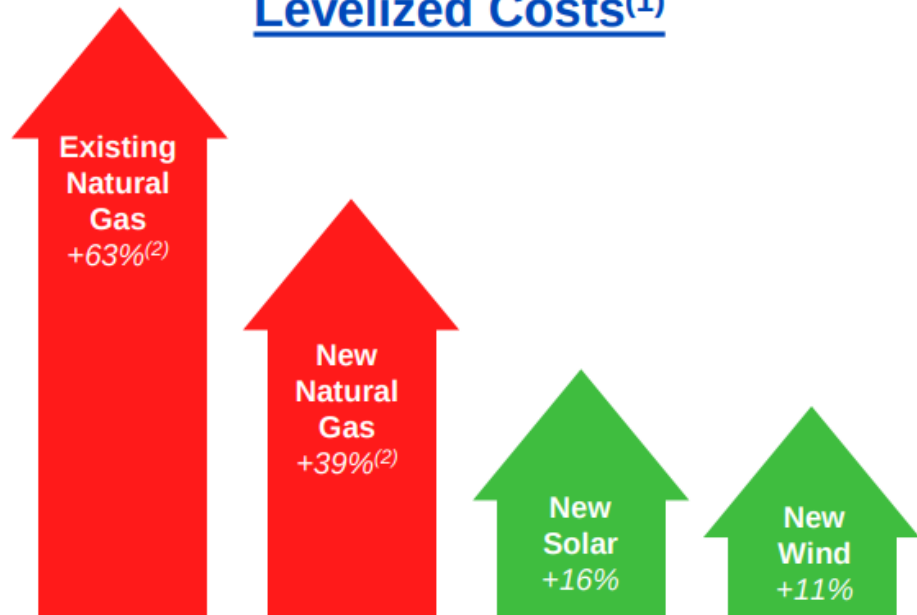
View of Difference in Energy Cost from New Renewables and New Natural Gas CCGT



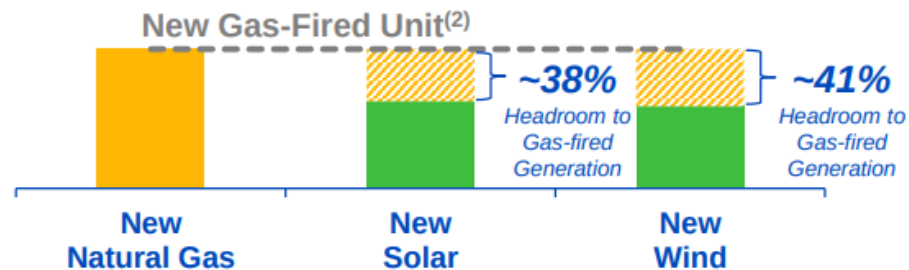
On a relative basis, renewables are now even cheaper than new gas fired generation after accounting for the impacts of the circumvention investigation and inflation

Prevailing Inflation Impacts on Levelized Costs⁽¹⁾

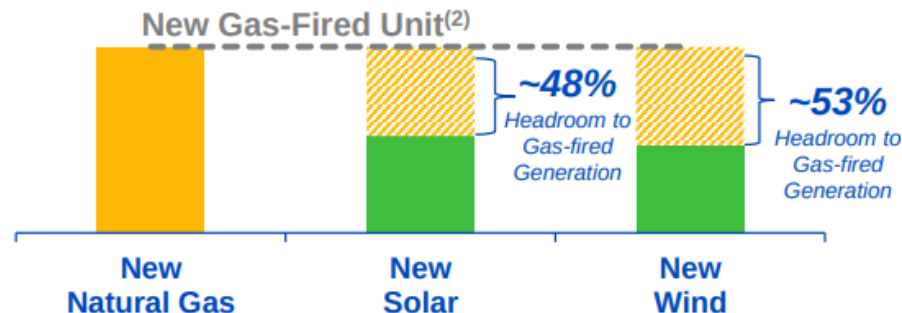
Impacts of Inflation on Levelized Costs⁽¹⁾



\$/MWh Comparison in 2021⁽³⁾



\$/MWh Comparison in 2022⁽³⁾



Source: from NextEra June 14 analyst presentation
Retrieved from [NextEra Energy](#) on June 14, 2022 6

Storage Systems Definitely Making Progress



- Lazard reports at end of 2021 on estimated lowest unsubsidized energy costs for a range of storage systems (10 kw to 100 MW):

Peaker Replacement (4 hr @ 100 MW)

- Lithium Ion \$131/MWh

Utility Scale PV + Storage (PV @ 40 MW + storage of 20 MW @ 4 hr)

- Lithium Ion \$85/MWh

C&I BTM Standalone (2 hr @ 1 MW)

- Lithium Ion \$442/MWh

C&I BTM PV + Storage (PV @ 1 MW + storage of .5 MW @ 4 hr)

- Lithium Ion \$235/MWh

Residential BTM PV + Storage (PV @ 20 Kw + storage of 10 Kw @ 4 hr)

- Lithium Ion \$416/MWh

- PPA bid at El Paso Electric - **PV plus battery at \$21/MWh**

Current Levelized Cost of Hydrogen Production — 100 MW Electrolyzer



		Alkaline (100 MW)				
		Electrolyzer Capex (\$/kW)				
Energy Cost (\$/MWh)	\$/kg	\$510	\$570	\$630	\$690	\$760
	\$20	\$1.76	\$1.77	\$1.79	\$1.80	\$1.81
	\$30	\$2.50	\$2.51	\$2.53	\$2.54	\$2.55
	\$40	\$3.24	\$3.25	\$3.27	\$3.28	\$3.29
	\$50	\$3.98	\$3.99	\$4.01	\$4.02	\$4.03
	\$60	\$4.72	\$4.73	\$4.74	\$4.76	\$4.77

- Sensitivity to Electricity Cost and Electrolyzer Capex

Source: Fuel Cell and Hydrogen Energy Association, National Renewable Energy Laboratory, Pacific Northwest National Laboratory, and Lazard and Roland Berger estimates.

