Integrating Renewables: A Perspective from the United States

Norman C. Bay
Head of Energy Regulatory & Enforcement Group
NBay@Willkie.com
202 303 1155
Twitter: @NormanCBay

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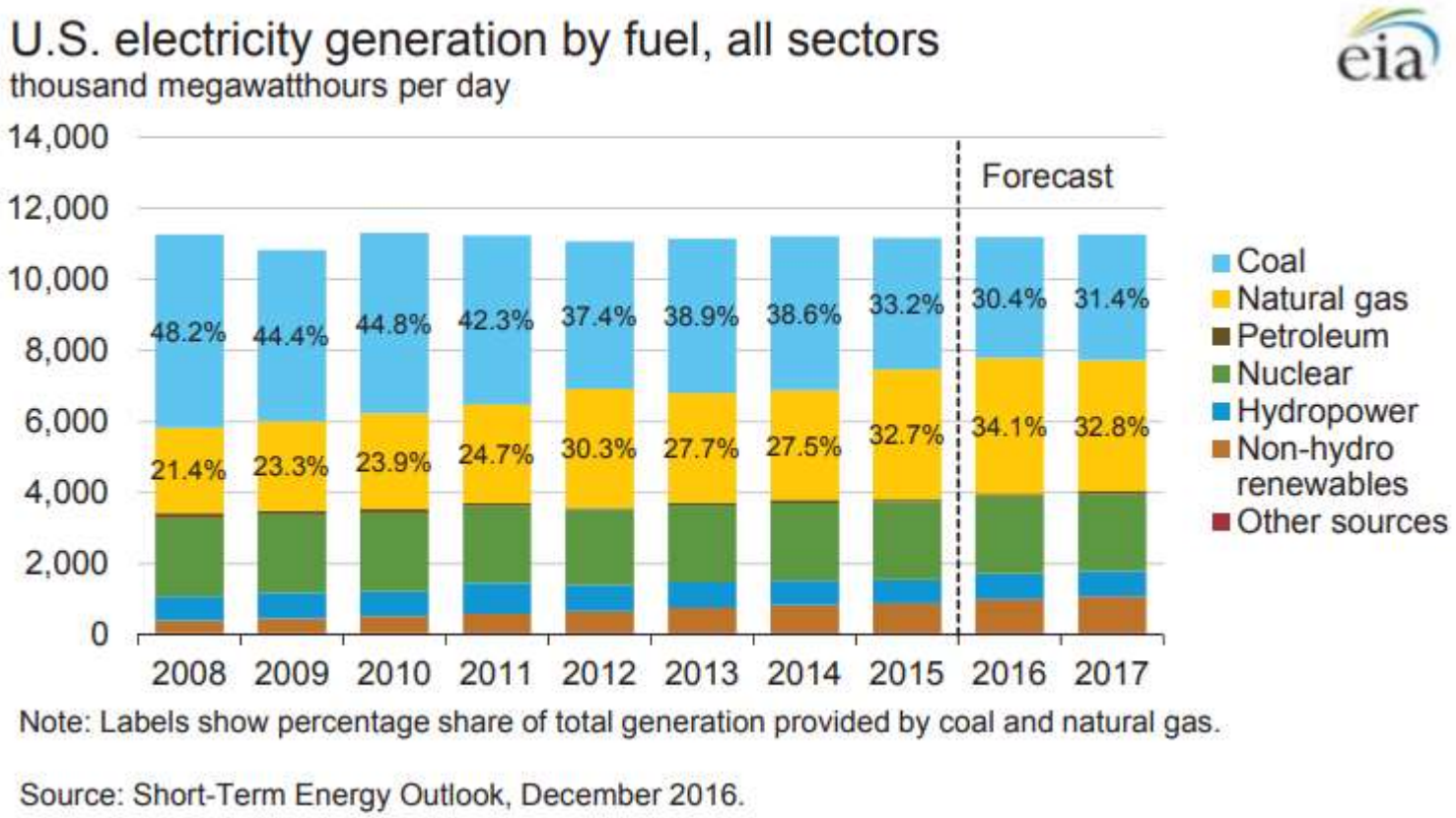
A Time of Dramatic Change

The Changing Generation Mix



Source: EIA

Net Capacity Additions (1950-2015)

