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# Why New Reactors Are The Wrong Tools For Decarbonization

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# My Background

- Degrees in Astronautical Engineering from the Massachusetts Institute of Technology (MIT) and Stanford University
- Law Degree from Stanford School of Law
- Studied nuclear engineering & project management courses in non-degree program at MIT
- Worked on energy, utility and environmental issues for over five decades
- Testified as an expert witness in state regulatory commissions in over 35 U.S. states, before the U.S. Nuclear Regulatory Commission (NRC) and the Federal Energy Regulatory Commission (FERC), and in state and federal court proceedings
- Filed expert testimony in over 130 state regulatory commission proceedings
- See my work at www.schlissel-technical.com and www.ieefa.org

# Key Definitions

- Plant construction costs generally presented in dollars per kilowatt ($/kW)
- **Overnight cost estimate** – assumes hypothetically that new plant can be built overnight – excludes escalation or financing costs
- **All-In cost estimate** – includes escalation and financing costs
- A **Positive Learning curve** – means when multiple copies of the same reactor design are built, the costs will go down as more are built
  - U.S. nuclear industry has never had a positive learning curve – has had a negative learning curve where costs have gone up
  - Even French nuclear program – 56 reactors with very similar designs – did not show a positive learning curve

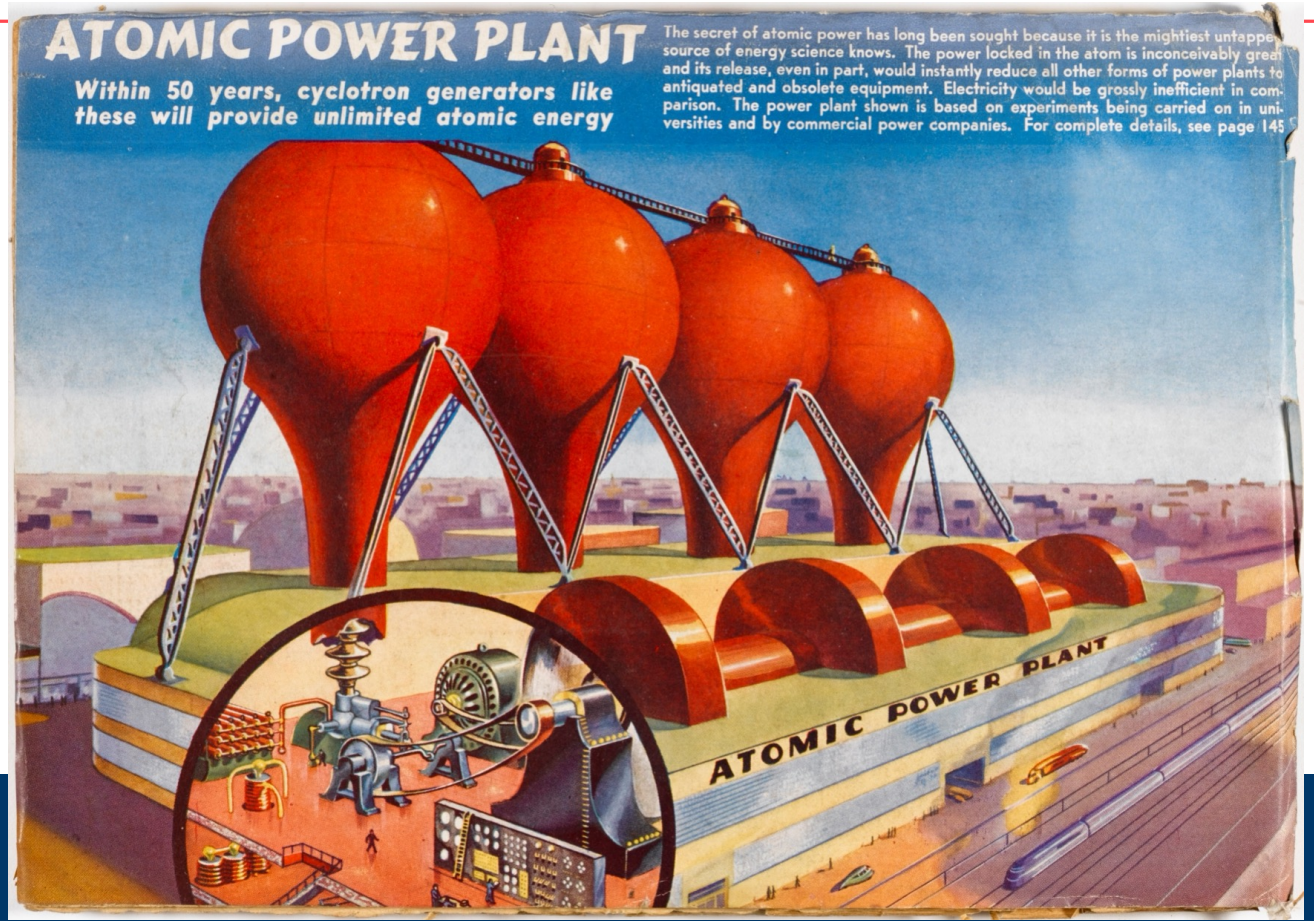
# Key Definitions - What Are SMRs

- Small modular reactor (SMRs) are generally less than 350MW in size – however plans are to build multiple number of SMRs with same design at the same sites – so the total size will likely be comparable to today's 1100 MW large reactors
- SMRs involve untested technologies or technologies that have failed previously
- No SMR has been built in the U.S. or is under construction
- The only reactor design being marketed in the U.S. that has started construction anywhere else in the world is the BWRX-300 which just started work on its reactor building in Canada in March of this year

# A Very Short History of Nuclear Power in the U.S.

# Initial Claim About The Economics of Atomic Energy

*Atomic power would be "too cheap to meter"*



# Reality – Nuclear Plants Became Too Expensive to Build

**Estimated vs Actual Overnight Cost of 75 Reactors that Started Construction in 1966-77** (1982 dollars)


**Estimated Construction Schedule at Start of Construction vs Actual**


*Results of 1986 DOE study understated cost and schedule overruns: (1) overnight costs don't include financing costs or inflation & (2) many of most expensive reactors were not included*

Source: IEEFA

# The Nuclear Reality

- High reactor costs led to “rate shock” for ratepayers when expensive new reactors were put into rates
- Approximately 125 reactor projects were cancelled – many due to soaring costs
- Ratepayers had to pay for some of the costs of some of the cancelled projects – e.g., Shoreham reactor closed in 1989 but Long Island ratepayers still paying
- Cover story “*Nuclear Follies,*” in February 11, 1985 issue of *Forbes:*
  - ”The failure of the U.S. nuclear power program ranks as the largest managerial disaster in business history, a disaster on a monumental scale. The utility industry has already invested $125 billion… only the blind or the biased, can now think that the money has been well spent….”