Note: Sensitivity is based on a 98% electrolyzer utilization rate.

Inflation Reduction Act (IRA) of 2022 per Investment Bank Credit Suisse 9/22 Research Note



- IRA “will have a **profound effect across industries** in the next decade and beyond”
- IRA’s most important provisions, such as its incentives for electric vehicles and zero-carbon electricity, are “uncapped” tax credits. That means that as long as you meet their terms, the government will award them. **There’s no budget or limit written into the law that restricts how much the government can spend.**
- U.S. is “poised to become the world’s leading energy provider”. IRA could further enhance its advantage in all forms of energy production, giving it a “competitive advantage in low-cost clean electricity and hydrogen production, infrastructure, geologic storage, and human capital”. **By 2029, U.S. solar and wind could be the cheapest in the world at less than \$5 per megawatt-hour, the bank projects; it will also become competitive in hydrogen, carbon capture and storage, and wind turbines. (This reflects a PTC of \$26/MWH plus a 10% bonus for \$28.60/MWH.)**
- For big corporations, the IRA “**definitively changes the narrative from risk mitigation to opportunity capture.**” They should be scared of missing out on the economic growth that the energy transition (and the IRA) will bring about.
- Clean energy is now the safe, smart, government-backed bet for conservative investors. **It’s really a shocking reversal of the past 40 years. It is such a change that it hasn’t yet been metabolized by the world of people involved in the issue.**

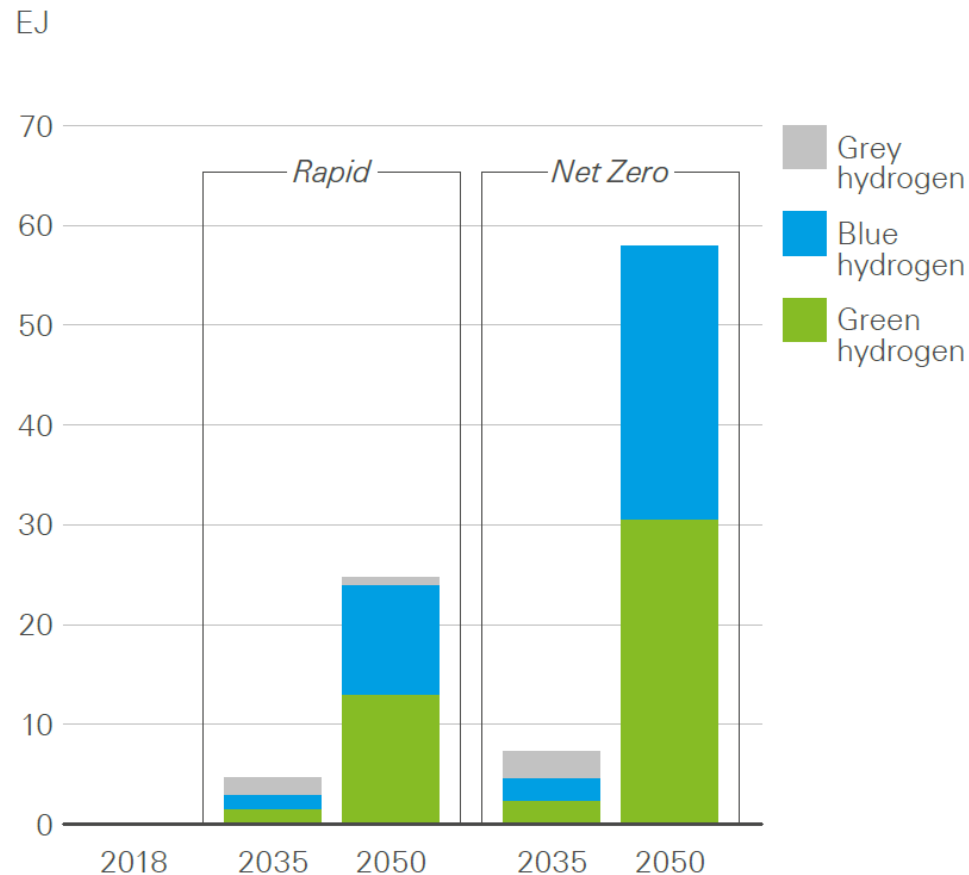
What Are They Saying at NARUC (Nov 17, 2022)