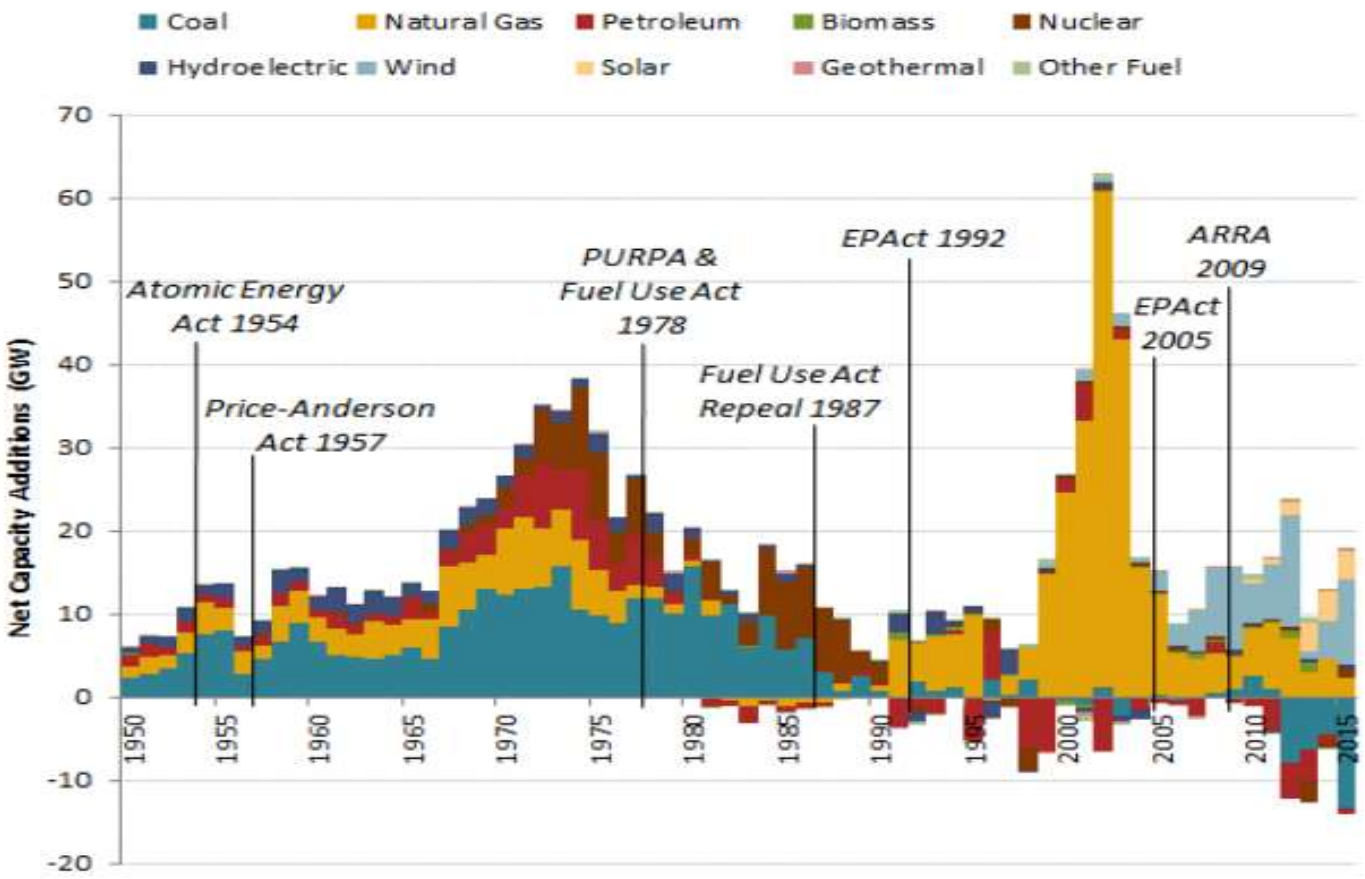
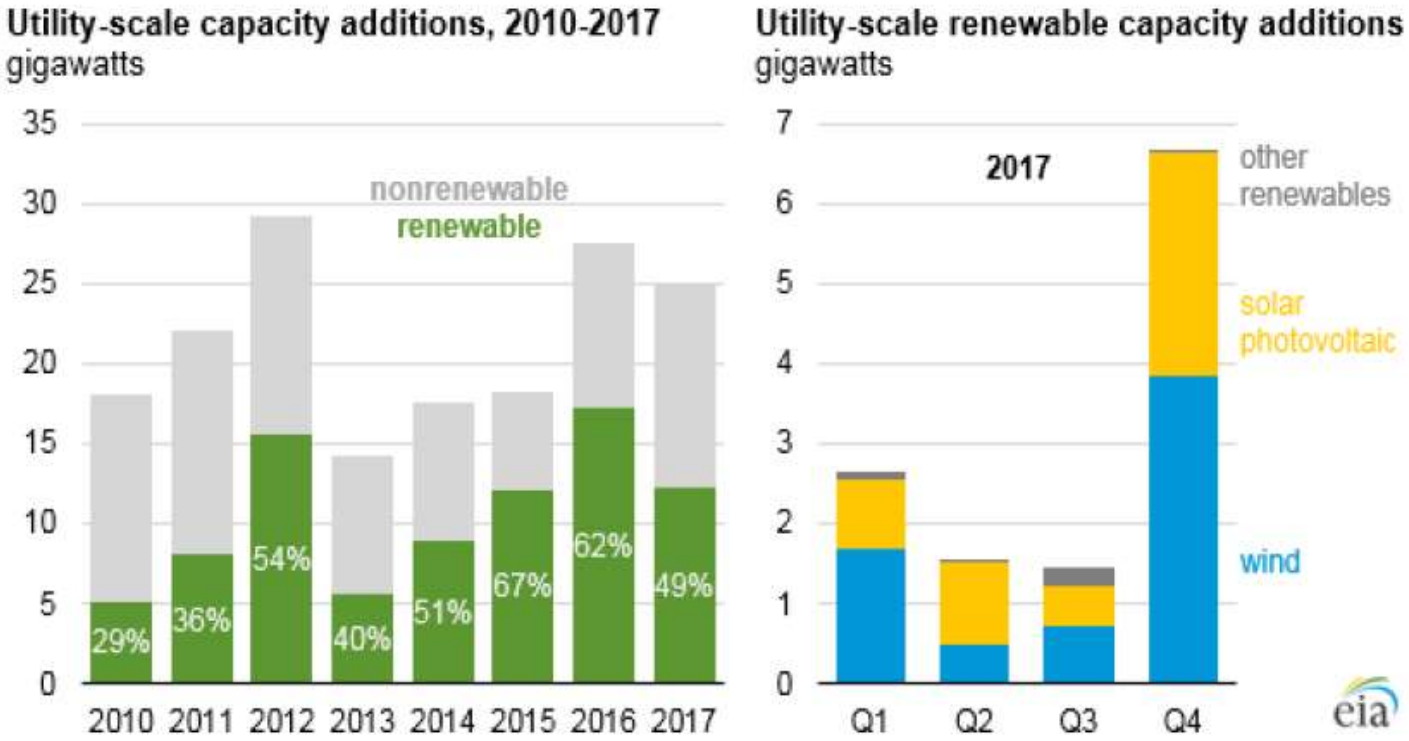


