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## Challenges and Opportunities for U.S. Nuclear Energy

UT CEE Nuclear Roundtable

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\*Disclosures begin on page 11

# Discussion Topics

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- Retirements: Outlook for ~45 GW of merchant nuclear generation
- Low power prices driven by low natural gas prices and zero marginal cost, subsidized wind generation during off peak hours
- TPHe ~9 GW (24%) of merchant nuclear capacity is at risk
- Polar Vortex in early 2014 made it clear to state/federal regulators how important it is to have capacity with guaranteed fuel supply.
- Key is higher capacity prices along with market based solutions/PPAs
- We believe the only new nuclear plants that have a chance of coming online will be in regulated jurisdictions
- We believe Summer and Vogtle (under construction) are likely the last plants to start construction in the near to intermediate term

# Announced Merchant Nuke Retirements

Nuclear Plant	Majority Owner	MW	2014 CF (%)	Incr. Nat Gas Demand (bcfd)	State	Power Hub	Capacity Market	Announcement Date	Expected Retirement Date
FitzPatrick	ETR	850	90%	0.17	NY	NYZA	NYISO (ROS)	Nov'15	Late 2016/Early 2017
Pilgrim	ETR	684	96%	0.14	MA	MASS HUB	ISO-NE (SEMA-RI)	Oct'15	No later than June 2019
Oyster Creek	EXC	637	87%	0.13	NJ	PECO	PJM (EMAAC)	Dec'10	Dec'19 (EXC retirement date)
		<b>2,171</b>		<b>0.44</b>					

## Retirements due to Poor/Challenged Economics:

- **Kewaunee (May '13)** – Single unit plant in Wisconsin (570 MW) suffering from poor economics with PPA rolling off.
- **Vermont Yankee (Dec '14)** – Single unit plant (620 MW) with poor economics/political pressure to close.

## Retirements to Avoid Large Capital Investment:

- **Crystal River 3 (Feb '13)** – Single unit plant (860 MW) with repairs too expensive to fix.
- **SONGS (Jun '13)** – Important Southern CA nuke (2.3 GW) with repairs too expensive to fix.

# Challenged Merchant Nukes: Single-units most at Risk?

## Challenged U.S. Merchant Nuclear Plants at Risk of Early Retirement

Nuclear Plant	Majority Owner	MW	2014 CF (%)	Incr. Nat Gas Demand (bcfd)	State	Power Hub	Capacity Market	Earliest Likely Retirement Announcement Date
Quad Cities	EXC	1,817	97%	0.36	IL	NI HUB	PJM (RTO)	Deferred decision a year to mid-2016
Byron	EXC	2,384	92%	0.48	IL	NI HUB	PJM (RTO)	Deferred decision a year to mid-2016
Davis-Besse	FE	908	73%	0.18	OH	AD HUB	PJM (ATSI)	OH PPA settlement/PUCO approval
Clinton	EXC	1,078	94%	0.22	IL	NI HUB	MISO (Zone 4)	Deferred decision a year to mid-2016
R.E. Ginna	EXC	583	91%	0.12	NY	NYZA	NYISO (ROS)	2018 (after RSSA rolls off)
Palisades	ETR	810	82%	0.16	MI	NI HUB	MISO (Zone 7)	2022 (after PPA rolls off)
Three Mile Island	EXC	829	101%	0.17	PA	PJM WEST	PJM (MAAC)	Mid-2016
		<b>8,409</b>		<b>1.69</b>				