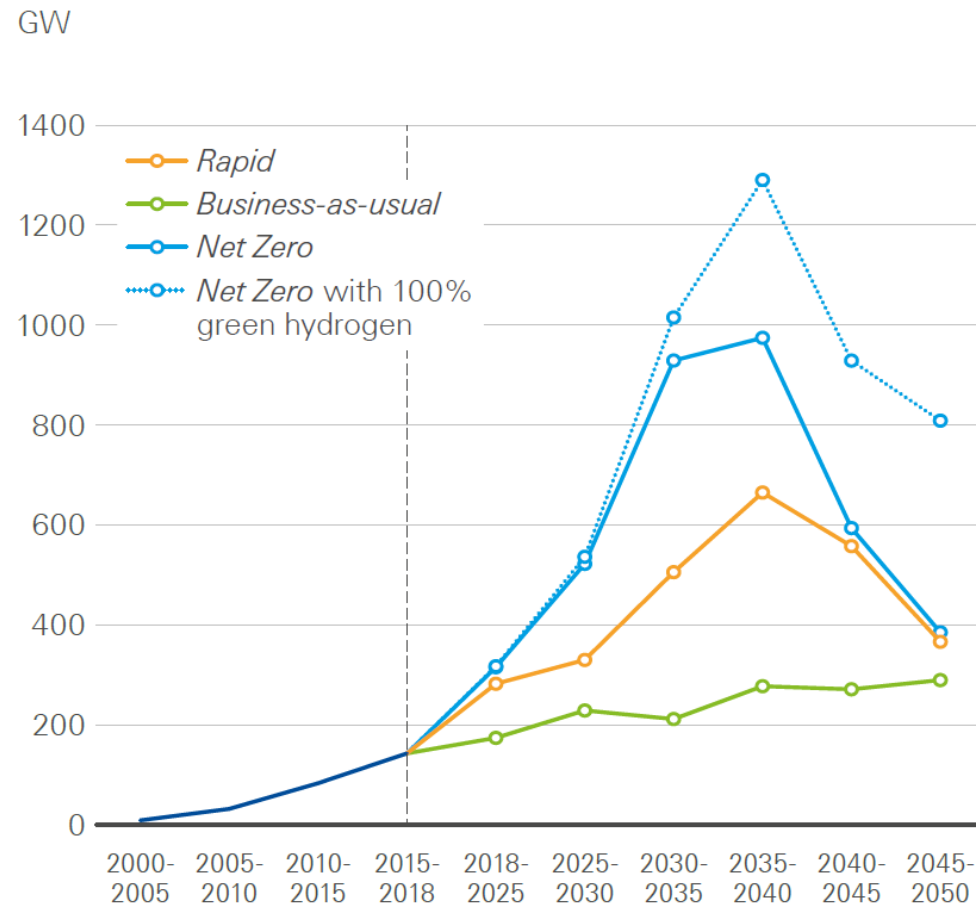
- The Inflation Reduction Act will upend key tenets of utility resource planning, including the need for bottom-up forecasting to account for a pending surge in electric vehicle and building load, according to panelists at a National Association of Regulatory Utility Commissioners (NARUC) meeting on Nov 17, 2022.
- Wind and solar paired with battery storage is in the \$20/MWh to \$30/MWh range, making them competitive with natural gas-fired generation, said Matt Pawlowski, NextEra Energy Resources executive director of business management and regulatory affairs.
- Later this decade, **with the IRA, NextEra expects wind coupled with a 4-hour battery system will cost \$14/MWh to \$21/MWh**, according to a Nov. 4 company presentation. **Solar with batteries will cost \$17/MWh to \$24/MWh, the company estimates.**
- **An existing natural gas-fired power plant will cost \$35/MWh to \$47/MWh to operate, assuming gas is in the \$4/million British thermal units to \$5/MMBtu range**, according to NextEra.
- The prices for solar and batteries and wind and batteries are about 35% to 44% lower than cost estimates NextEra provided in a mid-June presentation before the IRA was released.
- **“We have a once-in-a-lifetime set of incentives that are on the table. The biggest risk for ratepayers would be a failure to capitalize on that right now,”** said Walsh, DOE OGC.