Figure ES-1. Net capacity additions (GW) by fuel type, 1950–2015

Utility-Scale Renewable Capacity



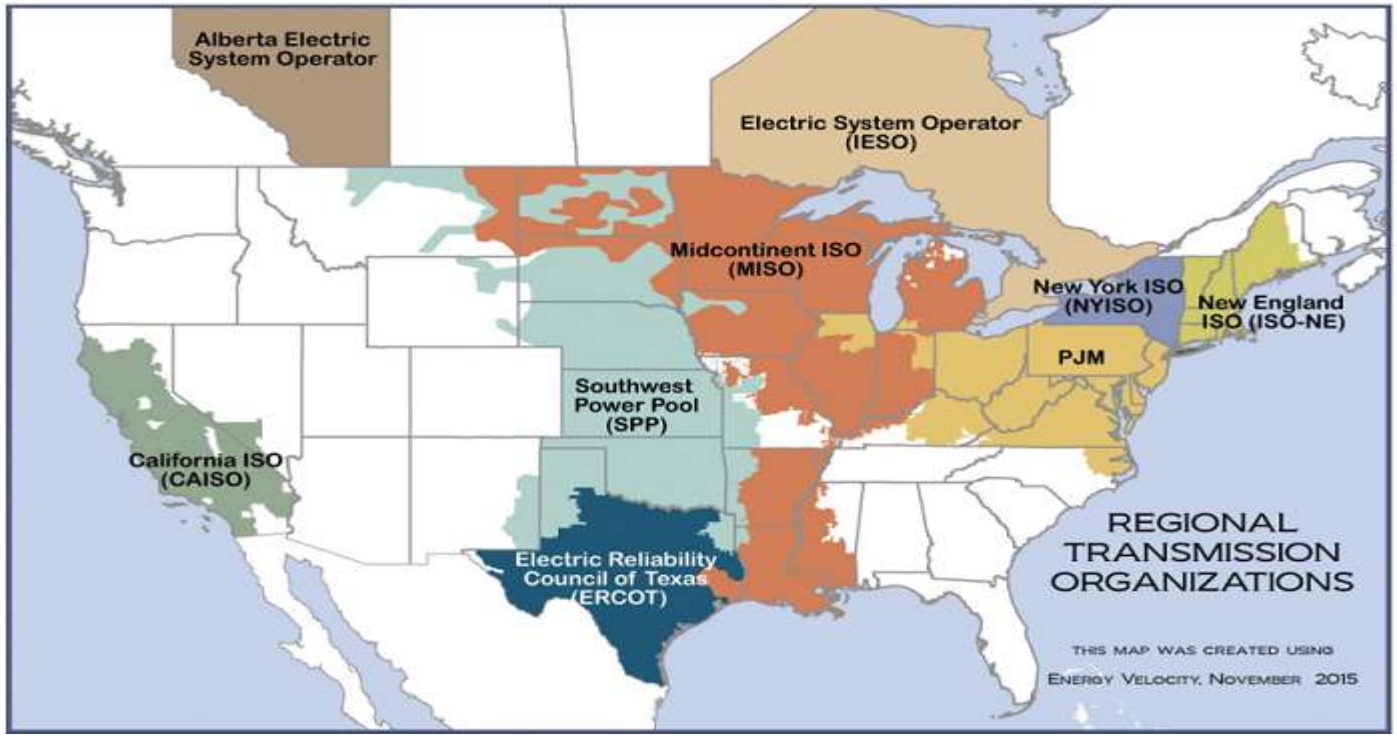
Source: Form EIA-860M, Preliminary Monthly Electric Generator Inventory

The Regulatory Framework for Energy Is Complex

- **Federal Energy Regulatory Commission (FERC): wholesale markets for electricity and natural gas; transmission (the grid) and interstate pipelines.**
- **State Public Utility Commissions: retail markets for electricity and natural gas; local distribution systems. Note that cities and counties may have their own authorities under state law.**
  - **Thus, how are policies are developed and who pays depends on the resource at issue. If it is at the grid level, FERC develops the policies and wholesale customers bear the cost (typically, load serving entities). If it is at the distribution level, states develop the policies and retail customers pay. Examples: AMI, the states and retail customers; grid storage, FERC and wholesale customers.**

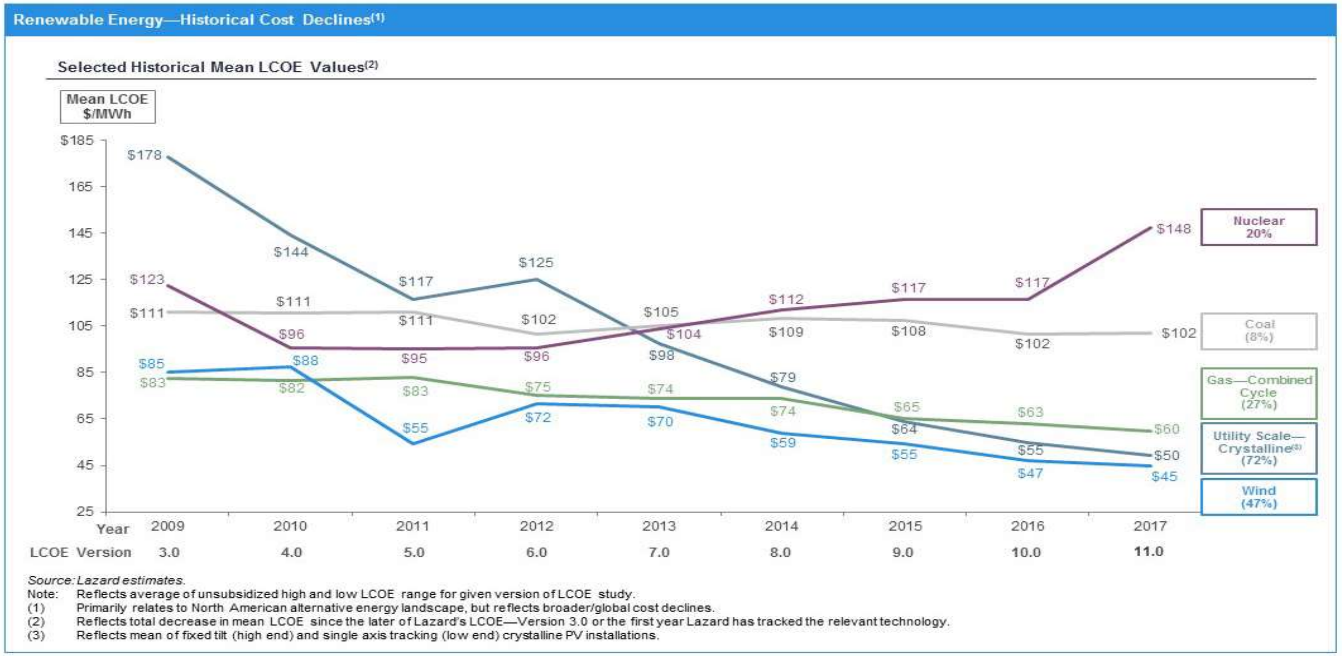
Competitive Wholesale Markets

- **Regional Transmission Organizations (RTOs) and Independent Systems Operators (ISOs) serve about two-thirds of the United States. They operate energy markets and dispatch power. The market rules are complicated and vary across markets.**