## Single-unit Merchant U.S. Nuclear Plants

Single-unit U.S. Merchant Nukes	Majority Owner	MW	2014 CF (%)	Incr. Nat Gas Demand (bcfd)	State	Power Hub	Capacity Market	In-Service Year	NRC Operating License Expiration	Year PPA Rolls Off
Hope Creek	PEG	1,161	102%	0.23	NJ	PJM EAST	PJM (EMAAC)	1986	2046	N/A
Perry	FE	1,298	92%	0.26	OH	FE ZONE	PJM (ATSI)	1987	2026	N/A
<b>Davis-Besse</b>	FE	908	73%	0.18	OH	AD HUB	PJM (ATSI)	1977	2017	N/A
<b>Three Mile Island</b>	EXC	829	101%	0.17	PA	PJM WEST	PJM (MAAC)	1974	2034	N/A
<b>Oyster Creek</b>	EXC	637	87%	0.13	NJ	PECO	PJM (EMAAC)	1969	2029	N/A
<b>Clinton</b>	EXC	1,078	96%	0.22	IL	NI HUB	MISO (Zone 4)	1987	2026	N/A
<b>Palisades</b>	EXC	810	82%	0.16	MI	NI HUB	MISO (Zone 7)	1971	2031	2022
Duane Arnold	NEE	622	76%	0.12	IA	NI HUB	MISO (Zone 3)	1775	2034	2025
Seabrook	NEE	1,247	93%	0.25	NH	MASS HUB	ISO-NE (ROP)	1990	2303	2034
<b>R.E. Ginna</b>	EXC	583	91%	0.12	NY	NYZA	NYSIO (ROS)	1970	2029	2017
		<b>9,173</b>		<b>1.84</b>						

\*Red highlighted nukes above represent at risk plants for early retirement (TPH).

\*\*Oyster Creek slated for retirement by Dec '19.

\*\*\*CF = Capacity Factor

# On Peak Nuclear Margins: Heavily Dependent on Gas Prices

As Gas Prices Increase → Power Prices Increase

	Power Prices	Coal Plants	Nuclear Plants	Gas Fired Plants
As Gas Prices RISE...	Rise	Profits Rise	Profits Rise	Profits Rise, but not as much
As Gas Prices FALL...	Fall	Profits Fall	Profits Fall	Profits Fall, but not as much
Gas Position		Economically Long Gas	Economically Long Gas	Not as levered to Gas Price
Correlation to Gas price		Positively Correlated	Positively Correlated	
Coal/Uranium Position		Economically Short Coal	Economically Short Uranium	
Fuel Correlation to Gas price			NO Correlation	

**TAKEAWAYS:**

**Electricity Sales Revenue - Fuel Cost = Gross Margin**  
 COAL & NUKE PLANT OUTLOOK POSITIVELY CORRELATED TO GAS PRICE OUTLOOK.  
 GAS PLANT NOT AS SENSITIVE

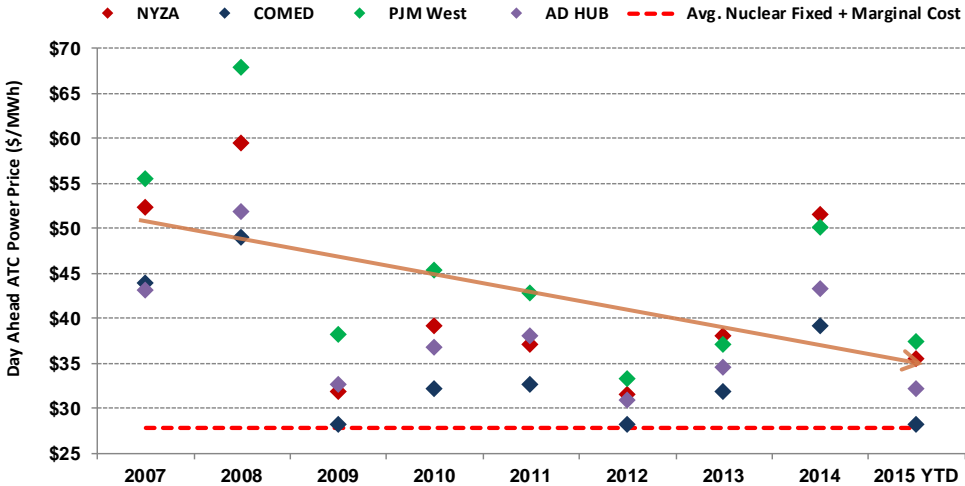
Markets operate through a single clearing price so the marginal power plant sets the price of power for everyone.