# What Was The Nuclear Industry's Response After The First Wave of Reactors Were So Expensive?

The Industry claimed

*New reactor designs would benefit from modular construction in terms of both shorter construction time and lower costs*

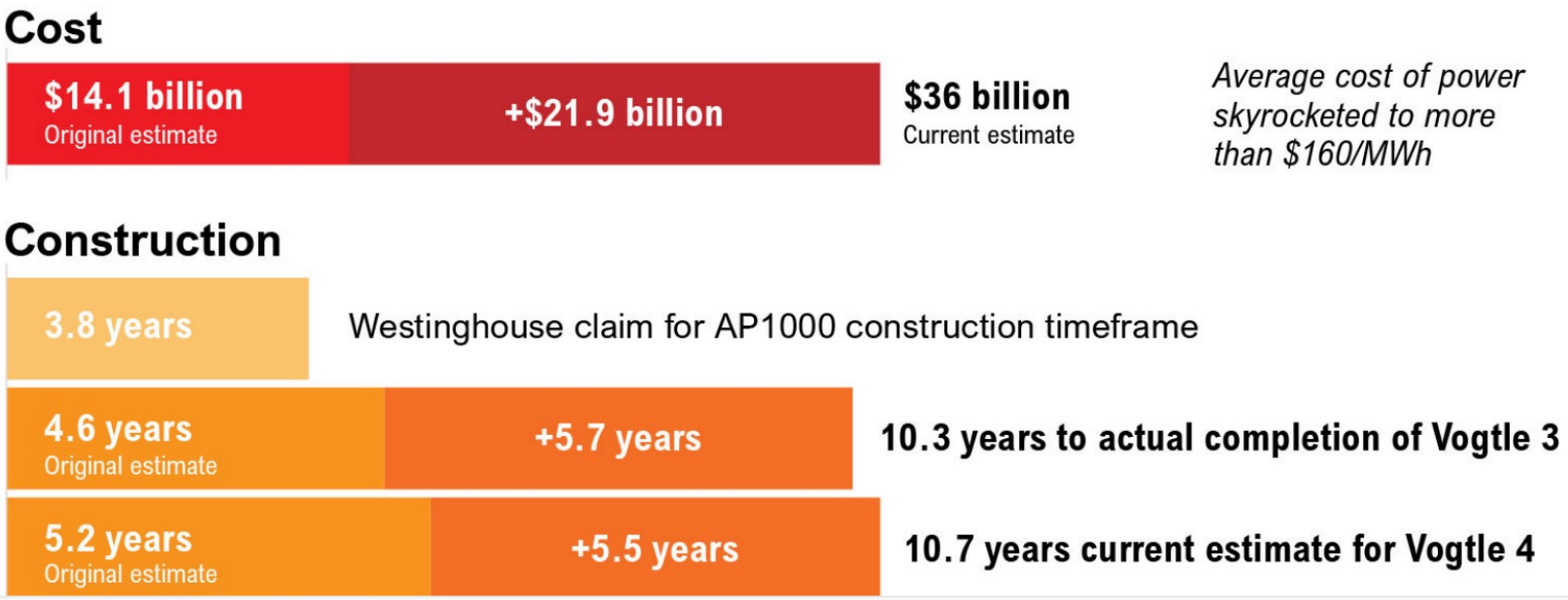
Westinghouse's promotional materials for its new AP1000 reactor design even claimed the construction for its new reactors would only take three years from placement of nuclear concrete to fuel load

# Did This Lead To Less Expensive Reactors?

- **No**


- South Carolina ratepayers are still paying for the two cancelled reactors in that state
- The Vogtle Nuclear Project in Georgia ended up costing 2.5 times what was claimed before start of construction and took five+ years longer to build

# The Vogtle Nuclear Project Was An Affordability Disaster




Source: IEEFA

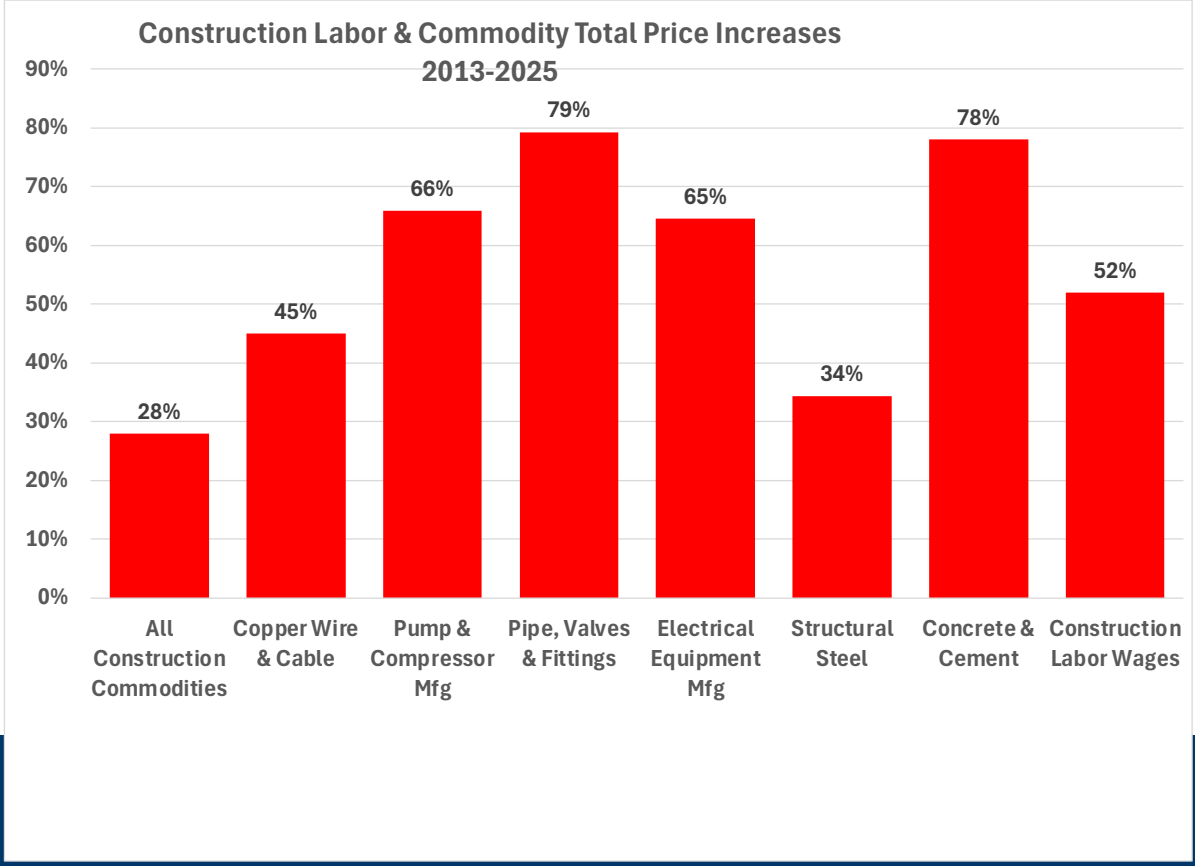
# Government and Industry Claims After Vogtle

- So what do the gov't and nuclear industry say after a 50-year history of rising reactor construction costs, with massive cost & extensive schedule overruns, including the disaster at Vogtle? Proponents now:
  1. Make almost exactly the same claim that Westinghouse made before Vogtle, that, new reactors (large and small) will be built faster and at lower cost than existing reactors because they will use modular construction and build multiple copies of the same designs
  2. Ignore the new economic environment in which new reactors would be built
  3. Claim, falsely, that federal and state nuclear subsidies will make building new reactors less risky for electric ratepayers and taxpayers