Innovation: The Economic Choice Is Increasingly the Environmental One

- **Lazard's 2017 levelized cost of energy study (Nov. 2, 2017) shows wind and solar being cheaper than thermal generation on an unsubsidized basis.**



Xcel's Solicitation for Generation (Dec. 2017)

- **Median price bid for wind+storage was $21/MWh and for solar+storage $36/MWh.**
- **Caveats: projects come on line in 2023, storage size is not specified, renewables are sited at favorable locations, and there are tax credits.**

RFP Responses by Technology

Generation Technology	# of Bids	Bid MW	# of Projects	Project MW	Median Bid Price or Equivalent	Pricing Units
Combustion Turbine/IC Engines	30	7,141	13	2,466	$ 4.80	$/kW-mo
Combustion Turbine with Battery Storage	7	804	3	476	6.20	$/kW-mo
Gas-Fired Combined Cycles	2	451	2	451		$/kW-mo
Stand-alone Battery Storage	28	2,143	21	1,614	11.30	$/kW-mo
Compressed Air Energy Storage	1	317	1	317		$/kW-mo
Wind	96	42,278	42	17,380	$ 18.10	$/MWh
Wind and Solar	5	2,612	4	2,162	19.90	$/MWh
Wind with Battery Storage	11	5,700	8	5,097	21.00	$/MWh
Solar (PV)	152	29,710	75	13,435	29.50	$/MWh
Wind and Solar and Battery Storage	7	4,048	7	4,048	30.60	$/MWh
Solar (PV) with Battery Storage	87	16,725	59	10,813	36.00	$/MWh
IC Engine with Solar	1	5	1	5		$/MWh
Waste Heat	2	21	1	11		$/MWh
Biomass	1	9	1	9		$/MWh
Total	430	111,963	238	58,283		

Consumer Preference

- **Individual**
  - **Economics, sustainability, energy autonomy**
- **Corporate**
  - **Examples: the RE100; "We Are Still In"**
- **Supportive State and Federal Policies**

State and Federal Public Policies

- **State: Renewable Portfolio Standards and renewable energy credits (RECs); net metering; green tariffs that facilitate corporate procurement of renewable energy; other support for renewables and energy storage; carbon markets; nuclear subsidies (IL and NY)**
- **Federal: Mercury and Air Toxics Standards (MATS); Investment Tax Credit and Production Tax Credit; tax credits for electric vehicles; Research & Development (Department of Energy and National Labs).**
  - **But rollback on Clean Power Plan and Paris Accord, and threatened cuts to DOE R&D budget**
  - **Efforts to bailout coal and nuclear: Department of Energy Notice of Proposed Rulemaking (denied by FERC); First Energy Services request for emergency action (leaked DOE draft document)**

What Will the Future Look Like Over the Next Decade?

- **Less coal, with greater reliance on gas, especially flexible, fast ramping gas.**
- **More renewables.**
- **Continuing consumer preference at individual and corporate levels for renewables.**
- **More distributed energy resources.**
- **Wider deployment of storage as it becomes increasingly cost competitive.**
- **Increased energy efficiency and demand side management.**
- **Increased digitalization, using big data, IoT, machine learning, cloud technologies, and perhaps blockchain technology to optimize system performance both behind and in front of the meter.**
- **Greater electrification, especially of transportation, with increased adoption of electric vehicles (EVs).**

How Fast Will the Change Happen, and How Sweeping Will It Be?

- **EPA's Clean Power Plan (CPP)**
  - **Issued in August 2015**
  - **Calls for 32% reduction in carbon emissions from 2005 levels by 2030**
  - **Never implemented; stayed in federal court with effort by Trump Administration to replace the CPP.**
  - **Today, we're about 87% of the way towards meeting the CPP's goal with 12 years to go (a 28% reduction in carbon emissions from 2005 levels in 2018) and wholesale power prices remain low.**
  - **Under a mass-based approach, CPP projected a generation mix in 2030 that was 19% nuclear, 28% coal, 32% gas, and 20% renewables.**
    - **In 2017, the generation mix was 20% nuclear, 30% coal, 32% gas, 15% renewables, and 3% other.**

Another Data Point

- **Peak oil demand as a proxy:**
  - **Shell: 2025-2030**
  - **Equinor/Statoil: 2030**
  - **Bank of America: 2030**
  - **Wood Mackenzie: gasoline by 2030 and oil after 2035**
  - **Total: as soon as 2040**
  - **IEA & BP: after 2040**
  - **Saudi Aramco, Chevron, Exxon Mobil: no peak foreseen**

BP's Projection: Base Case, Fast Case, Faster Case, and ICE Ban

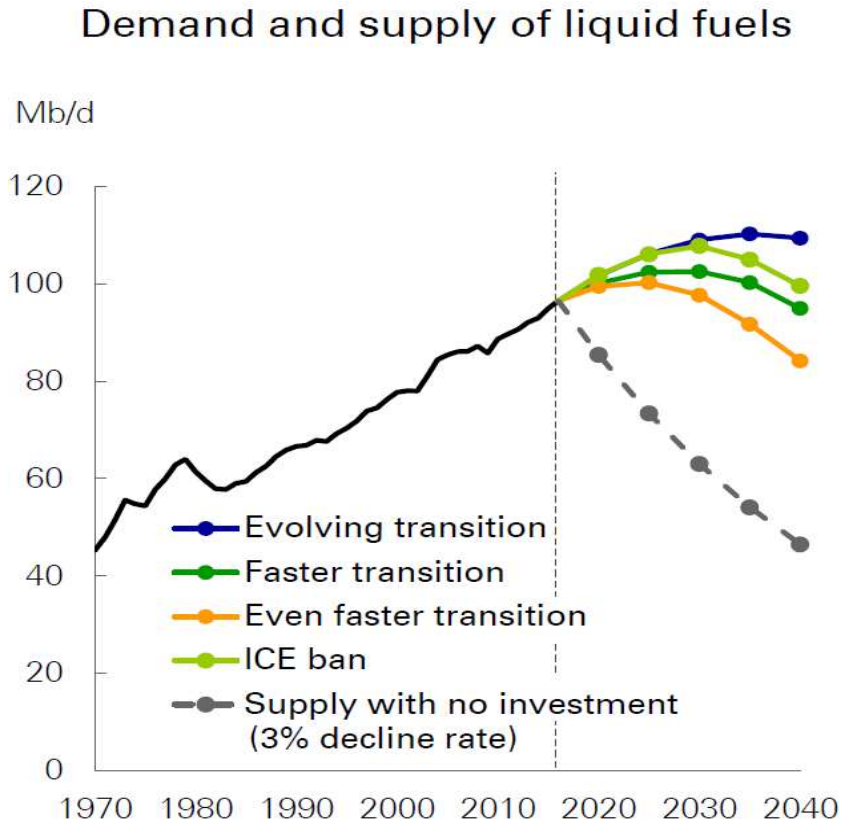
<u>Key Variables</u>:

Economic growth

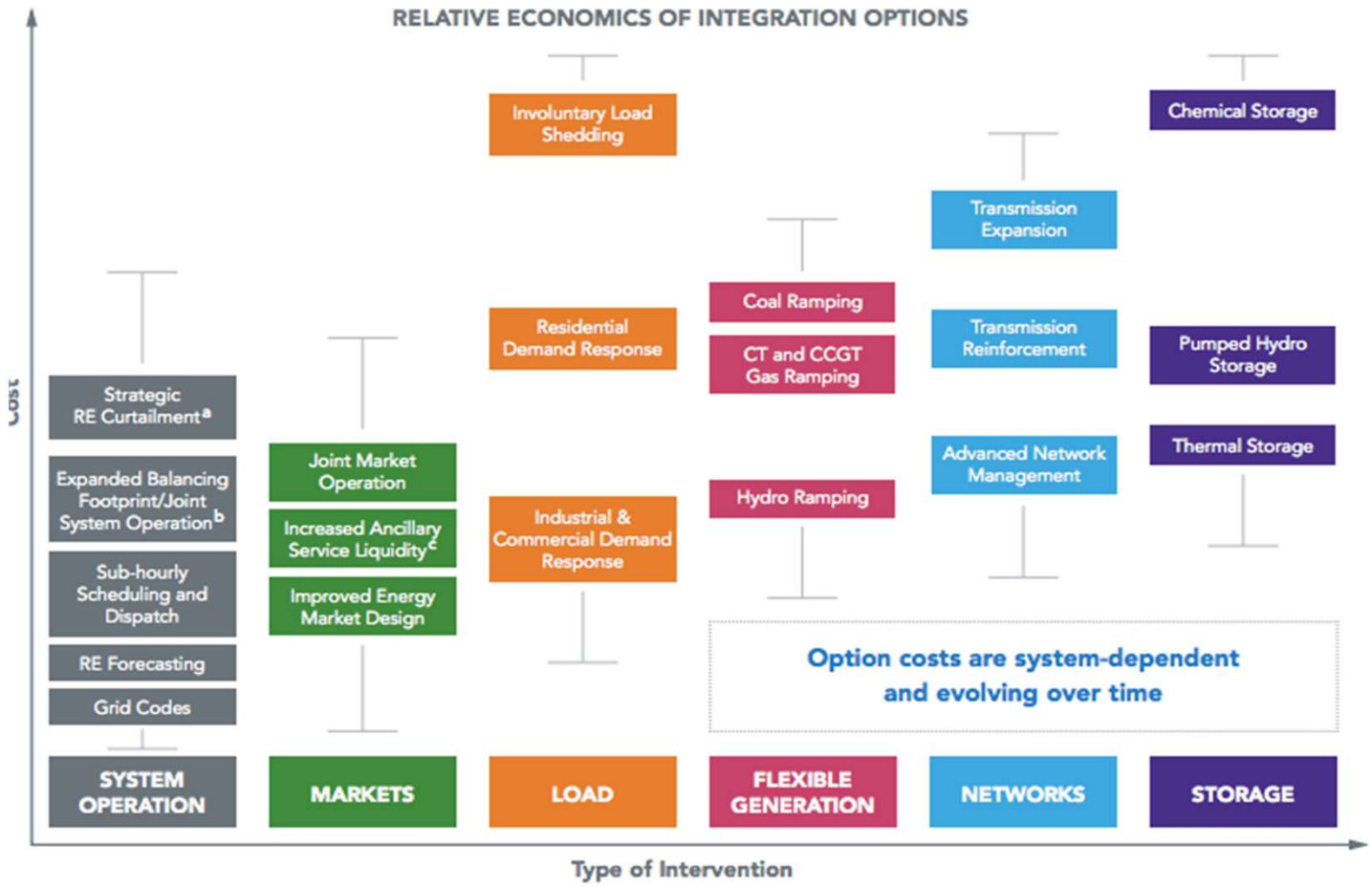
Climate policy

Electric vehicle adoption

Under 3 of 4 cases, oil demand could begin to decline by 2035.