Most Hydrogen Production by 2050 is a Combination of Green & Blue Hydrogen

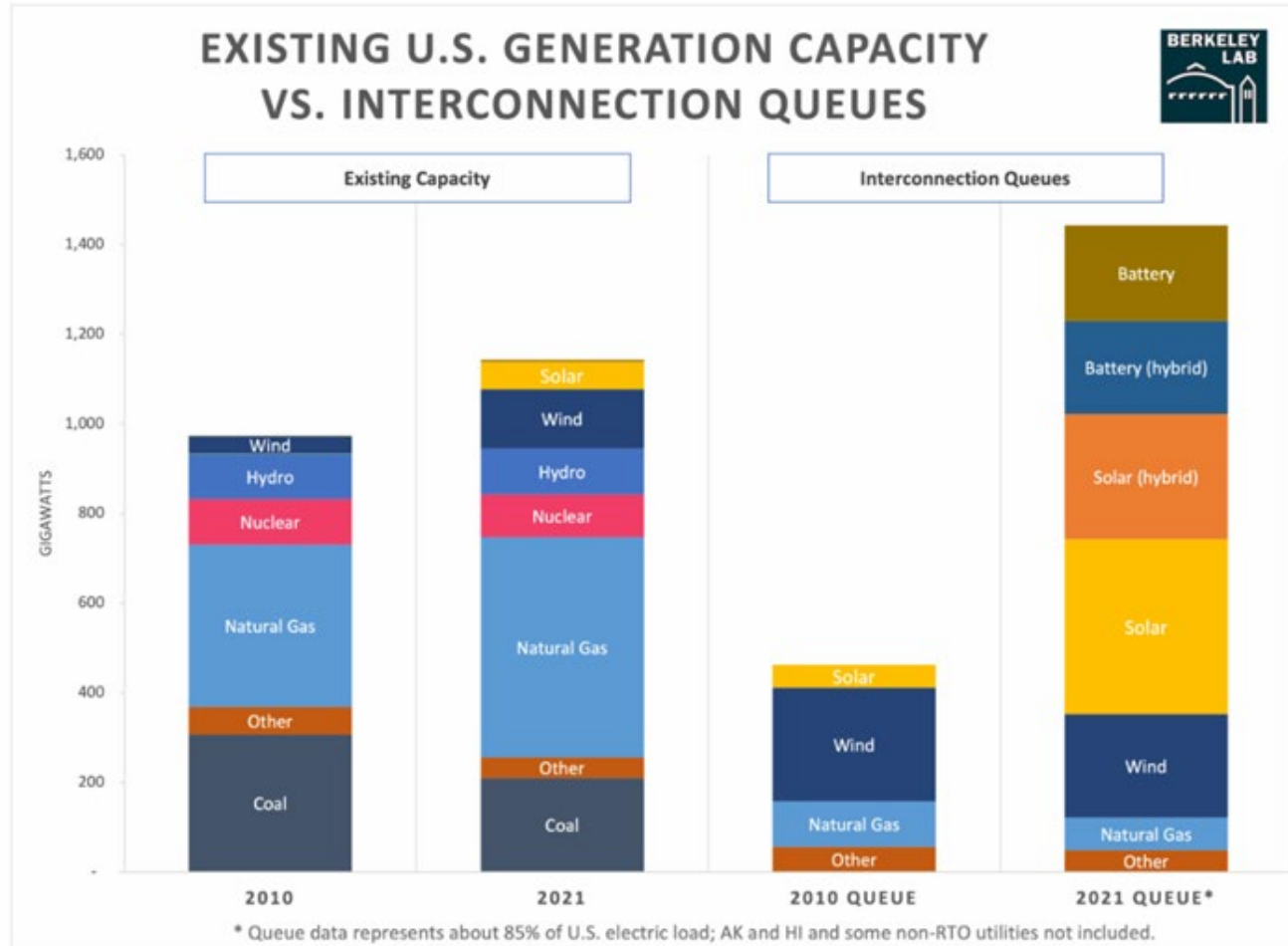
Hydrogen production by type



Annual average increase in wind and solar capacity



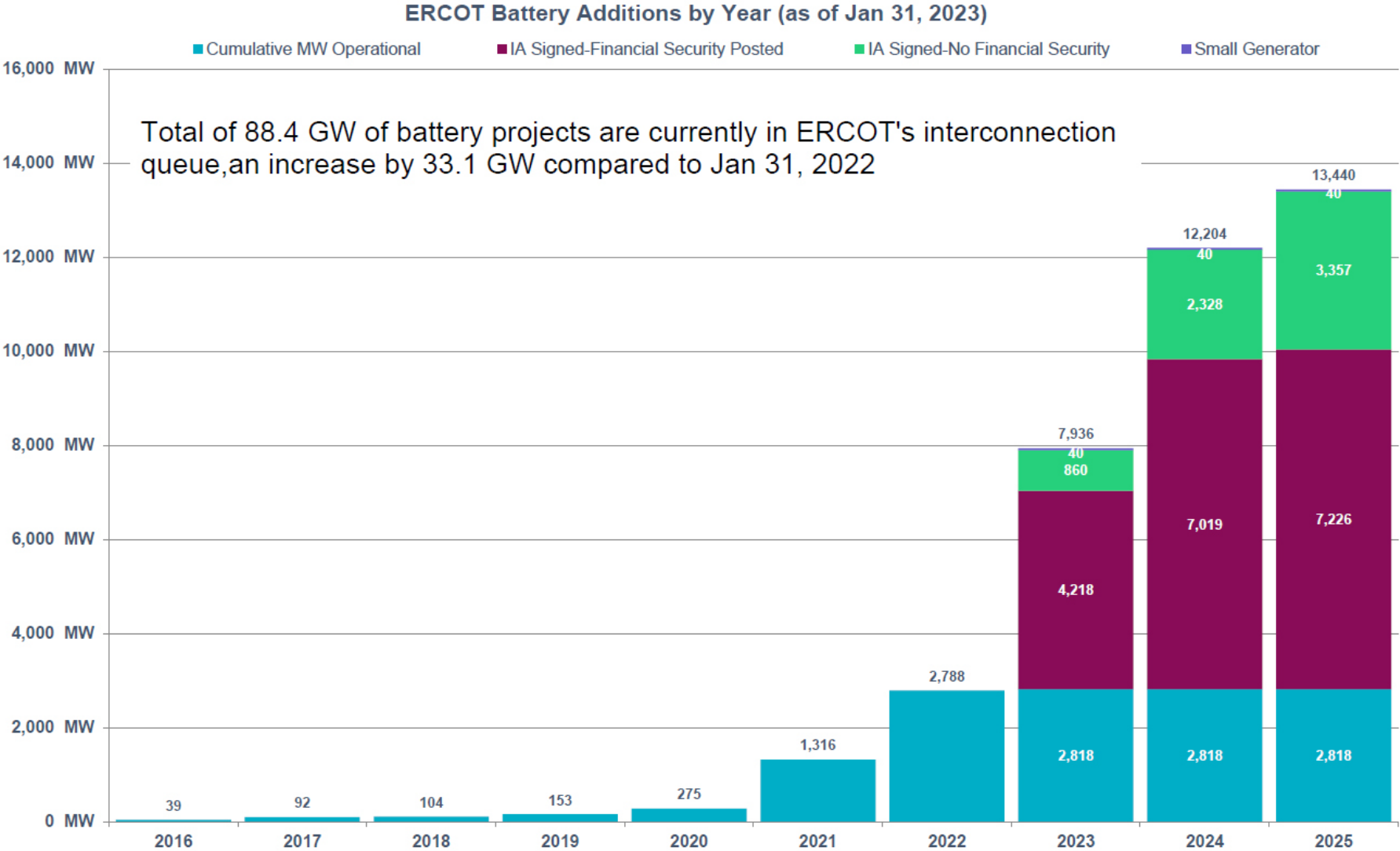
Generating Capacity and Queues – Then and Now



Source: Lawrence Berkeley National Laboratory

Figure 1: Existing U.S. capacity (2010 and 2021) compared to interconnection queue capacity (2010 and 2021).