# What's Wrong With Nuclear Supporter Claims That Future Reactors Will Be Built Faster and at Lower Cost?

1. This is just an assumption, without any supporting evidence
2. Modular construction didn't reduce the cost of the Vogtle reactors or shorten their construction times
3. Federal and state subsidies will not reduce the costs of new reactors
4. will merely transfer reactor costs and the risks of cost and schedule overruns to federal and state taxpayers

# What Is Different About The Future Economic Circumstances During Which New Reactors Would Be Built?



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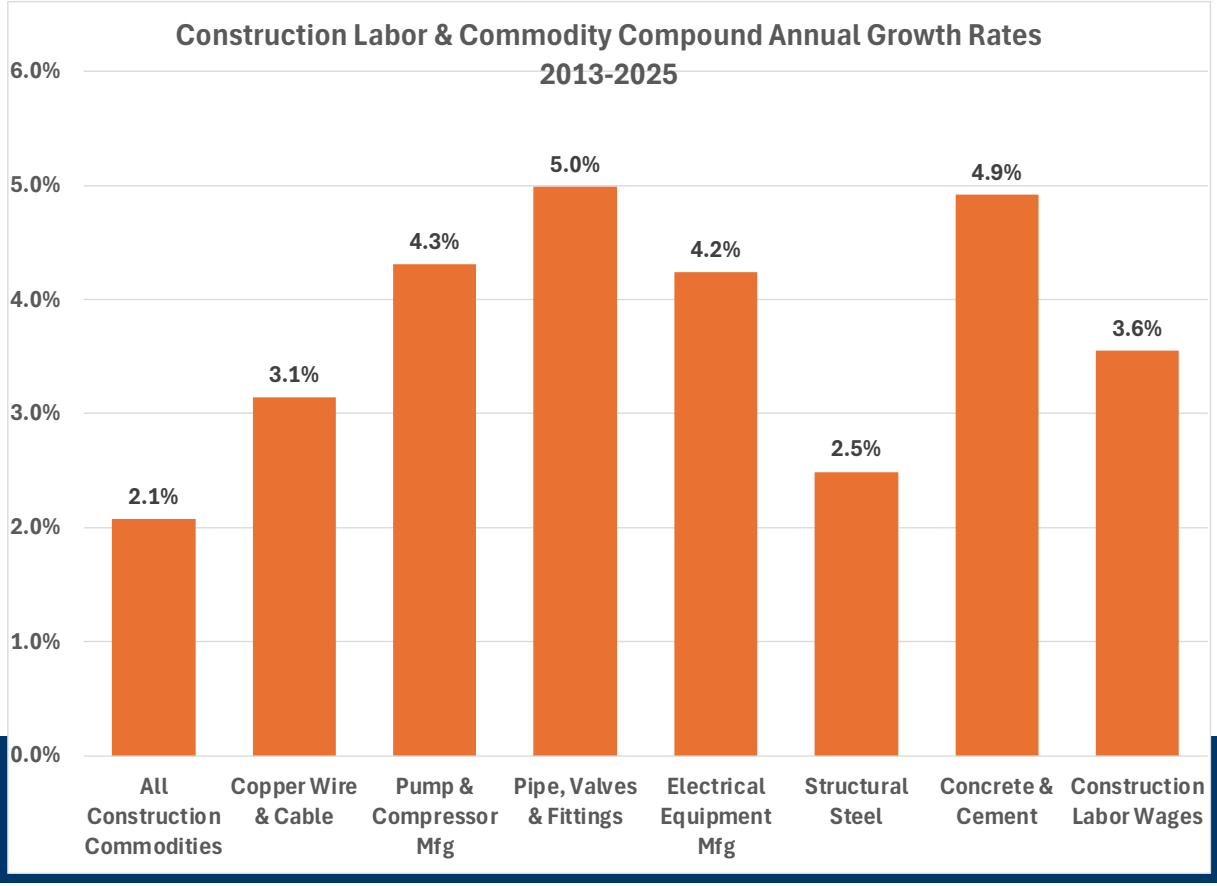
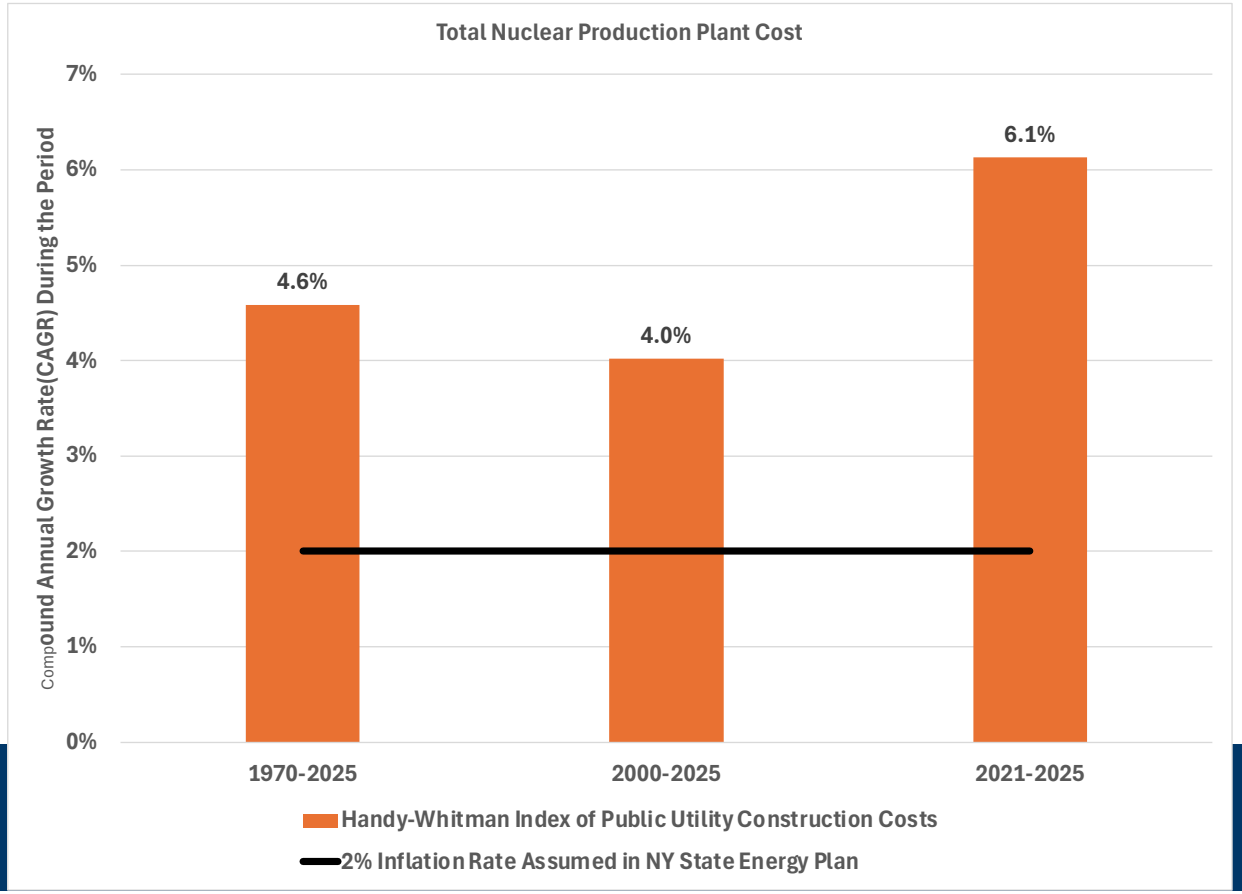