**Power Price = Natural Gas Price (\$/MMBtu) x Market Heat Rate (MMBtu/MWh)**

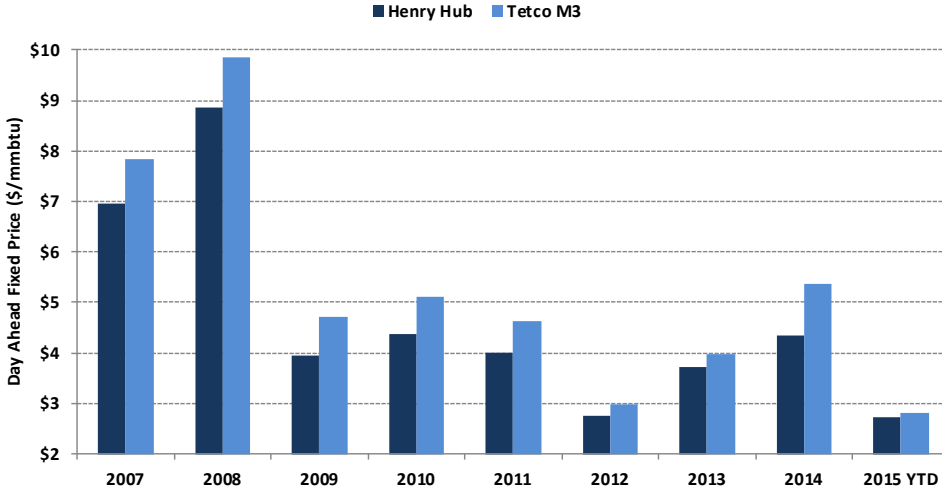
Source: TPH

# Weak Power/Gas Prices Squeezing Nuke Margins

Nuclear Margins: Avg. ATC Power Prices vs. Fixed + Marginal Nuke Costs



Gas Prices Significantly Below 2007/2008 Levels When Newbuild Nuke Decisions Finalized

