Institute for Energy Economics and Financial Analysis

Alternatives to Comanche Unit 3

Town Hall Meeting Pueblo, Colorado

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My Background

- Engineering Degrees 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 proceedings
- See my work at www.ieefa.org and www.Schlissel-technical.com

Options for Replacing Comanche 3:
#1 Nuclear reactor (large or small)

Benefits	Risks
• Would provide jobs but at a very high total cost to Xcel's ratepayers • Would pay property taxes but amount is undetermined after 2040	• Small modular reactors (SMRs) involve **untested and not-yet-approved** technologies • Industry has history of huge **cost overrun**s and years-long **schedule delays** • **High construction costs** will lead to opposition from Xcel customers who will pay for the power from the reactor • Not good tool for fighting climate change – **too expensive, too late and competes with renewables** • Issues with disposal of **highly radioactive, long-lived nuclear waste**

Options for Replacing Comanche 3:
#2 Natural gas plant with carbon capture & storage (CCS)

Benefits	Risks
• Would provide jobs but fewer than with a nuclear plant • Would pay property taxes but less than a nuclear plant	• Technologies for capturing carbon dioxide (CO_2) are **unproven at commercial-scale** – only limited experience was capturing CO_2 from a small slip-stream of the flue gases from a gas-fired plant • CO_2 capture will be very **expensive** • Large **upstream methane emissions** between well and power plant would not be captured • Not a good tool for fighting climate change – large gas units with CCS would **compete with renewables** • **CO_2 leaks** from pipelines, injection wells and underground storage sites

Options for Replacing Comanche 3:
#3 Convert Comanche site to battery storage + renewables

Benefits

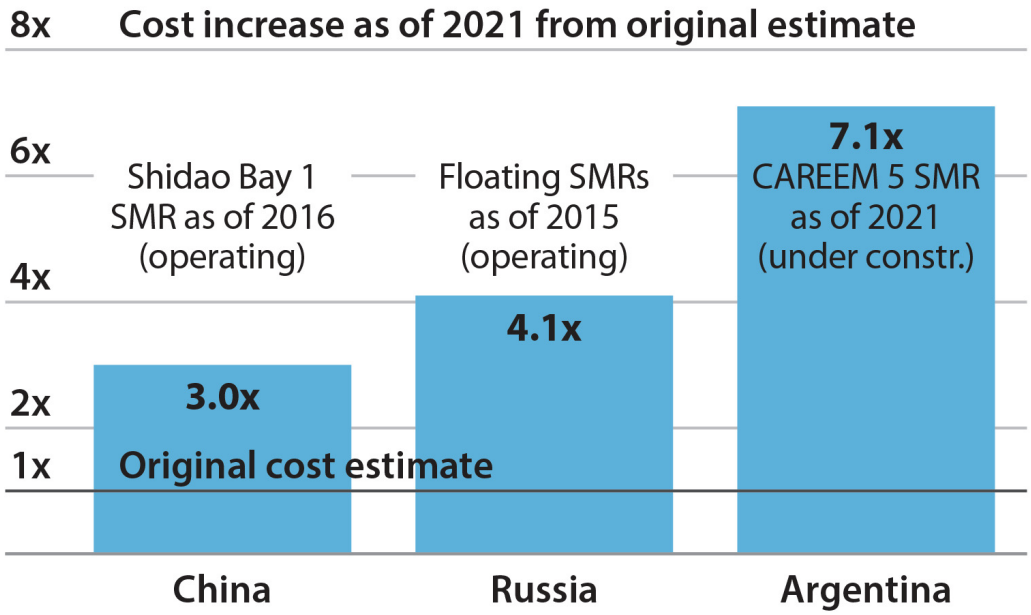
- **No technology risk** – in widespread use today with significant research on extending battery lives (Xcel testing longer duration Form Energy **100-hour batteries** on retired coal plants in CO & MN)
- **Declining cost** industry – prices per megawatt hour have declined by more than 80% in just the last decade
- **More jobs** if additional solar and wind resources are included in the plan
- Can be **online much sooner** than nuclear or gas with CCS alternatives, even before 2031
- Much less expensive so likely to stir **less opposition** from Xcel customers