# A 4% Annual Escalation Rate Is Conservative for Nuclear Costs

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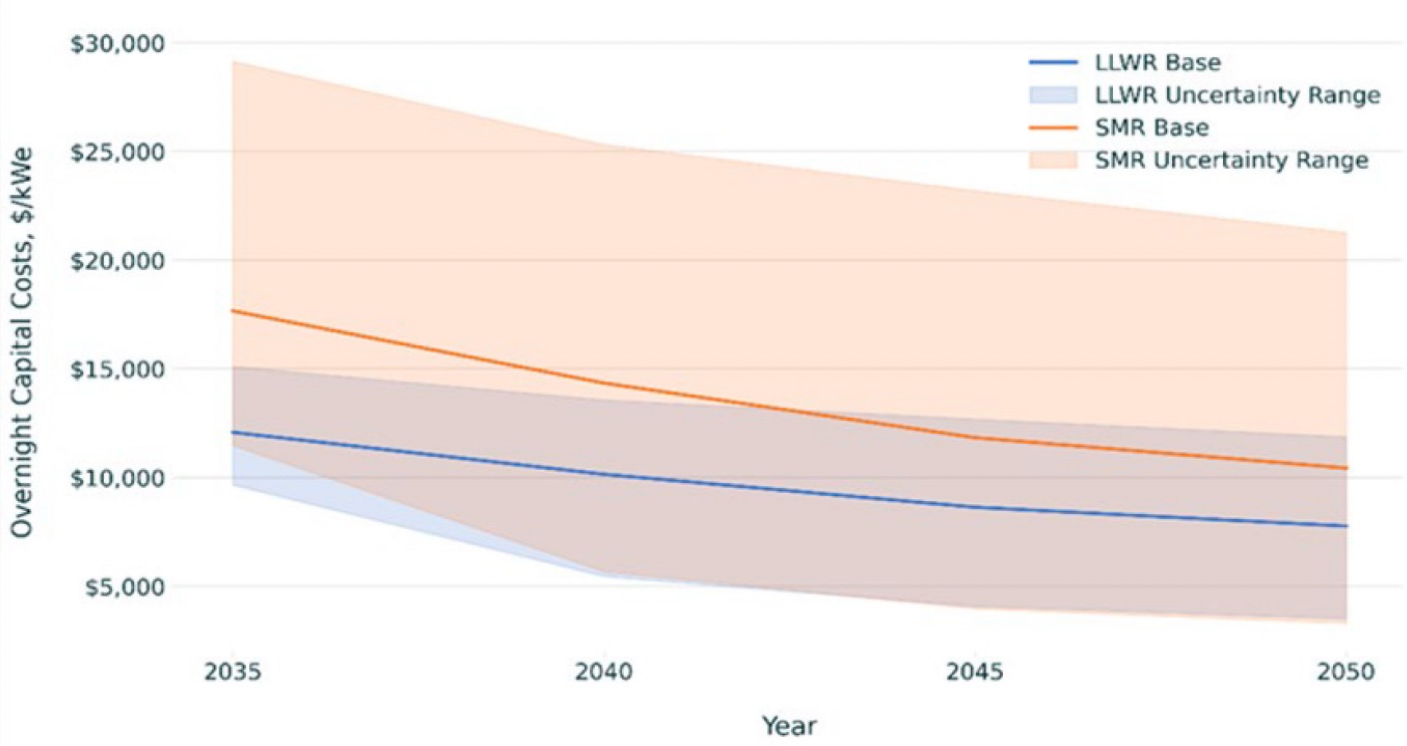
# There Is Uncertainty As to What Future Reactors Actually Will Cost – But The Industry Pretends Its Not There

**And Even When They Acknowledge There Is Uncertainty They Don't Model It In Analyses**

Note that these are "Overnight" capital costs in 2024$ without escalation or financing costs

Source: EPRI *Zero by 2040 Technoeconomic Assessment*

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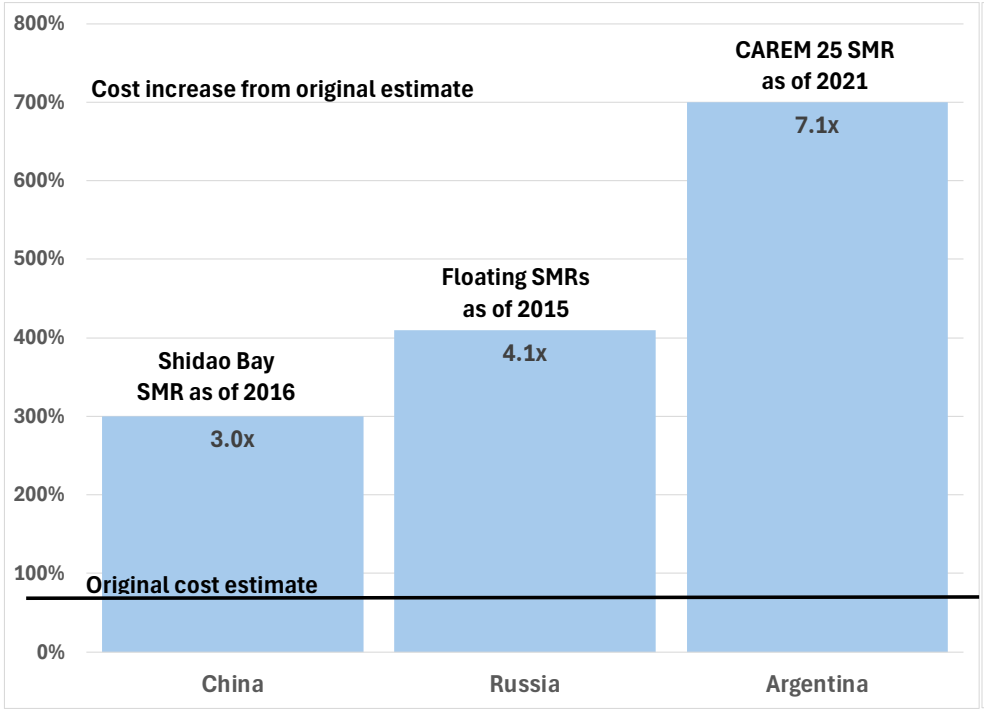
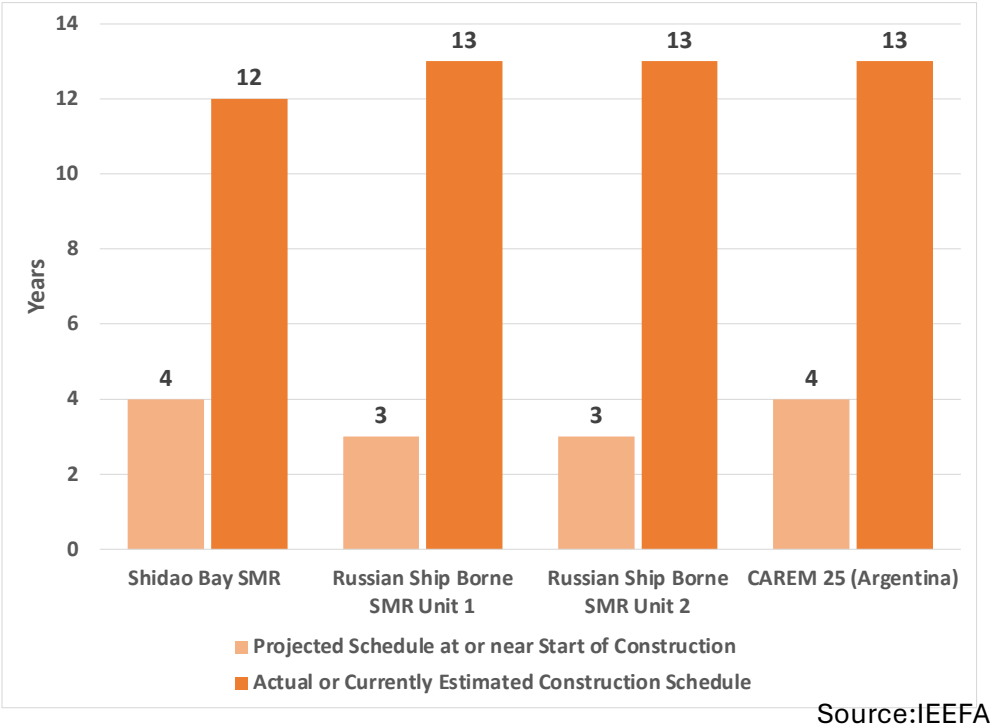
# SMRs Built in Other Countries Have Experienced Significant Cost and Schedule Overruns



