



The Future of U.S. Nuclear Power

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Urgent Problem



- U.S. nuclear power threatened
 - Economic issues for existing and new nuclear
 - Existing units closing early
 - New units not being built

- Loss of U.S. nuclear power will
 - Reduce U.S. nuclear industrial capability & influence
 - Increase reliance on natural gas generation

- Strong and swift action needed
 - Return to regulation and/ or remove markets
 - Out-of-market solutions (e.g., ZEC payments)

Nuclear power plants in trouble



More than half of U.S. Nuclear plants are losing money - *BNEF, 14 Jun 2017*

If New Jersey's nuclear plants were allowed to close, the ripple effects would be felt in communities and businesses: increased unemployment, decreased incomes, drastic cuts in tax revenues and a potential drop in property values - *PSEG, May 2017*

Spate of nuclear power plant closures could be start of full-fledged crisis - *Washington Examiner 19 Jun 2017*

Retiring Nuclear Power Plants May Undercut U.S. Climate Goals

- *Brad Plumer, NYT, 13 Jun 2017*

The energy market in PJM has not adapted to the evolution of the nuclear fleet

- *Exelon, NRC letter on closure of TMI-1, 20 Jun 2017*

Lost generation from SONGS was met largely by in-state natural gas plants and the SONGS closure increased carbon dioxide emissions by 9 million tons in the first twelve months (the equivalent of putting 2 million additional cars on the road.

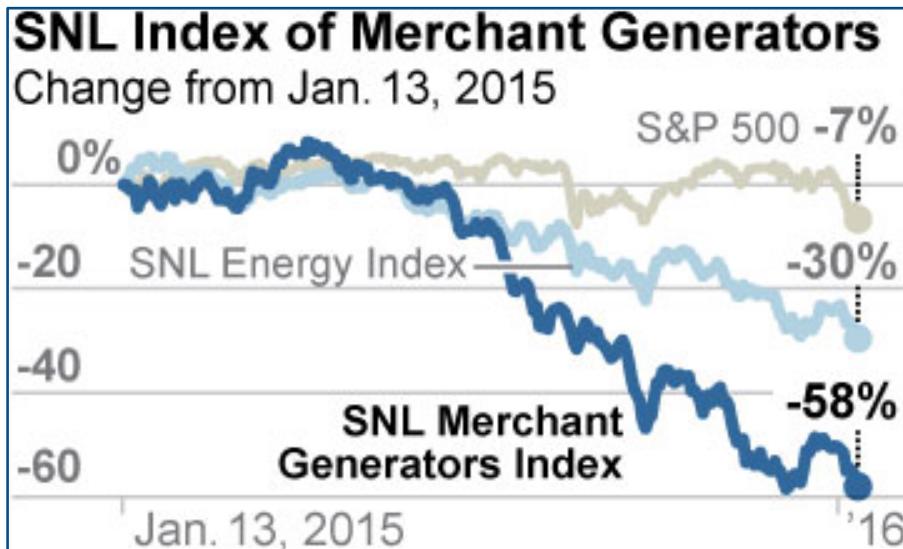
- *Davis & Hausman, Applied Economics, 2016*

19 of 33 nuclear power plants operating in competitive power markets may incur fuel and O&M costs that exceed electricity revenues in 2016 - *CRS, 14 Dec 2016*

Midwest's cheap power prices and, in some states, deregulated markets make it hard for nuclear to compete with cheaper natural gas and renewables. Recent reports have identified numerous nuclear power plants in Illinois, Michigan, Ohio and Nebraska as likely to shut down before 2025.

- *Lyderson, Midwest Energy News, Aug 2016*

Merchant generator model broken



Outlook for merchant generators is gloomy

- *UtilityDIVE* Mar 2014

Large merchant generators could experience another wave of bankruptcies

- *Power Engineering* Jun 2017

GenOn, a unit of NRG Energy with a 15.3 GW fleet of gas, fuel oil and coal power stations, filed for bankruptcy this week

- *Reuters* Jun 2017

Breakdown of the Merchant Generation Business Model - Investors must anticipate the boom/bust cycle of electric power prices, the potential for disruptive new generation technologies or significant regulatory changes, and changes in the relative costs of generation fuels, all of which can alter the expected profitability of new & existing power plants.