Risks

- Would pay lower property taxes than a nuclear plant

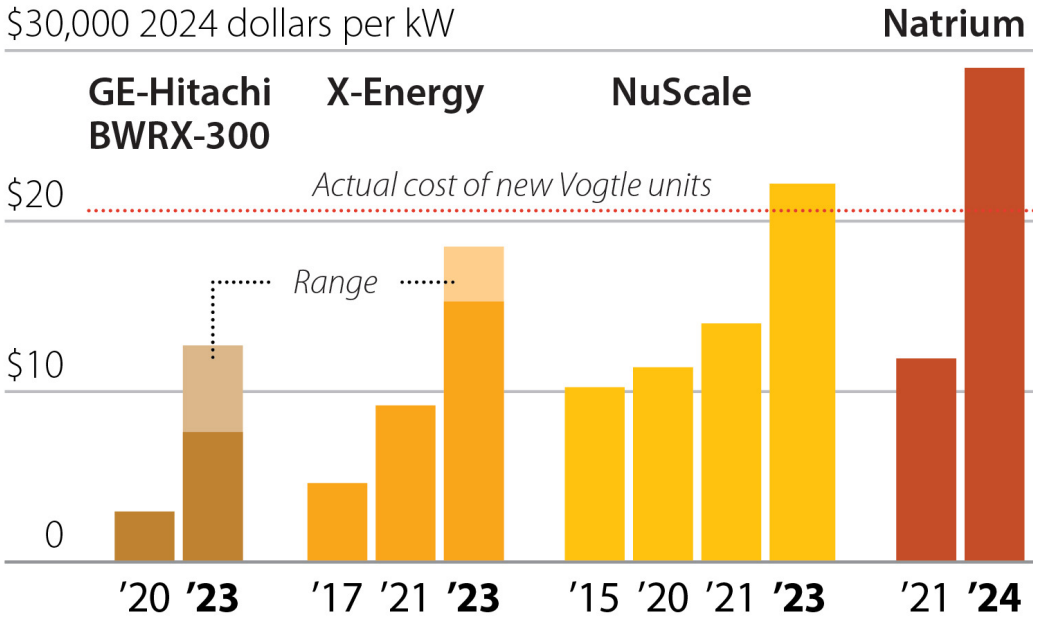
Actual Costs of Building SMRs Have Been Much Higher than Originally Predicted

- Actual costs of building SMRs have been much higher than originally predicted
- Construction costs could be even higher than shown here
- Of the small modular reactor (SMR) designs that are under construction for which data are available, none have met the original project cost estimate
- Costs estimates ballooned either during project planning phases or once construction began



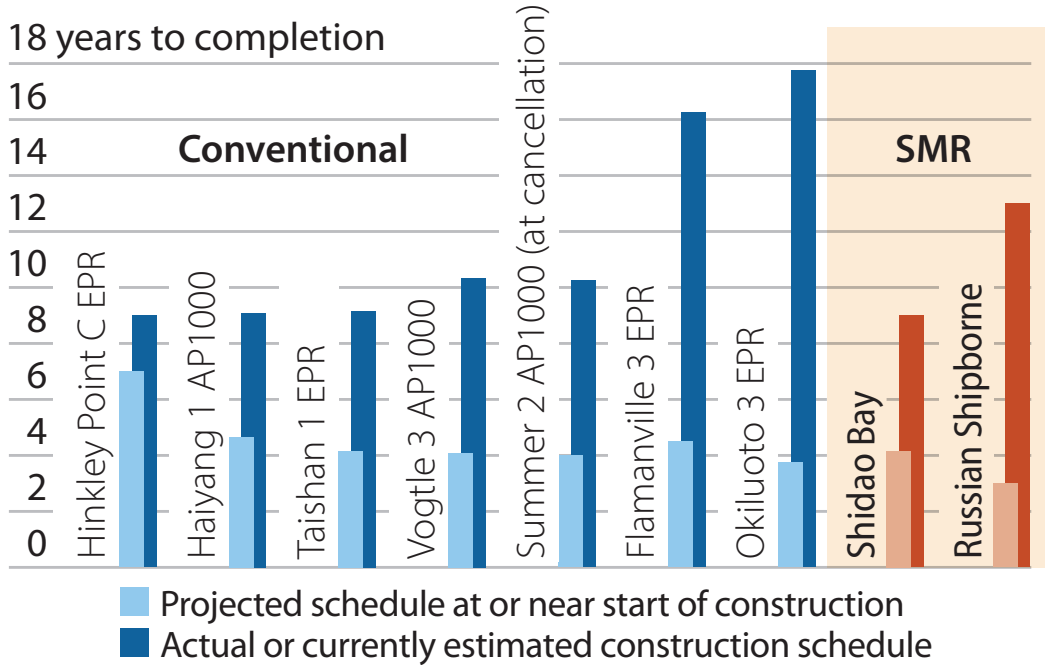
Estimated Costs of Proposed U.S. SMRs Have Risen Sharply, Years Before Construction Scheduled to Start

- Estimated costs of proposed U.S. SMRs have risen dramatically, years before construction has started
- None of the SMR designs marketed in the U.S. have been licensed by the NRC
- Additional cost increases should be expected after NRC permit is granted and actual construction begins (actual cost of the recently completed Vogtle Nuclear Project increased 157% *after* construction began)
- Costs of plants overseas have increased even more during construction