ERCOT Battery Interconnection Queue



An Industry Maturing – Globally



- Global wind capacity end of 2022 (various): 950 GW
- Global PV capacity end of 2022 (various): 1100 GW
- Variously Estimated Global VG installations in 2022
 - Wind 100 GW
 - PV 150 GW

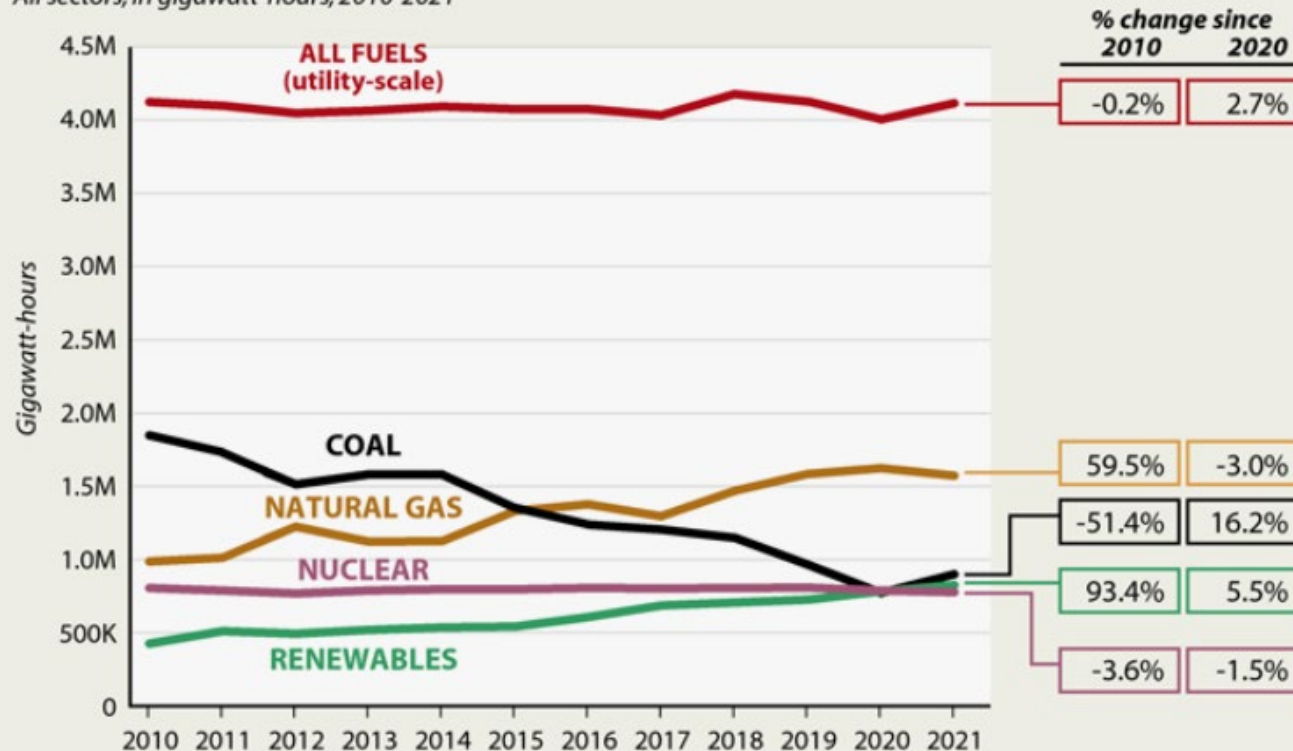
Still a Ways to Go in the US

Renewables, Coal on the Rise

Renewable energy gained ground in 2021, but it was still passed by coal, which had a comeback after a major decline in 2020. Natural gas and nuclear each lost ground.

U.S. NET POWER GENERATION

All sectors, in gigawatt-hours, 2010-2021



NOTE: Renewables includes the EIA categories of "conventional hydroelectric" and "other renewables."

Recent Industry Trends



- **“EEI is advocating for policies that support our clean energy transition.** We voiced our support for America rejoining the Paris Agreement, as well as getting critical transmission and energy grid infrastructure built more quickly. The transmission system is key to integrating more renewables, more clean energy, and more technologies into the grid affordably and reliably.” Tom Kuhn, President, EEI
- **NextEra plans to cut all carbon emissions by 2045**, partly via FPL adding 90 GW solar, 50 GW batteries, without increasing customer bills due to lower cost of renewables. **Plan includes converting 16 GW of GT to run on green hydrogen.** Sees \$4T investment opportunity in decarbonizing the US economy by 2050.
- **Utilities plan to close more than 70 gigawatts of coal plants by 2028, one-third of all coal capacity in the US**
- **NuScale and UAMPS announce price increase from \$58/MWh to \$89/MWh for SMR (small modular reactor) energy cost after subsidies, driven by 75% increase in construction cost estimates**

Some Recent Hydrogen Headlines



- **Global green hydrogen pipeline exceeds 250 GW**
- World's largest green hydrogen project unveiled in Texas, with plan to produce clean rocket fuel for Elon Musk. **The 60 GW Hydrogen City project will be powered by wind and solar, with an on-site salt cavern for H2 storage.** First 2 GW phase scheduled to begin operation in 2026.
- The largest single-site green hydrogen project announced had been the Western Green Energy Hub in Western Australia, which would be powered by 50 GW of wind and solar, with first production anticipated by 2030
- Germany announces plans to build 25 GW of “hydrogen ready” gas plants to back up wind and solar
- EverWind fuels company announces plans to build \$6 billion facility in Nova Scotia to produce 1 million tons of green hydrogen and ammonia per year with 2 GW wind plant
- Norwegian start-up Blastr announces plans to build **\$4.2 billion green steel plant in Finland**, producing 2.5 million tons of steel annually with green hydrogen produced onsite from locally produced wind power
- **The DOE Hydrogen Shot, launched in June 2021, seeks to reduce the cost of green hydrogen by 80%, from \$5 to \$1 per kilogram (\$8/MMBTU), by 2030, which is competitive with fossil fuel sources of hydrogen. Think of it as along the lines of the ambition of the DOE Sunshot program of the last decade.**
- **New EU hydrogen strategy 'marks beginning of the end of the fossil-fuel era'. European Commission announces target of 100 GW of green hydrogen capacity by 2030, with at least 40 GW of renewables-powered electrolyzers made in Europe. March, 2023.**