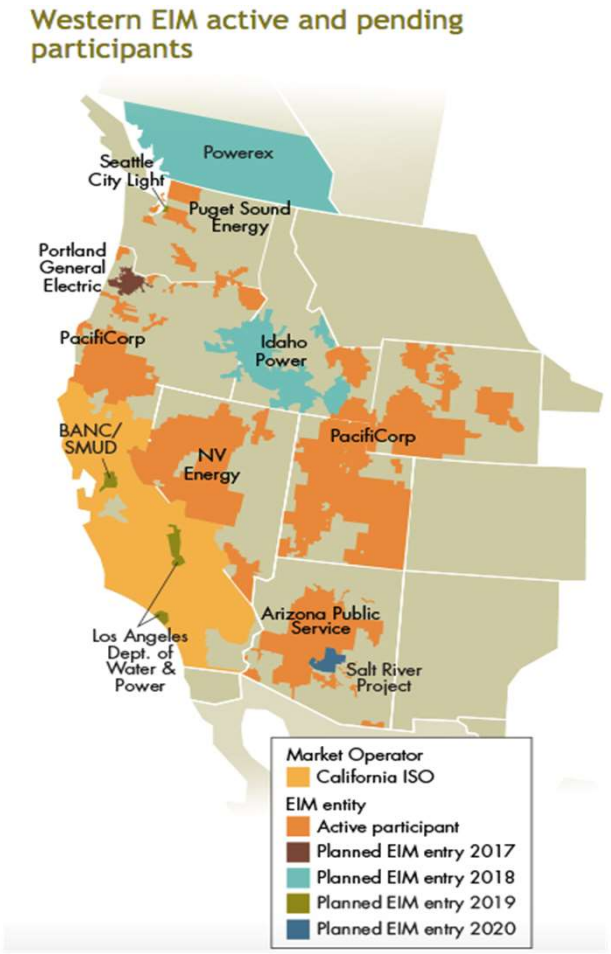
Options for Integrating Renewables



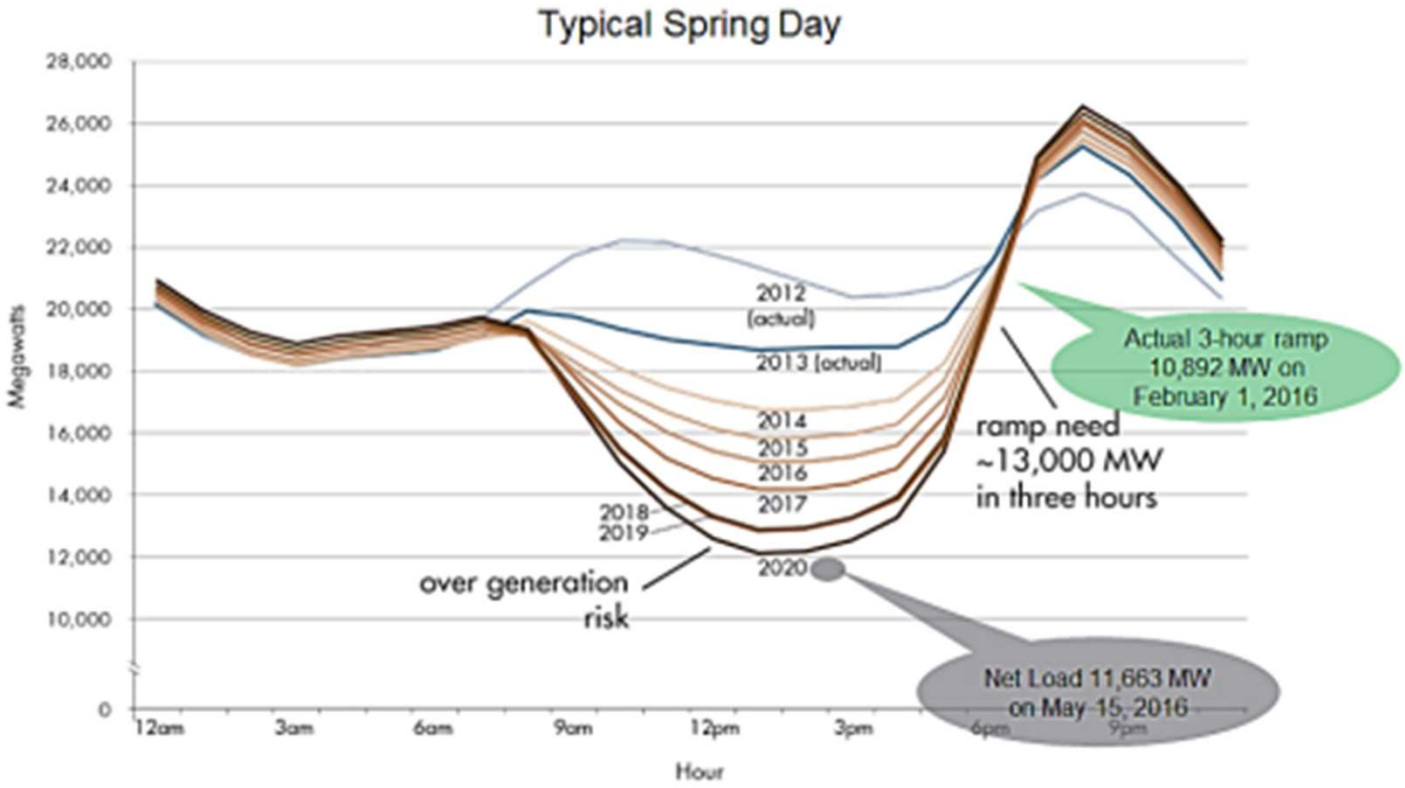
Source: National Renewable Energy Laboratory (NREL)

Markets

Western Energy Imbalance Market (EIM)



Why the EIM Matters: the "Duck Curve" in California



Source: CAISO

Benefits of EIM

- More efficient dispatch
- Reduced renewable energy curtailment
- Reduced flexibility ramping reserves needed in all balancing authority areas
- Estimated benefit of $401.7 million since November 2014

Source: Western EIM (June 30, 2018)

Market Rules (System Operations)

- **Requiring transmission providers to offer intra-hour scheduling at 15-minute intervals.**
- **Interconnection customers with variable resources provide meteorological and forced outage data to transmission operators.**
- **Requiring new variable resources to have reactive power capability.**
- **Streamlining interconnection processes (which helps all resources).**

Flexible Resources

- **Price Formation: Compensating resources for the value they provide when they provide it. Some megawatts are worth more than others.**
  - **Scarcity or shortage pricing; raising price caps**
  - **Aligning settlement and dispatch intervals**
  - **Fast start pricing to allow those resources to set locational marginal price (LMP)**
  - **Increasing uplift transparency**