Recent Reactors With New Designs Have Experienced Significant Schedule Overruns

- Recent reactors with new designs have experienced significant schedule overruns
- Recent large reactor projects have taken much longer to complete than originally estimated with delay as long as 12 to 14 years for Flamanville (France) and Okiluoto (Finland)
- The two SMR projects that have been completed also took much longer, between double and quadruple the original estimate

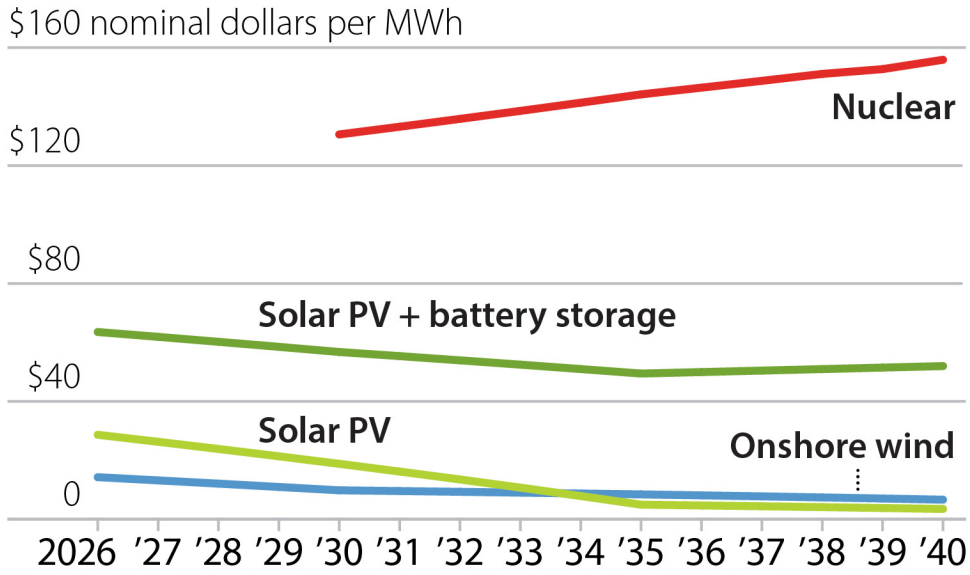


Illustrative Cost Comparison Shows Nuclear Much More Expensive than Renewables

- Nuclear is much more expensive than renewables and will continue to increase in cost
- Renewables are cheaper and will become even less expensive in the future
- Cost of gas with CCS would fall between renewables and nuclear
- Nuclear cost comparable to estimated average cost of recently completed Vogtle Nuclear Project of >$160 per megawatt hour without federal subsidies

Data from National Renewable Energy Lab (NREL) 2024 Annual Technology Baseline (ATB)

Costs shown have been adjusted to nominal year dollars from year 2022 dollars in the ATB



Most Cost-Effective and Durable Solution:
Battery storage backup for wind and solar generation

The PIESAC Committee has said that the conclusion that batteries can provide back-up to solar and wind "is not supported by facts." **This is simply wrong.**

1. Longer duration batteries are coming in the not-too-distant future but existing 4-hour batteries are increasingly being used to do the job until then. And they're doing it very well.
2. According to the U.S. DOE, the growth in installed utility-scale battery capacity in the U.S. has been dramatic – from nearly zero in 2020 to 20.7 Gigawatts (GW) in July of this year. Installed utility-scale battery capacity is expected to grow to ~40 GW by the end of 2025.
3. According to a recent study by the U.S. Berkeley Lab, the interconnection queues around the country include over 550 (GW) of hybrid solar + storage projects. Another nearly 500 GW of standalone storage projects are also in the queues.

Most Cost-Effective and Durable Solution:
Battery storage backup for solar and wind generation

Solar with storage projects are already online in the Pueblo area

Clearly, utilities like NextEra and other project developers believe that the combination of solar and storage is fast, economic and reliable

Solar + Battery Storage

Neptune Solar Power and Neptune Battery Storage
250 MW solar, 125 MW 4h batteries
June 2023; NextEra Energy Resources

Thunder Wolf Energy Center Hybrid
248 MW solar, 100 MW 4h batteries
June 2023; NextEra Energy Resources

Solar

Comanche Solar **120 MW**
Sept 2016; Onward Energy/JPMorgan Chase

Bighorn Solar 1 **240 MW**
Nov 2021, Lightsource bp Renewable Energy

Sun Mountain Solar 1 **200 MW**
Dec 2022, Lightsource bp Renewable Energy

Contact

Moss Landing Battey Storage Plant in California (750 MW/3,000 MWh)
Former fossil-fired plant converted to battery storage

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More information: **www.ieefa.org/SMR**