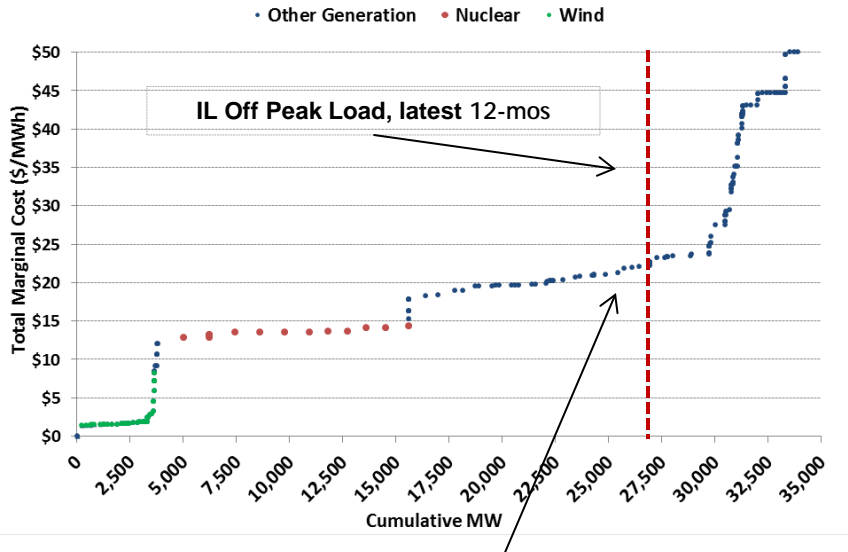


Source: Bloomberg, TPH, SNL

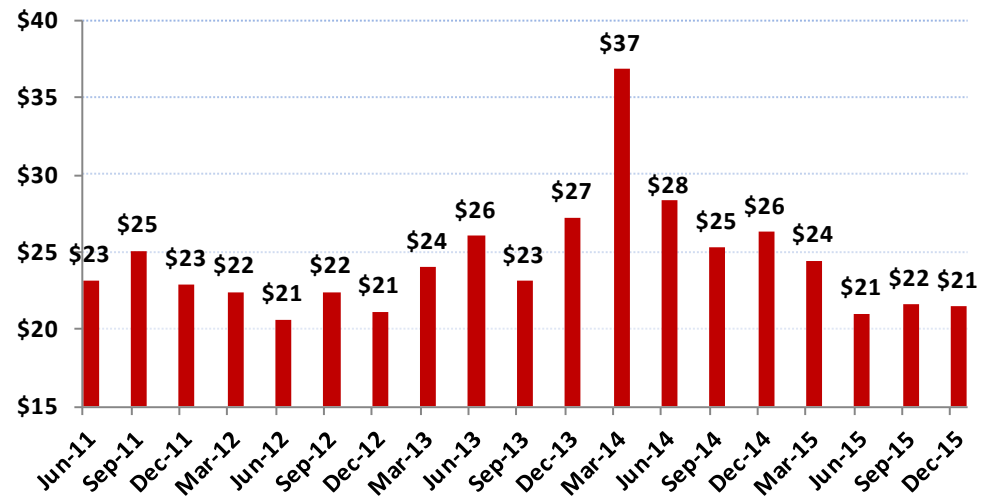
# Off Peak Prices – Wind Flooding the Market

- **Renewable subsidies** – Nukes don't stop running at night when wind speeds (supply) are highest and consumer demand is lowest, suppressing off-peak prices
- Wind subsidies make it economic for wind generation to sell power even if prices are negative.

Illinois' Electric Generation Dispatch Curve



NI-Hub Day Ahead Off Peak Power Prices (\$/MWh)



Illinois' PRB coal-fired gen fleet set the off-peak price of power on average the latest 12 trailing months. However, ~15% of that time, power prices are driven into negative territory by subsidized wind generation, which are economic even when power prices are negative.