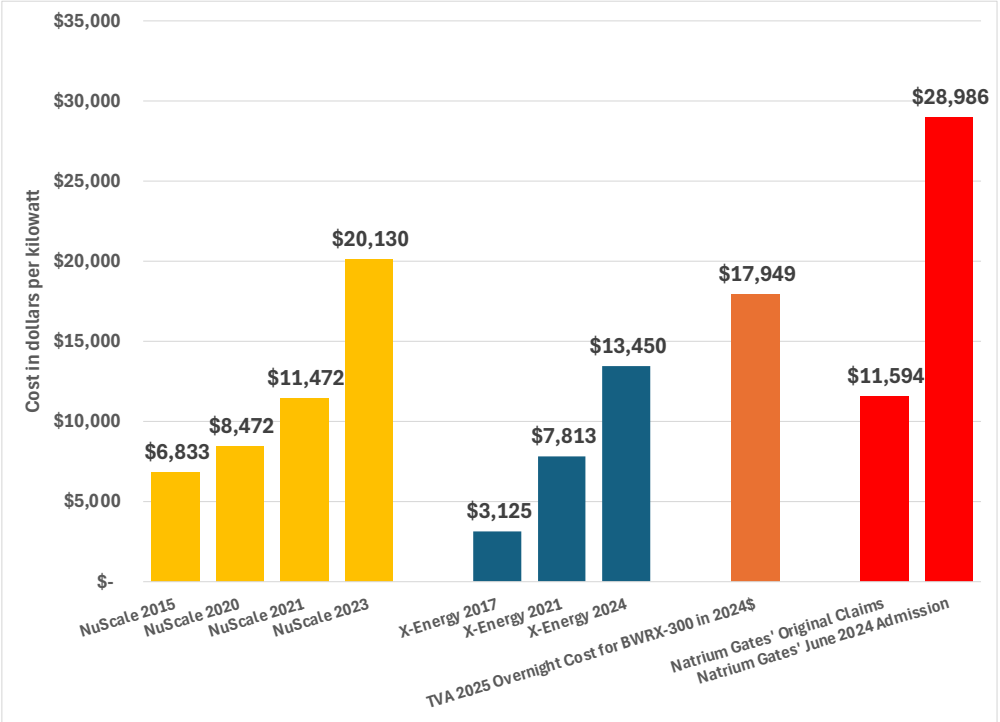

Source:IEEFA

# Reality - The Estimated Costs for SMRs Being Marketed in U.S. Already Have Gone Up Dramatically

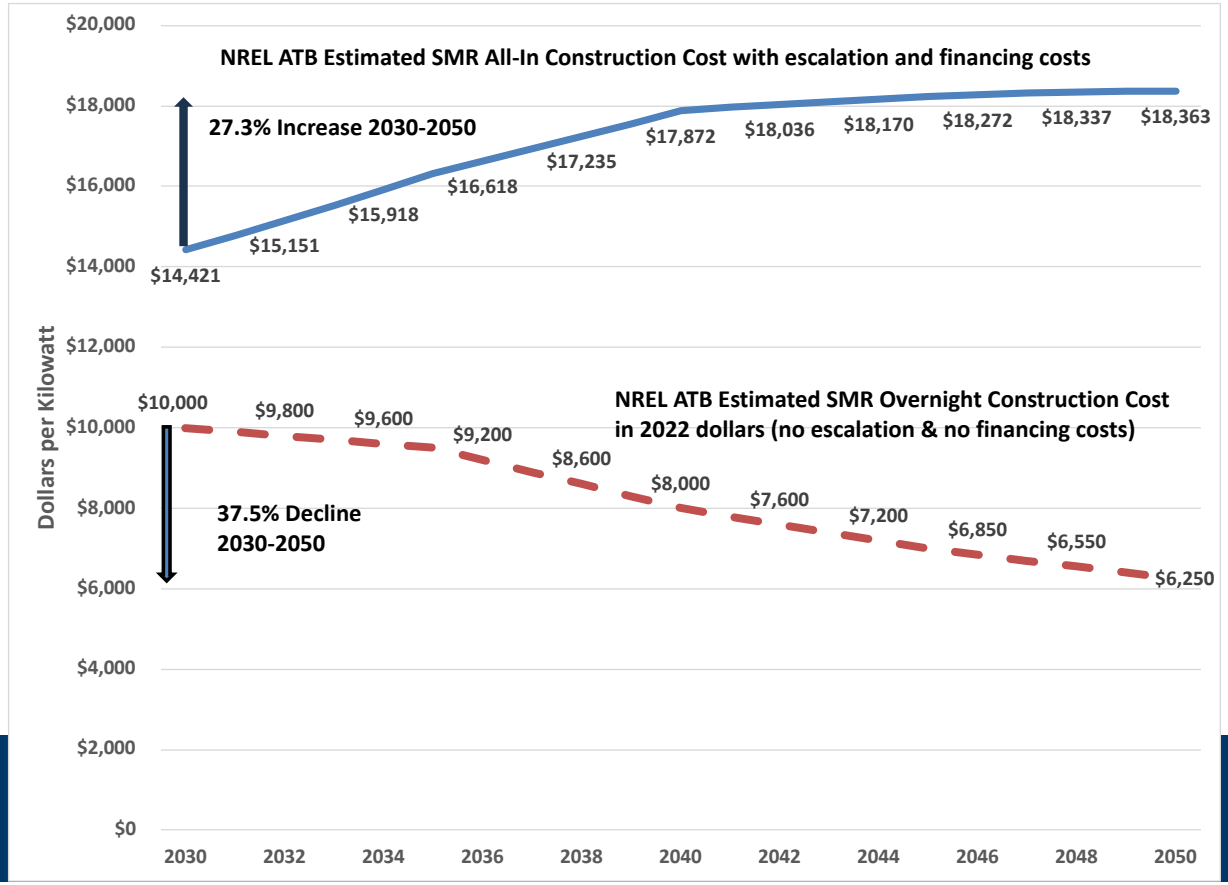
Estimated cost of NuScale's proposed UAMPS SMR, on a dollar per kW basis, increased by **138%** between 2020 and 2023.