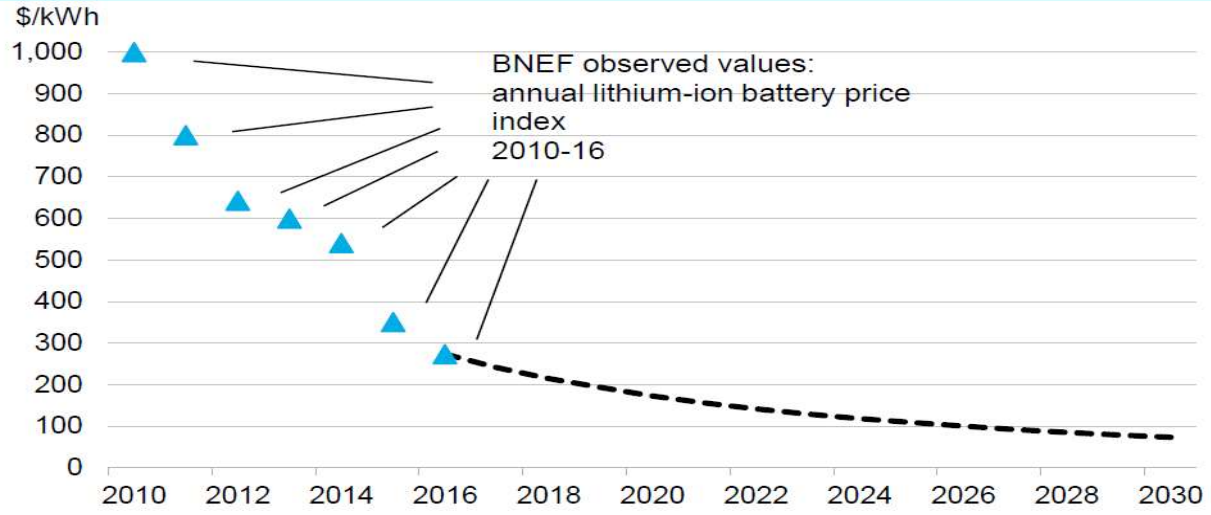
Load or Demand Side Management

- **FERC issues Order No. 745 (2011), which the Supreme Court upheld in *FERC v. EPSA* (2016).**
- **At wholesale level (RTO/ISO markets): Demand Response, which is able to offer energy and capacity.**
  - **PJM: 11,125 MW of DR and 2,832 MW of EE cleared in 2021/2022 capacity auction.**
- **At retail level: dynamic retail pricing or variable pricing**

Energy Storage
BNEF Study (June 2017)

BNEF forecasts lithium-ion battery pack prices will fall to as little as $73/kWh

- Intense price competition is leading manufacturers to develop new chemistries and improved processes to reduce production costs.
- Production costs have also come down significantly. Our models calculate that producing a battery in a Korean manufacturing plant in 2017 costs $162/kWh, dropping to $74/kWh in 2030.
- The BNEF battery price survey provides an annual industry average battery price for EVs and stationary storage. The learning rate (the price decrease for every doubling of capacity) is 19%.



Source: Bloomberg New Energy Finance

7 June 20, 2017

Bloomberg
New Energy Finance

WILLKIE FARR & GALLAGHER LLP

Changing Market Rules to Accommodate Storage

- **The Problem: Market rules were written for generation or transmission, and storage was not able to participate in all aspects of the RTO/ISO markets (energy, capacity, and ancillary services)**

- **The Solution: FERC issued Order No. 841 that creates a participation model for storage and that allows storage to be compensated for all services that it is technically capable of providing.**

Distributed Energy Resources (DER)

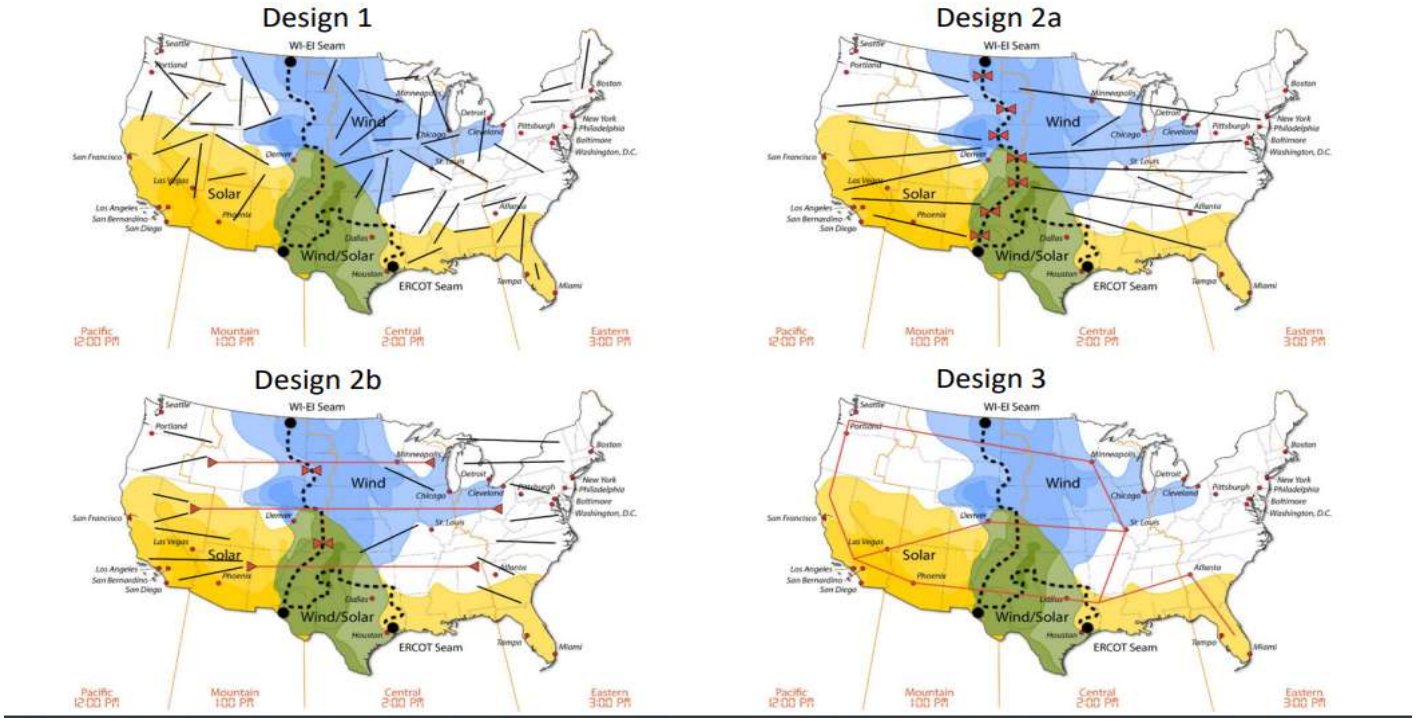
- **FERC issued a Notice of Proposed Rulemaking to allow aggregated DER to participate in the RTO/ISO markets**
- **FERC Technical Conference held in April 2018**
  - **Arguments for: DER can provide flexible resources to the grid, improving efficiency, reliability, and resiliency**
  - **Arguments against: jurisdictional and operational concerns**
- **But DER is happening, and it is real: an estimated 1.6 million solar installations in the US; Q1 2018, 15.9 MW of residential storage; 11.7 MW commercial; and 16 MW utility scale; and increasing use of microgrids.**