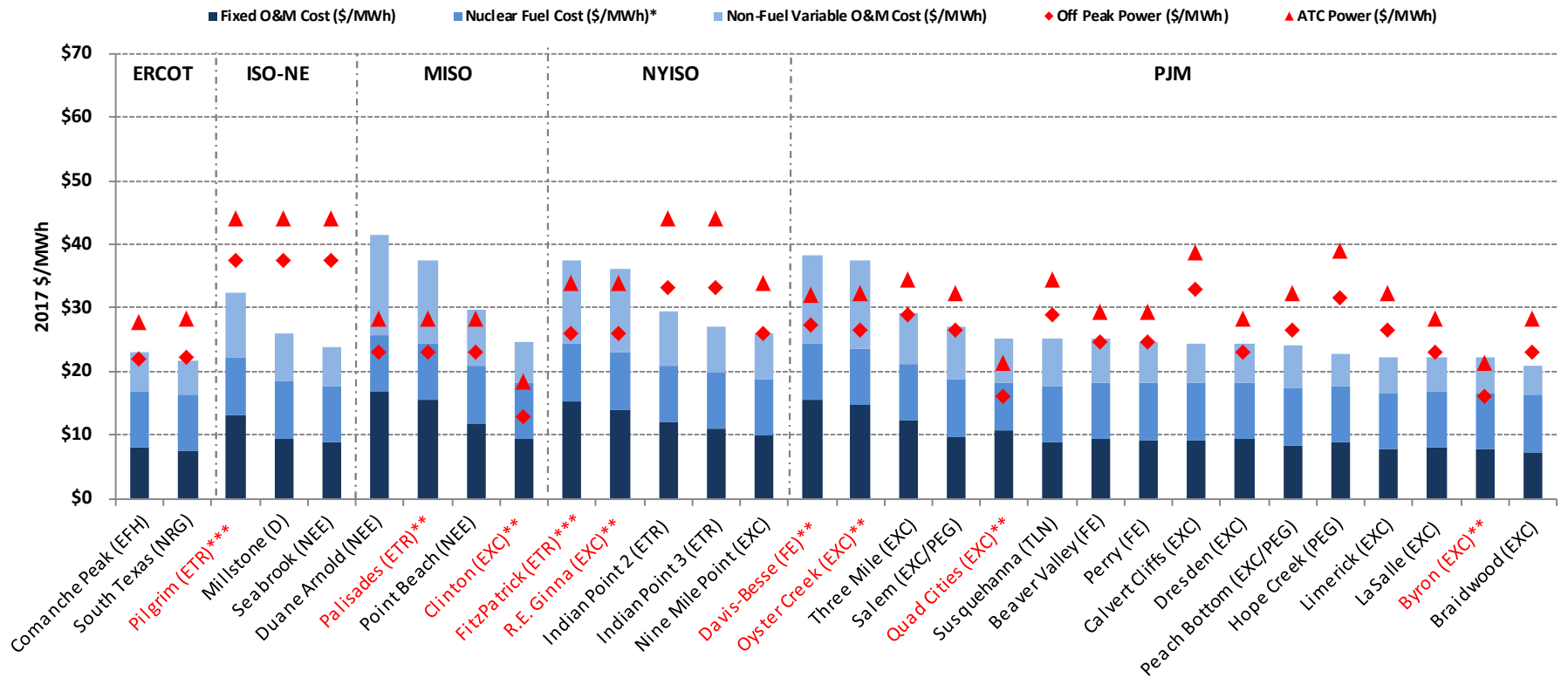
# Capacity Markets – An Overview

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- Capacity markets provide stable revenue for having their facilities ready to operate regardless of whether or not they are utilized.
- Goal: to ensure resource adequacy in periods of declining reserving margins.
- Most reliability standards set by ISOs are to prevent blackouts
- The Polar Vortex in Jan '14
- New England moving to a “pay-for-performance” capacity mechanism
- PJM now includes “capacity performance” (CP) obligations in the Base Residual Auctions



# Fixed & Marginal Cost vs. Power Price



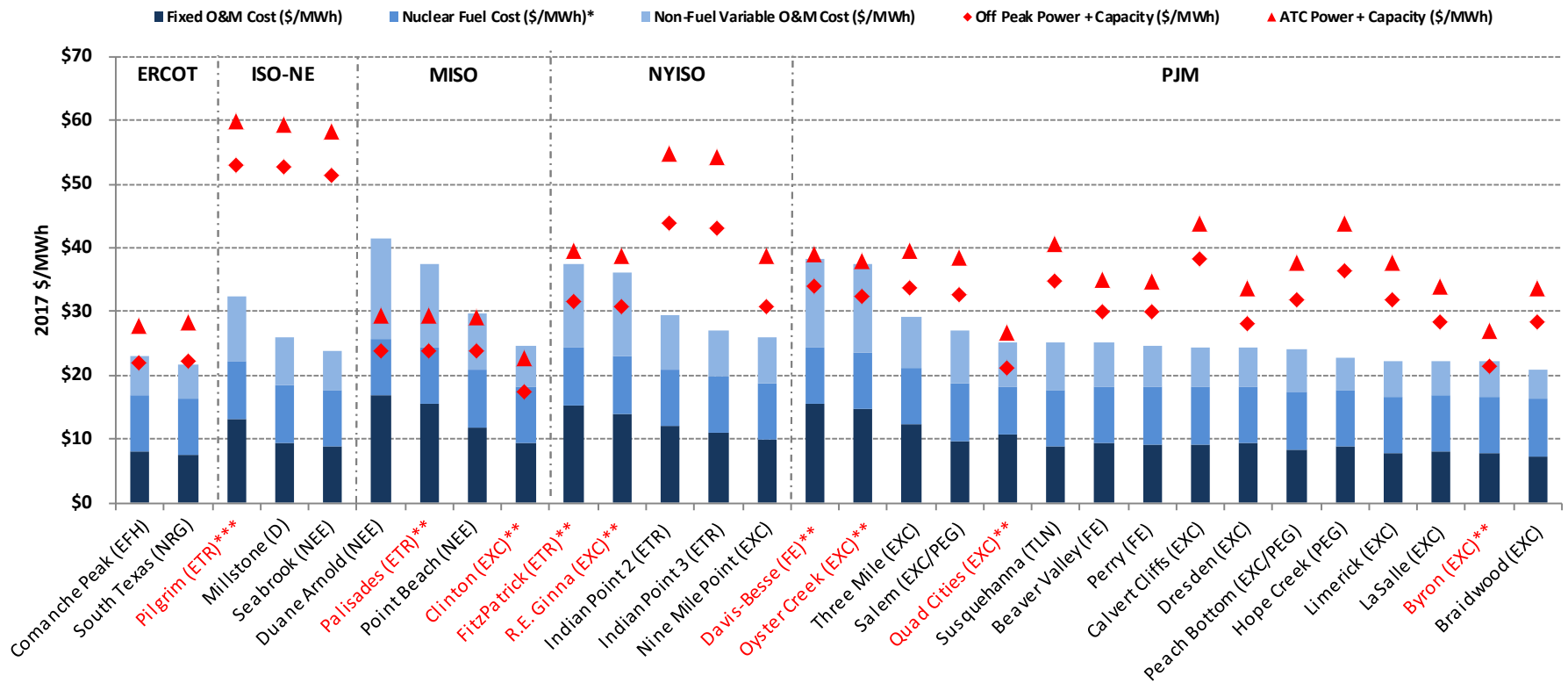
\*Nuclear fuel cost (\$/MWh) estimated by SNL.