- 2021 - Virtual Power Plants take off, earning revenues as wholesale market capacity or grid services
- **Sunrun provides 20 MW capacity from 5,000 customers in ISO-NE capacity market in summer of '22, a first in US**
- Swell startup in CA receives \$450 million for projects with 4 utilities in 3 states, for 200 MWh of dispatchable energy in 14,000 PV-battery systems
- Solar and battery provider Tesla has virtual power plants with Vermont utility Green Mountain Power and in Australia
- On the commercial side
 - Enel X is aggregating batteries, EV chargers and commercial and industrial demand response
 - Engie is pulling together solar, storage and demand response
 - Centrica Business Solutions acquired Restore Power to integrate its load flexibility into distributed energy offerings.
- Origin (AU energy provider) announces plan to grow its “in-house” VPP from 200 MW to 2,000 MW over next 4 yrs
- **Over 50 GW of VPP in operation in Europe**

- **In case you missed it - REPowerEU Action Plan would grow wind energy from 190 GW today to 480 GW in 2030.**
- U.K. contribution – 40 GW offshore wind target contribution to achieving its target of net-zero carbon by 2050. This includes a 5 GW clean hydrogen goal.
- US goal of 30 GW offshore wind by 2030, east coast state goals of 40 GW by 2040. DOE says meeting the 2030 goal will also “unlock a pathway” to 110 GW by 2050. **What’s the big concern? Transmission!**
- CA adopts 25 GW planning goal for offshore wind by 2045, bringing US targets to 77 GW
- **Denmark has approved a plan to build an artificial island for a 10 GW wind hub in the North Sea.** A 3 GW first stage is planned for completion around 2033. The 10 GW plant should be more than enough for the whole of Denmark, with spare capacity to sell to other nations, to create green hydrogen and store electricity in large batteries.
- Orsted and Copenhagen Infrastructure Partners form partnership to build 5.2 GW offshore wind in 4 plants in Denmark, including Power to X capability

- **Bans on internal combustion engines continue to grow:**
 - UK – 2030
 - Quebec – 2035
 - California – 2035
 - Washington – 2035
 - New Jersey - 2035
 - China – 2035
 - EU - 2035
- **GM to end the sale of all gasoline and diesel powered passenger cars and light-duty SUVs by 2035**
- SDG&E partners with GM to study EV bidirectional charging potential
- **New ONE Gemini battery achieves 752 mile range in Tesla Model S. 200 kwh battery in 100 kwh compartment. Lithium iron phosphate battery without cobalt, at the same price as the current 100 kwh battery by 2026.**