- *Wilkinson Barker Knauer / PRG* June 2017

Challenges facing merchant generators include continued low power and gas prices, rising costs related to environmental regulations, and competitive pressures from renewable generation.

- *Fitch* (on Edison Mission Energy bankruptcy) Mar 2014

Déjà vu?

The merchant power industry expanded in the late 1990s and early 2000s in the newly deregulated electricity industry. By late 2001, many of the merchant power companies were in financial distress

- An Examination of Distress in the Electric Power Industry, Stern School of Business, April 2005



“Mirant Corp., an energy producer that operates power plants in 14 states, filed for bankruptcy protection after slumping power prices and higher costs”

- LA Times, 15 July 2003

Embattled power producer Calpine Corp. filed for bankruptcy in a weak merchant power market

- Reuters Dec 2005

Prices for merchant power assets appear to have halted a three-year free fall”

- Power Engineering, 27 Dec 2005

Electricity Reform?



The PJM Capacity Market Crash:
What Happened?

- UBS, 24 May 2017

Today, there is no genuinely free market for
electricity

- Kavulla, Foreign Affairs, 20 May 2017

The promise of electricity restructuring was that it would result in competition that would in turn produce cost efficiencies in production and lower prices to retail consumers

Despite much advocacy, there is no reliable and convincing evidence that consumers are better off as a result of restructuring of the U.S. electric power industry

- *Restructuring the U.S. Electric Power Sector: A Review of Recent Studies*, John Kwoka, Nov 2006

Prior to the 1990s, most U.S. electricity customers were served by regulated, vertically-integrated, monopoly utilities that handled electricity generation, transmission, local distribution and billing/collections – model disrupted in the 1990s by “electricity restructuring.”

While the restructuring era dawned with great hope that regulatory innovations, and the incentives provided by competition, would dramatically improve efficiency and greatly lower consumer costs, that hope was largely illusory. In fact, rates rose in both regulated and deregulated states, and more rapidly in the deregulated ones in the early years of reform.

- *The U.S. Electricity Industry after 20 Years of Restructuring*, Borenstein and Bushnell, Haas WP 252R, May 2015

Two electricity industry approaches



- **Traditional: Regulated / Government utilities**
 - Plan, build, own & operate generation portfolio to:
 - Meet projected demand with high reliability
 - Manage system dispatch
 - Minimize the long-term total cost of electricity (i.e., capital costs, fixed costs, fuel costs, etc.)

- **New: Electricity markets + Private power**
 - Electricity market bid-based spot market to:
 - Manage system dispatch of independent generators
 - Minimize short-term marginal cost of electricity

How are these different?



Traditional

- Proven – 100+ years of experience
- Average cost pricing
- Financial support for generation and system investments
- Supports state electricity planning

New

- Unproven – recent innovation on top of existing generation build
- Marginal cost pricing
- Need out-of-market incentives for investment
- Conflicts with state electricity planning

Traditional approach



- State government and utility regulator in control of electric utility planning and investment
 - Obligation to serve by regulated monopoly utility
 - Vertical integration
- Planning for new generation to meet projected demand while minimizing long-term total system costs
 - Portfolio of generation types, fuels, and locations built
 - Power plants dispatched to meet real-time demand at lowest marginal system cost (i.e., fuel + variable O&M)

New Approach



- Experience limited – most U.S. markets implemented between 1997 and 2001

- Market reforms in each state
 - Vertically-integrated utilities required to divest or separate generation from regulated retail/distribution/transmission
 - Nuclear plants sold/divested with short-term PPAs