Estimated cost of X-Energy SMR increased by **72%** between 2021 and 2024.

Costs of building SMRs should be expected to continue to go up significantly in the years before any will be online.



# The Only Way To Show A Positive Learning Curve Is By Ignoring Costs (Use Overnight Instead of All-In Costs)

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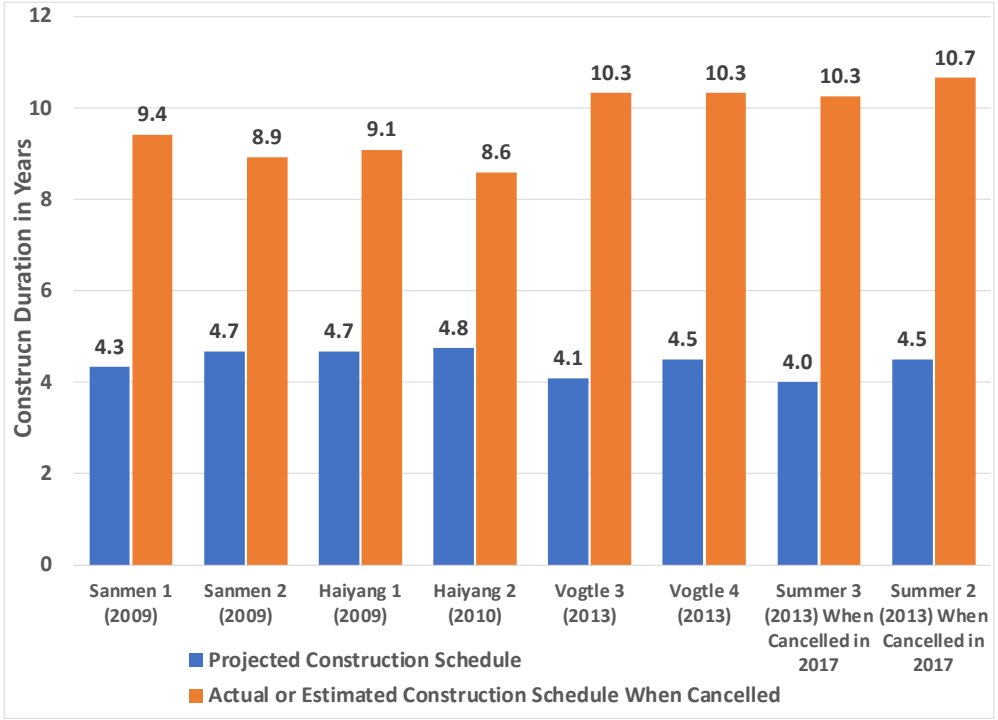
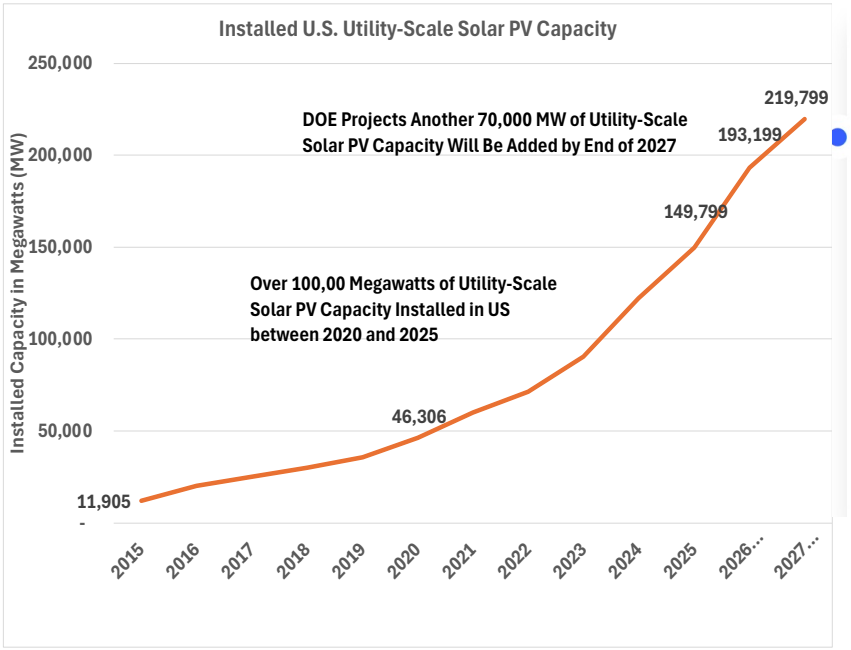
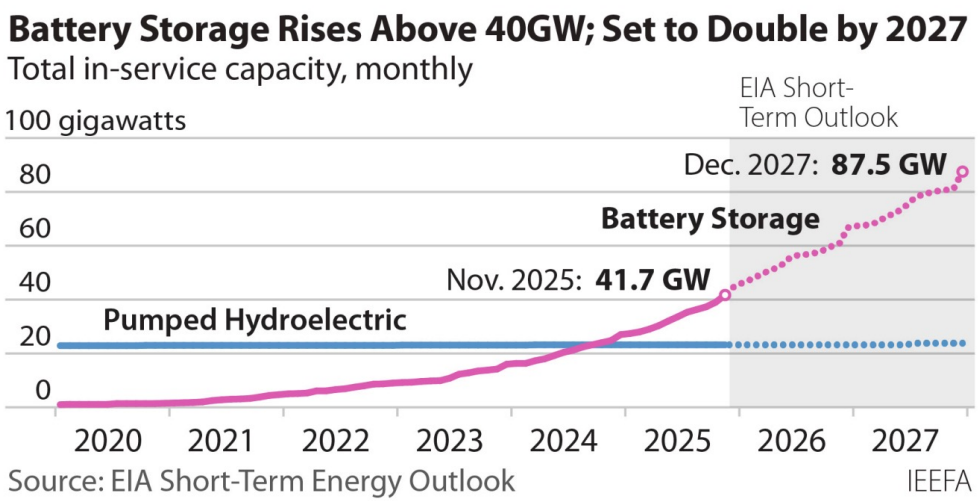
# There is No Evidence that Nuclear Has Achieved a Positive Learning Curve – Example AP1000 Construction Times