Bulk Storage Tidbits

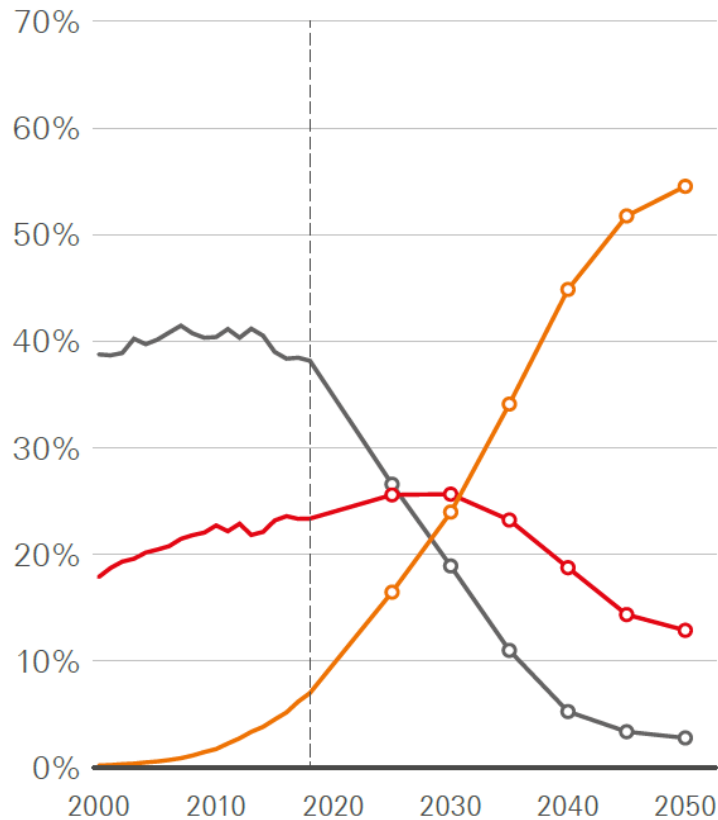


- US added 4 GW of battery energy storage in 2022, bringing the cumulative battery storage deployment to 9 GW.
 - CAISO had 5 GW and ERCOT 2.8 GW of installed battery capacity at the end of 2022
 - **With pumped hydro sitting at around 22.5 GW, this brings total US storage capacity to 31.5 GW at the end of 2022**
- **World's largest flow battery opens in Dalian, China.** The vanadium flow battery currently has a capacity of 100 MW/400 MWh, which will eventually be expanded to 200 MW/800 MWh
- **State Grid Corporation of China (SGCC) reportedly plans to increase its capacity of battery storage to 100 GW in 2030, and do the same for pumped hydro storage from 26 GW today**
- Queensland Government has announced the commencement of a detailed design and cost analysis for a potential 5-gigawatt, 24 hr pumped hydro energy storage (PHES) facility, which would be world's largest
- Eight large (200-300 MW) battery energy storage systems in Australia, totaling 2GW/4.2GWh, selected to receive funding support of AU\$176 million from ARENA. **All will be grid-forming, capable of providing system services.**
- Terra-Gen's Edwards Sanborn project in California, planning to reach 750 MW PV and 3,200 MWh of BESS in early 2023, said to be world's largest PV-battery project planned at the time in August 2021.

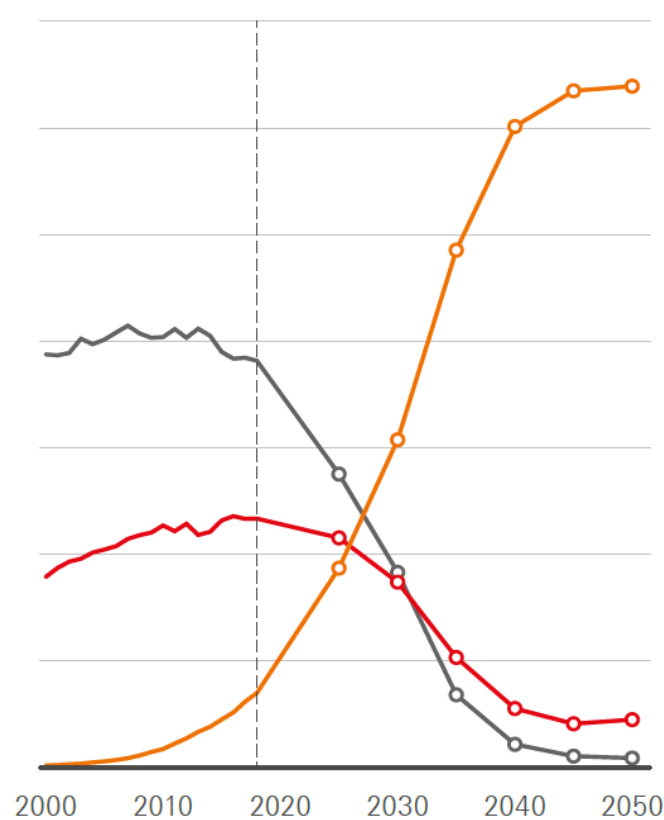
Growth in Power Generation is Led by Wind and Solar Power as Coal Loses Share