- State government and regulators left with unclear role in generation planning

How cost of electricity determined

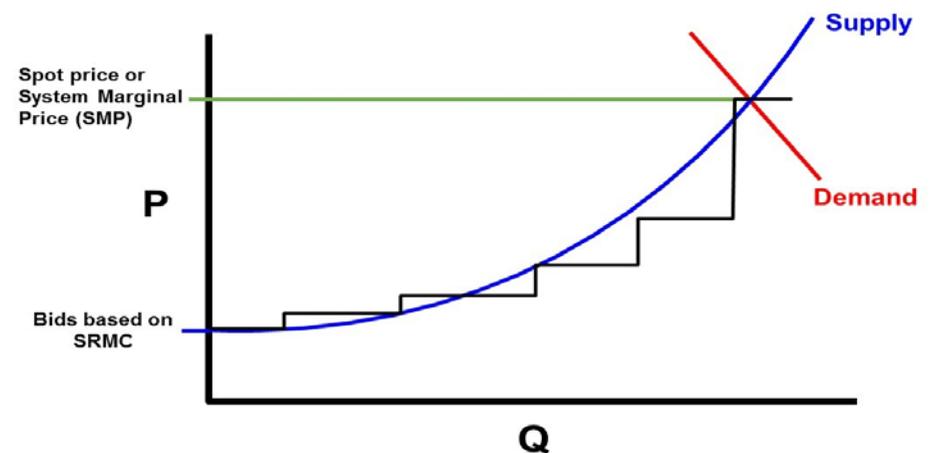


Traditional - Average cost

- All costs of generation and purchased power added up
- Spread over total power generated/purchased power
- Utility regulator oversees recovery from retail ratepayers

New - Marginal cost

- System Marginal Price



- Last bid selected sets the wholesale market price all electricity

How nuclear power attributes valued



Traditional

- Focus on long-term total cost of electricity
- Planning and ratemaking process:
 - Approving nuclear power investments by regulated utilities
 - Allowing recovery of nuclear ownership and operation costs in rates

New

- Focus on short-term marginal cost of commodity electricity
- No revenue for key nuclear attributes
 - Reliability
 - Clean operation
 - Long-term asset operation
 - Stable fuel costs
 - Generation fuel diversity
 - Macro-economic benefits

Market Failure . . .



- Early retirement of existing nuclear plants is market failure
 - Market does not provide profits for activities with net public benefits
 - Net public benefits when total (public + private) benefits greater than total costs
 - Activities or investments with private losses will not go forward, even if there are net public benefits

NECG Commentary #14 - <http://nuclear-economics.com/14-market-failure/>

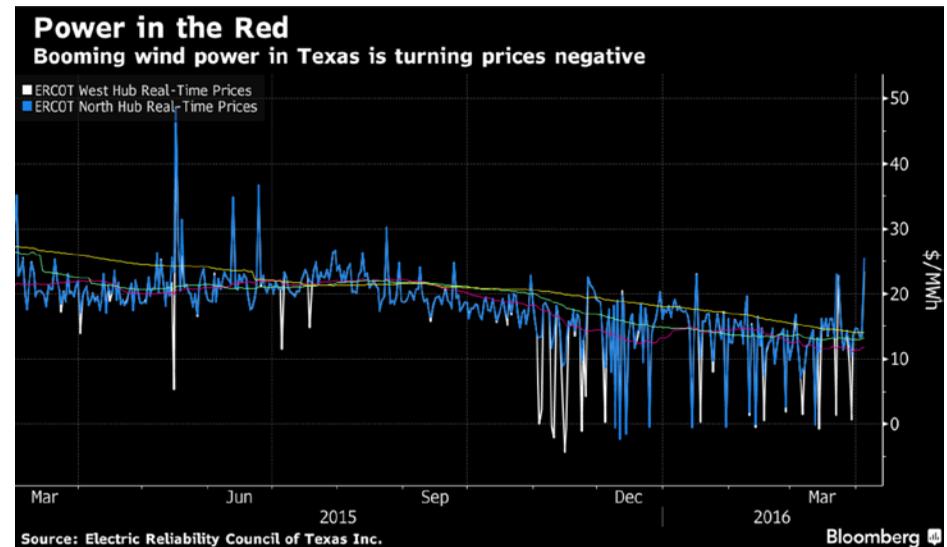
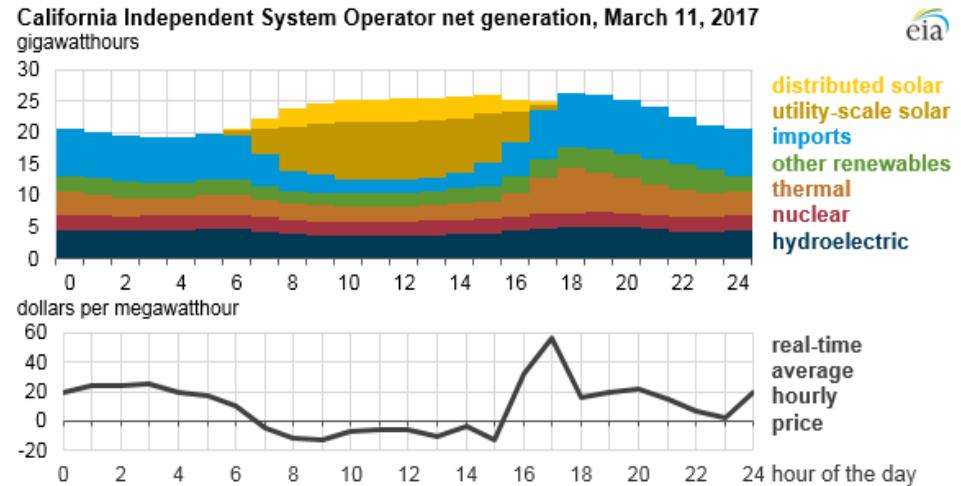
DOE 2016 - <https://gain.inl.gov/Shared%20Documents/Economics-Nuclear-Fleet.pdf>