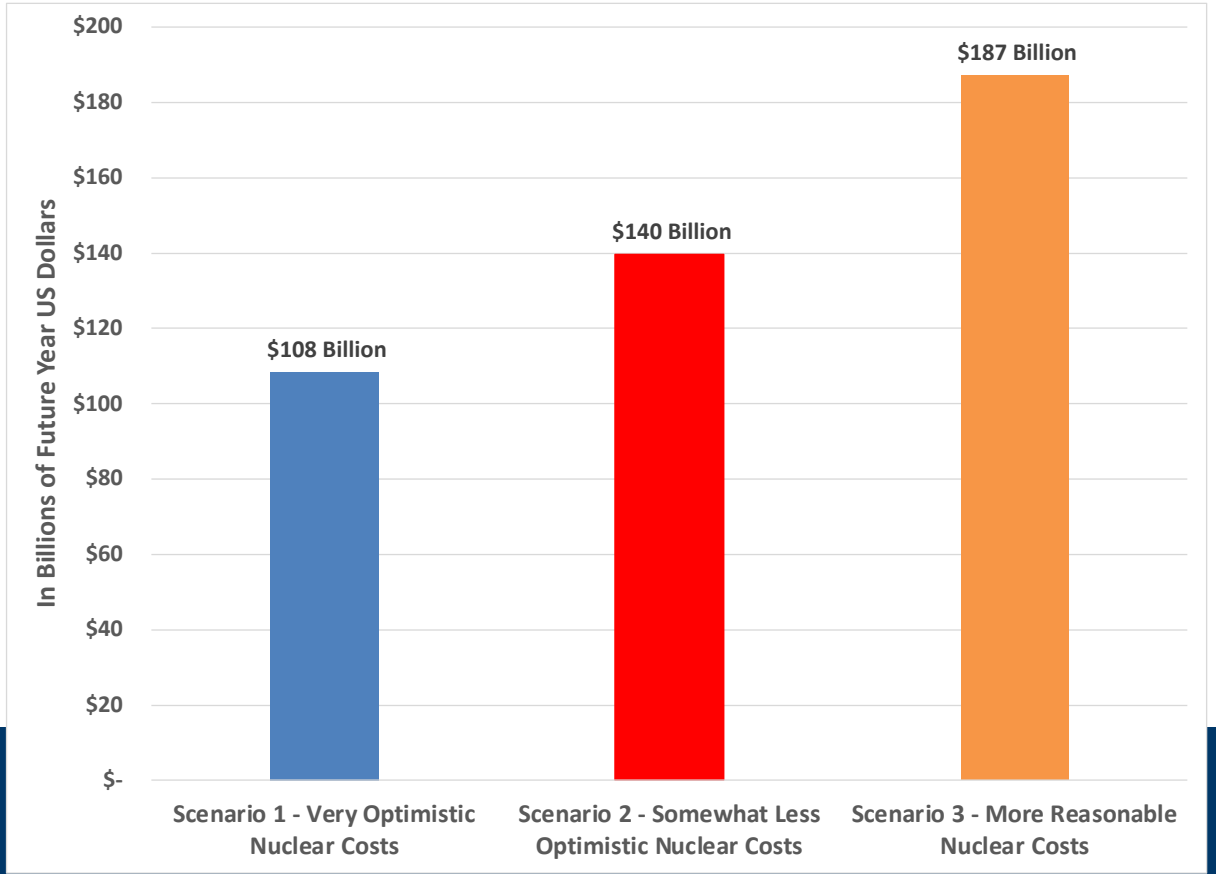


# Solar & Battery Storage Technologies Exist Today And Their Use In The U.S. Is Skyrocketing



# The Cost of Building Five New Reactors In New York State By 2040 Could Reach As High As $180 Billion

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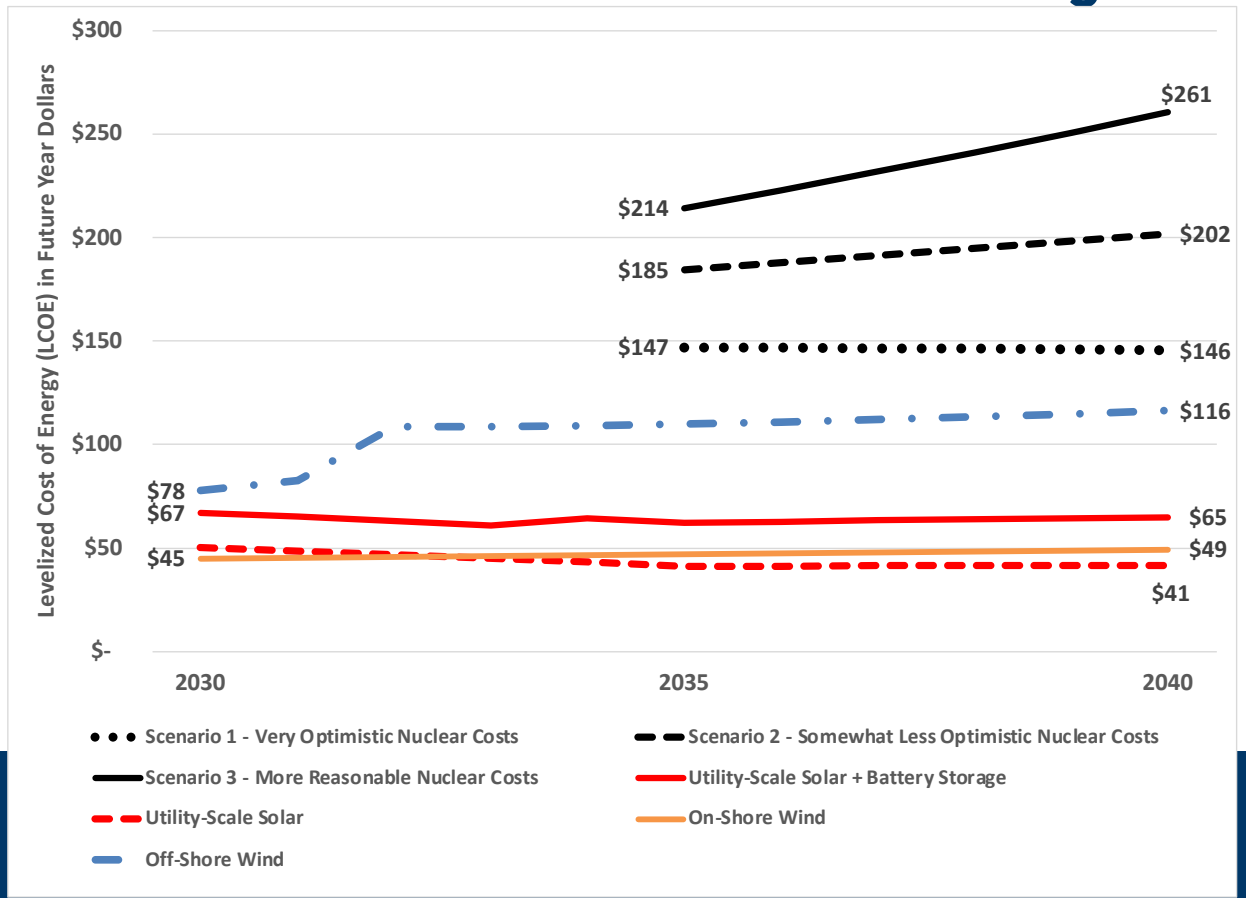
# The Cost of Energy From New Reactors Will Be Much More Expensive Than From Renewables and Storage