Digitalization

- **The Potential: Harnessing the power of sensors, Big Data, advanced analytics, machine learning, and wireless technology to create a platform that enables a more dynamic, flexible grid**
  - **According to IEA, the benefits are enormous, https://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf**
- **Smart Grid: Microsoft and Agder Energi Partner for Grid of the Future: https://www.youtube.com/watch?v=Z1NO4BiIfI0**
- **The Concerns: Market rules, and the technology is still developing**

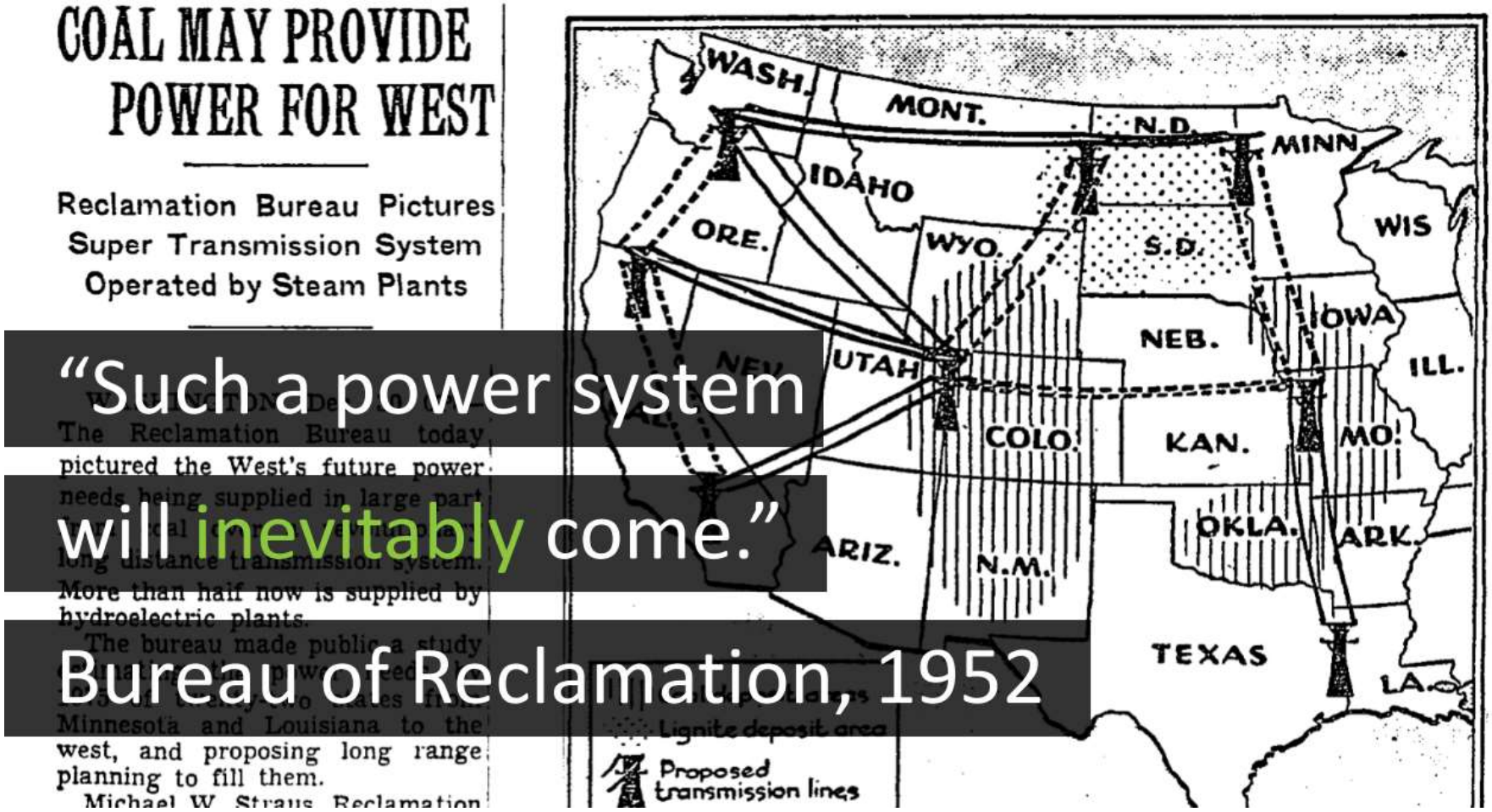
Networks or Transmission

- **Benefits: Economic, reliability, and public policy.**
  - **FERC Order No. 1000**
- **Concerns: Siting issues, planning and approval process, and cost allocation**



Source: NREL (Interconnection Seams Study 2018)

But Transmission Is Hard . . .



COAL MAY PROVIDE POWER FOR WEST

Reclamation Bureau Pictures Super Transmission System Operated by Steam Plants

The Reclamation Bureau today pictured the West's future power needs being supplied in large part [illegible] long distance transmission system. More than half now is supplied by hydroelectric plants.

The bureau made public a study [illegible] power needed [illegible] Minnesota and Louisiana to the west, and proposing long range planning to fill them.

Michael W. Straus, Reclamation

"Such a power system will inevitably come."

Bureau of Reclamation, 1952

Challenges and Opportunities for Policymakers in this Time of Dramatic Change

- **Preparing for a high renewables future. Which options are available to you? Which need to be developed? And which will work best for you?**
- **Recognize the push and pull between technology, policy, and regulation**
  - **Technology often evolves faster than policy and regulation**
- **How to plan for the future and close the gap between technology, policy, and markets?**
  - **Learn from policies around the world to identify best practices**
  - **Meet with key stakeholders**

Challenges and Opportunities for Policymakers, *cont.*

- **Harness the benefits of competition and markets**
- **Getting the market rules and design right is critical**
  - **Remove barriers to innovation, especially rules written for existing technologies**
  - **Market-based mechanisms and policies should be technology neutral**
  - **Performance-based incentives – pay for performance (Order No. 755 for frequency regulation compensation)**
  - **Transparency – price, data, and process. This helps with investment signals and minimizes risk.**

Challenges and Opportunities for Policymakers, *cont.*

- **Support policy innovation**
  - **In the U.S. , States have become laboratories for experimentation**
  - **Learning from one another; interaction among policymakers, research institutes, and NGOs**
    - ✓ **Context matters: avoid a one-size-fits-all approach**
    - ✓ **Doing the right thing, while being mindful of political constraints, to promote an efficient, reliable, and sustainable grid**

Questions?