. . . and failing electricity markets

- Marginal cost pricing is driving generator retirements, NOT new investments
- Market institutions (e.g., FERC & ISO/RTOs) focus on keeping wholesale electricity prices low – even when prices are already too low to support operation of some generators or new investments
- Market approach to investment = shift to lowest cost generation that may not result in:
 - Long-term system reliability
 - Lowest long-term total system cost

Negative electricity market prices

- Negative price hours increasing
- Negative prices - nuclear plant pays ISO to generate
- Markets will not work in zero-carbon electricity system (i.e., all marginal costs are zero or negative)



Fixing market failure



- Fix electricity markets if possible, end them if not
- Re-regulate electricity industry or nuclear plants
- Shift to Government / Public Power ownership
- Implement clean energy mandates (with nuclear)
- Pay for positive nuclear externalities (e.g., ZECs)
- Impose costs on negative externalities (e.g., carbon)

State Policy Actions



- State role in long-term planning
 - Regulated retail utilities can provide nuclear revenue
 - Move to regain utility planning role

- State Actions
 - New York - Clean Energy Standard, with ZECs
 - Illinois – Future Energy Jobs Bill, with ZECs

- Key battles in courts and FERC
 - Market institutions fighting for existence
 - States fighting to keep role in electricity industry

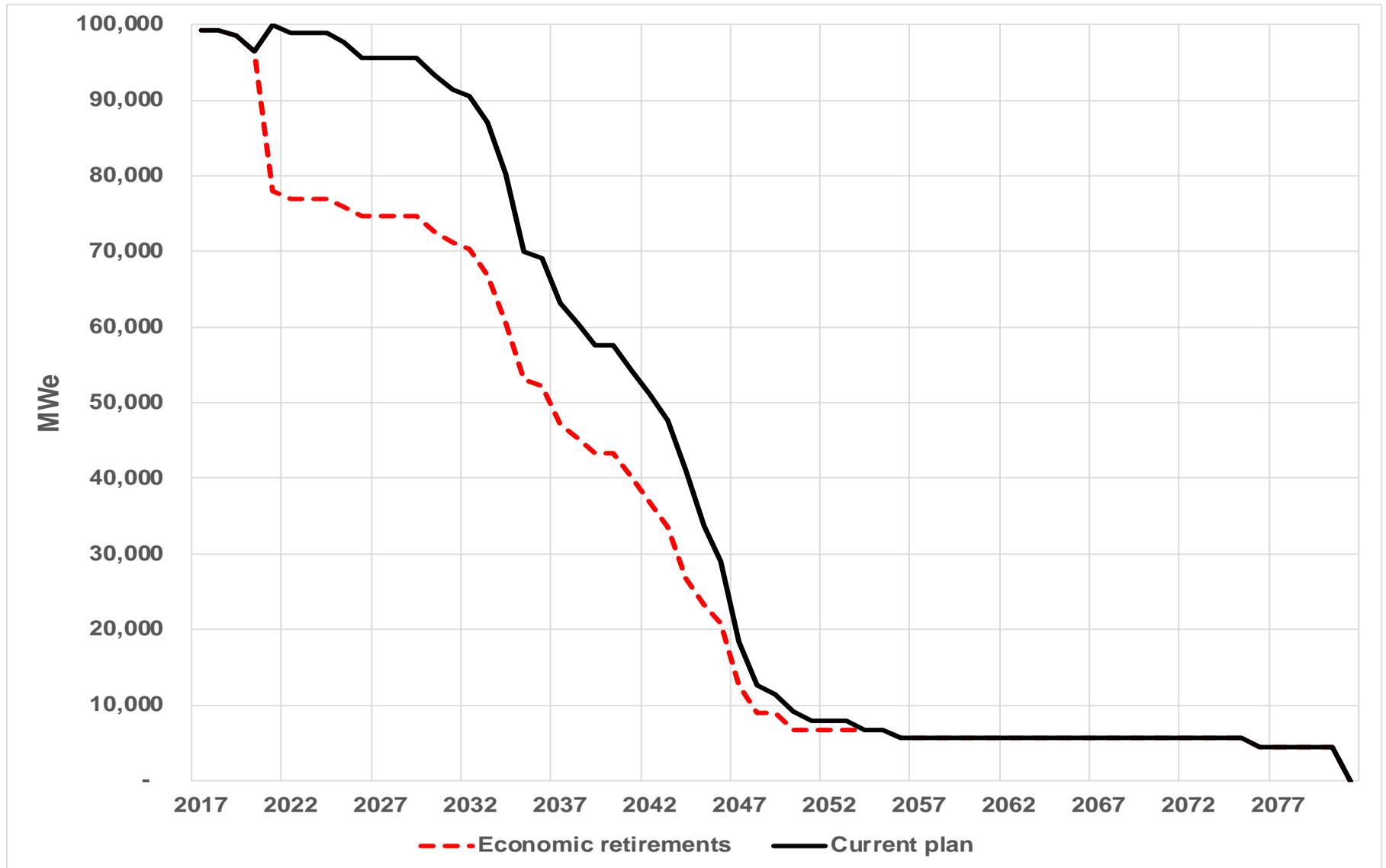
Summary



- U.S. nuclear market failure caused by
 - Market approach to electricity
 - Low electricity market prices
 - No compensation for nuclear public benefits

- Need swift and direct action to fix this problem
 - State action to provide revenue (e.g., NY and Illinois)
 - State action to regain role in electricity planning
 - Re-regulation or exit from electricity markets
 - Federal government role may be needed

U.S. nuclear capacity to 2080



References

ANS Toolkit



- ANS Special Committee on Nuclear in the States
- Toolkit - policy and market tools to prevent nuclear closures and promote new nuclear
- Version 2.0 issued in June 2016
 - <http://nuclearconnect.org/issues-policy/nuclear-policy-in-the-states>
 - <http://nuclearconnect.org/wp-content/uploads/2016/02/ANS-NIS-Toolkit-V2.pdf>

■ Papers/Articles

<http://nuclear-economics.com/resources/publications/>

- Market failure and nuclear power (BAS, 2016)
- Carbon pricing not enough to help nuclear power (WNN, 2016)
- Can nuclear succeed in liberalized power markets? (WNN, 2015)
- U.S. nuclear industry in decline (NEI magazine, 2015)
- Role of government in nuclear (KP paper, 2014)
- Rescuing U.S. merchant nuclear power (Electricity Journal, 2014)

■ NECG Commentaries

<http://nuclear-economics.com/commentary/>



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