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# The Cost of Energy From New Reactors Will Be Much More Expensive Than From Renewables And Storage

All costs are in Dollars per Megawatt-Hour ($/MWh)

| Resource/Scenario | 2030 LCOE | 2035 LCOE | 2040 LCOE |
|---|---|---|---|
| Scenario 1 – Very Optimistic Nuclear Costs | NA | $147 | $146 |
| Scenario 2 – Less Optimistic Nuclear Costs | NA | $185 | $202 |
| Scenario 3 – More Reasonable Nuclear Costs | NA | $214 | $261 |
| Utility-Scale Solar PV and Battery Storage | $67 | $62 | $65 |
| Solar PV | $41 | $41 | $41 |
| On-Shore Wind | $45 | $47 | $49 |
| Off-Shore Wind | $78 | $110 | $116 |

Sources - Analysis by David Schlissel using data, assumptions and spreadsheet from NREL's 2024 Annual Technology Baseline, *New York 2025 State Energy Plan*, *EPRI/NYSERDA ZERO By 2040 Technoeconomic Assessment*, DOE's September 2024 *Pathway to Commercial Liftoff: Advanced Nuclear*, and the *Handy-Whitman Index of Public Utility Construction Costs,*

# Large Reactors

# How Big Is A Large Reactor

- Size refers to the power of the reactor in megawatts (MW)
- A large reactor is on the order of 1000 megawatts and more
- A small modular reactor (SMRs) is generally on the order of 350 MW or less
- SMRs are also being marketed in packages – 2, 4 , whatever, so the total built at one site may be far higher than 350 MW
  - For example, NuScale SMR can have 12 modules at 77 MW each = 924 MW
- The only large reactors currently being marketed in the U.S. are Westinghouse AP1000 design, same as the two Vogtle reactors
- Despite the name AP1000 reactors have a 1135 (net) power rating

# Small Modular Reactors

# Announced Schedules for Three SMR Designs Being Marketed in the US Have Already Slipped by Years

- NuScale originally claimed that its first SMR project would be producing electricity by 2015-2016
  - The reactor's start of commercial operations was subsequently delayed twice – first to 2026-2027 and then to 2029-2030
  - The project was subsequently cancelled in 2023 after its estimated cost increased by 59%
- Similarly, the Xe-100 reactor project planned for Washington State was initially scheduled to be completed in 2027-2028 but is now not expected to be in operation until September 2033
- Bill Gates initially said the Natrium reactor would begin generating power in 2028 but they have delayed its schedule until 2030, of course, blaming someone else for the delay

# How Nuclear Proponents Bias Analyses In Favor of Building New Reactors

1. Claim or Assumption – There will not be any cost or schedule overruns in the building of new reactors

   **Fact** – the nuclear industry has experienced massive cost overruns and years-long schedule overruns in building reactors since 1970. There is no evidence suggesting that similar overruns will not be experienced in the future

# How Nuclear Proponents Bias Analyses In Favor of Building New Reactors

2. Claim or Assumption – Do not discuss or model potential any uncertainty for either the costs or how long it will take to build future reactors

   **Fact** – There is great uncertainty in future reactor costs and how long it will take to construct them – which even some nuclear proponents acknowledge

# How Nuclear Proponents Bias Analyses In Favor of Building New Reactors

3. Claim or Assumption – There will be a positive learning curve in building new reactors which means that their overnight costs will decline as more reactors with the same design are built and the time it takes to build them also will go down

   **Fact** – Such a positive learning curve has never been achieved in the U.S. either in the costs of building new reactors or the time to take to build them

   Even French nuclear program which built 56 reactors with very similar designs experienced increasing costs

# How Nuclear Proponents Bias Analyses In Favor of Building New Reactors

4. Claim or Assumption – The All-In costs of new reactors in the future will escalate at only very low annual rate – e.g., current CPI forecast of 2.4% over next 10 years

   **Fact** – Nuclear costs have historically increased at an annual 4% rate and have exceeded 6% in recent years

   Even pro-nuclear study from Idaho National Laboratory has noted that CPI represents the average cost of bundle of consumption goods, rather than capital goods, and that the use of the CPI could be biased because it does not represent capital goods or inputs specifically for nuclear energy

# How Nuclear Proponents Bias Analyses In Favor of Building New Reactors

5. Claim or Assumption – It is implicitly assumed that there is currently a supply infrastructure for building new reactors or that one will be available in very near future in the near future so that five  new reactors can be built in New York State by 2040

   **Fact** – As the U.S. Department of Energy and even some pro-nuclear reports have acknowledged, there is no robust nuclear supply infrastructure in place in the US at this time and it is unclear how soon one can be created

# How Nuclear Proponents Bias Analyses In Favor of Building New Reactors

6. Claim or Assumption – Nuclear reactors are less expensive that renewable resources such as solar, battery store, wind (offshore and onshore)

   **Fact** – This is untrue

# How Nuclear Proponents Bias Analyses In Favor of Building New Reactors

7. Claim or Assumption – Nuclear reactors are needed because we can't meet decarbonization goals by relying on just renewable resources

   **Fact** – This also is untrue. Renewable technologies are here today and can meet future electricity demands sooner and at lower cost than building more nuclear reactors

# Renewable Resources, Battery Storage & Energy Efficiency Are Cheaper, Faster Way To Reduce NYS's Carbon Footprint

- Solar & battery storage technologies exist today
- Can be added in 2-3 years, much sooner than the at-least 10 years it will take to add one new reactor
- Provide needed grid flexibility – can be cancelled without huge stranded costs if forecasted demands do not materialize or additional capacity can be added if future demands are higher than currently projected
- Electricity costs less than from a new reactor
- Better solution for powering proposed data centers

# Conclusions

- Nuclear projects pose substantial financial, fiscal & economic risks for federal & state taxpayers & utility ratepayers who will be asked to bear rising costs
    - Just ask the customers of Georgia Power who recently experienced “Rate Shock” when hit with a 23.7% rate increase to pay for the 2 Vogtle reactors
    - This was on top of an over 10% rate increase in 2011 which forced ratepayers to pay for the reactors while they were being built
- There is no benefit or award from rushing and being first in starting a reactor project – better to take your time & learn from others’ successes and mistakes

# For More Information

Contact

david@schlissel-technical.com

Also see

Small Modular Reactors: Still Too Expensive, Too Slow and Too Risky (co-authored with Dennis Wamsted, IEEFA)

And

Nuclear Hype Ignores High Cost, Long Timelines – Nuclear Options Are Years Away, While Solar, Storage and Geothermal Are Clean, Cost-Effective Options Ready Now (co-authored with Dennis Wamsted, IEEFA)