\*\*TPHe at risk nukes

\*\*\*Retirement announced

Source: TPH July 2015 US Nuclear Report, SNL, Bloomberg

# Fixed & Marginal Cost vs. Power + Capacity Price



\*Nuclear fuel cost (\$/MWh) estimated by SNL.  
 \*\*TPHe at risk nukes  
 \*\*\*Retirement announced  
 Source: TPH July 2015 US Nuclear Report, SNL, Bloomberg

# ~17 GW Proposed, Minimal Likelihood of Construction

Nuclear Plant	Majority Owner	MW	Reactor Technology	Capacity Market	Regulatory Status	Gas Demand Offset (bcf/d)	City	State	Earliest Online Year	NRC COL Application Filed?	Under Construction?
<u>Under Construction</u>											
Watts Bar 2	TVA	1,150	PWR	N/A	Muni	0.23	Spring City	TN	2016	Yes	Yes
V.C. Summer 2-3	SCANA	2,234	AP 1000	N/A	Regulated	0.45	Jenksville	SC	2019/2020	Approved	Yes
Vogtle 3-4	SO	2,220	AP 1000	N/A	Regulated	0.44	Waynesboro	GA	2019/2020	Approved	Yes
	<b>Total</b>	<b>5,604</b>			<b>Total</b>	<b>1.12</b>					
<u>Under Development</u>											
UAMPS	Twin Buttes	600	NuScale SMR	N/A	Merchant	0.12	Idaho Falls	ID	2023	No	No
Fermi 3	DTE	1,600	ESBWR	MISO Zone 7	Regulated	0.32	Newport	MI	2025	Approved	No
River Bend 2	Entergy	1,550	ESBWR	MISO Zone 9	Regulated	0.31	Francisville	LA	2025	Yes	No
North Anna 3	Dominion	1,453	ESBWR	PJM RTO	Regulated	0.29	Mineral	VA	2027	Yes	No
South TX Project 3-4	NRG	2,700	ABWR	N/A	Merchant	0.54	Bay City	TX	2027	Yes	No
William States Lee III	Duke	2,234	AP 1000	N/A	Regulated	0.45	Cherokee	SC	2027	Yes	No
Turkey Point 6-7	NextEra	2,200	AP 1000	N/A	Regulated	0.44	Homestead	FL	2028	Yes	No
Grand Gulf 3	Entergy	1,443	ESBWR	MISO Zone 9	Regulated	0.29	Port Gibson	MS	N/A	Yes	No
Blue Castle	EnergyPath	2,200	AP 1000	N/A	Merchant	0.44	Green River	UT	N/A	No	No
Clinch River Nuclear	TVA	720	NuScale SMR	N/A	Muni	0.14	Oak Ridge	TN	N/A	No	No
	<b>Total</b>	<b>16,700</b>			<b>Total</b>	<b>3.34</b>					

- **Likelihood of commercial operation low** – The 4 yellow highlighted plants are regulated plants – we see absolutely no chance of merchant nuclear newbuilds reaching construction.
- Of the 4, **only 1 (maybe 2)** might actually reach commercial operation by the end of the next decade.
- **Watts Bar 2 not a “new” nuclear project** – The unit began construction in 1973, suspended construction in 1988 due to weak electric demand growth expectations, and then picked-up where it left off in 2007.

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