Share of global power generation by energy source

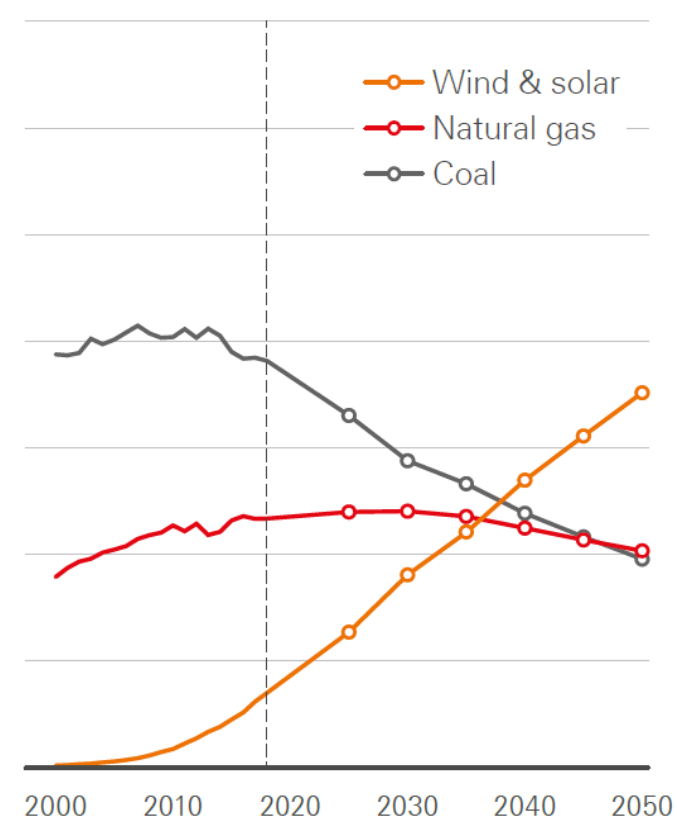
Rapid



Net Zero



Business-as-usual



Source: BP Energy Outlook 2020

Users Groups Structure



Operations &
Maintenance

Ninotchka Bosworth & Stanton Peterson

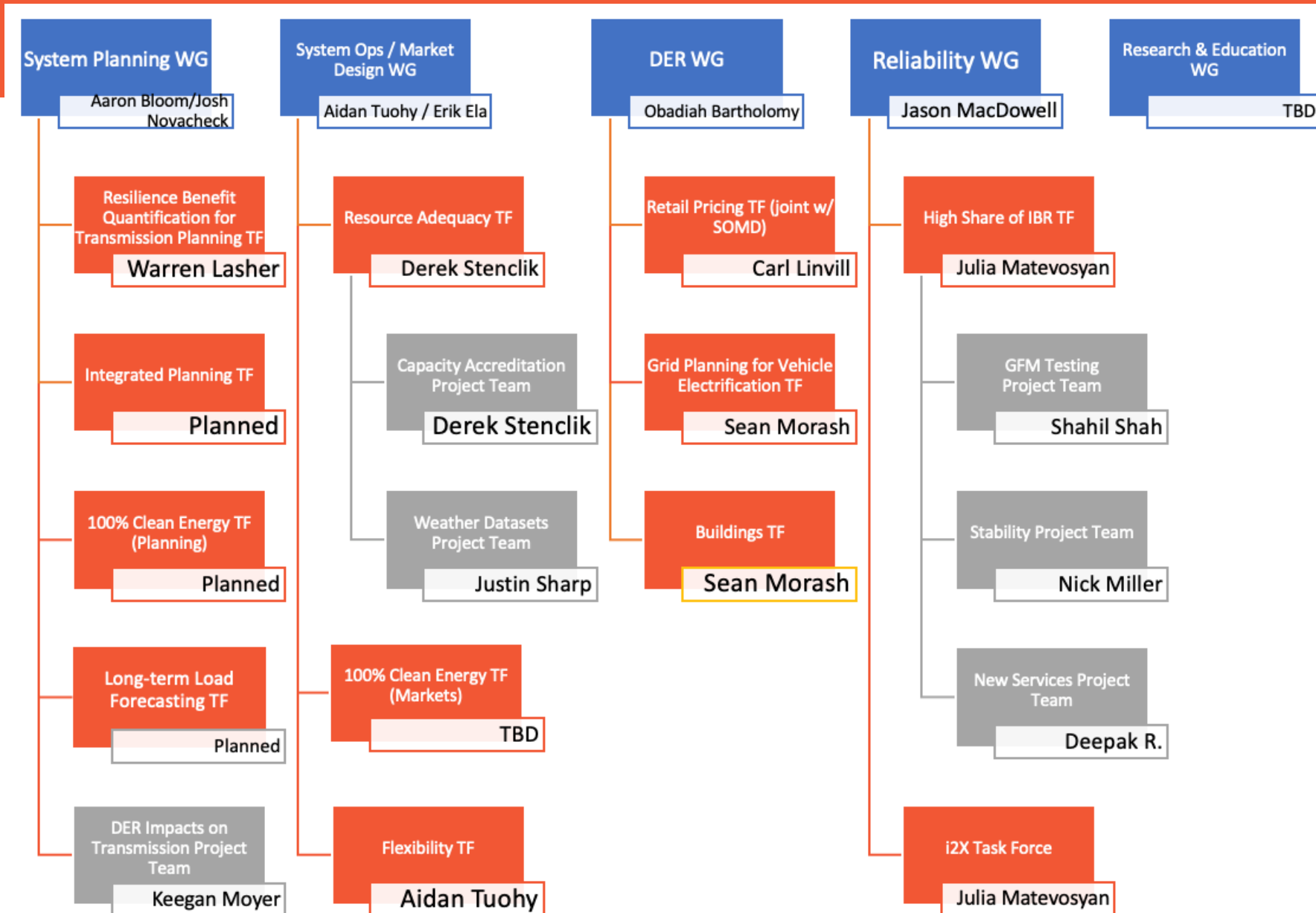
Probabilistic Forecasts in
Planning & Operations

Nitika Mago

GETs

Planned

Working Groups / Task Forces Structure



Upcoming Meetings – 2023 and 2024



2023 Meteorology and Markets Workshop

2023 Load Forecasting Workshop

June 13 – 15, 2023

Denver, CO

2023 Fall Technical Workshop

October 23 - 26, 2023

San Diego, CA

2024 Spring Technical Workshop and Annual Meeting

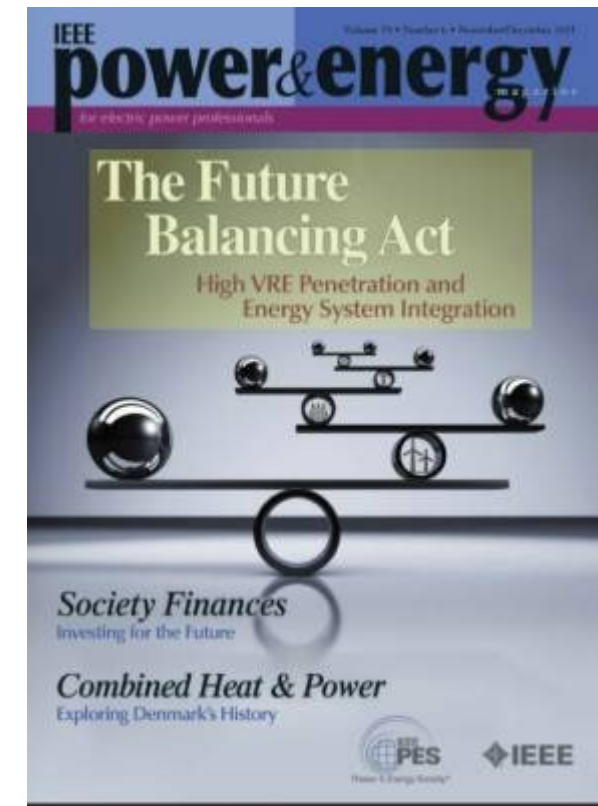
March 25 – 28, 2024

Tucson, AZ

Onward and Upward

- Latest IEEE P&E magazine integration issue published November 2021
- A warm welcome to real and virtual visitors from afar:

- | | |
|------------------|-----------|
| - Australia | - Japan |
| - Colombia | - Canada |
| - United Kingdom | - Vietnam |
| - Korea | - Ukraine |
| - China | - Texas |
| - Belgium | |
| - Germany | |
| - Denmark | |



- Take the time to make some new friends!
- Looking forward to another great meeting!



THANK YOU

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