CHALLENGES FOR SMRS AND ADVANCED NUCLEAR POWER

Allison Macfarlane

Southern Legislative Conference

Energy & Environment Committee

July 23, 2024

Energy Transition
The Global Energiewende

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Poland's answer to the climate crisis: one hundred nuclear reactors

by Paul Hockenos
14 Nov 2023

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New-wave reactor technology could kick-start a nuclear renaissance — and the US is banking on it

Lou Robinson, CNN

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Green

Can Small Nuclear Reactors Help Solve Climate Change?

SCIENCE

Smaller, cheaper, safer: The next generation of nuclear power, explained

The nuclear industry's big bet on going small.

By Umair Irfan | May 1, 2023, 8:00am EDT

OPINION COMMENTARY Follow

Canada's Climate Plan: Nuclear Power

It's essential for keeping a clean-energy electrical grid.

By James Hansen and Chris Keefer
Feb. 22, 2024 at 6:18 pm ET

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SMR CLAIMS

Cheaper

Easier to build

- factory production of modules

More Efficient

More Jobs

Safer

Less Waste

Conventional wisdom with large reactors: Economies of Scale

- Does this no longer hold?

- One large reactor pressure vessel is cheaper than 5 small reactor pressure vessels

A FEW FACTS TO START WITH…

The majority of these reactors exist on paper only – no demonstration models yet

Engineering a reactor: design – build prototype – redesign – build full-scale model – redesign – deploy = high costs

This image is a mock-up!!

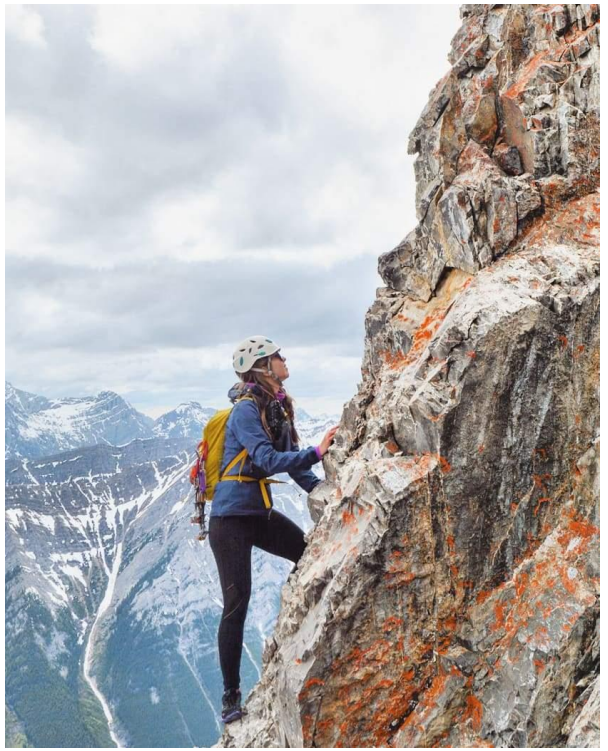
NUCLEAR HAS SIGNIFICANT CHALLENGES TO OVERCOME

Economics

Waste

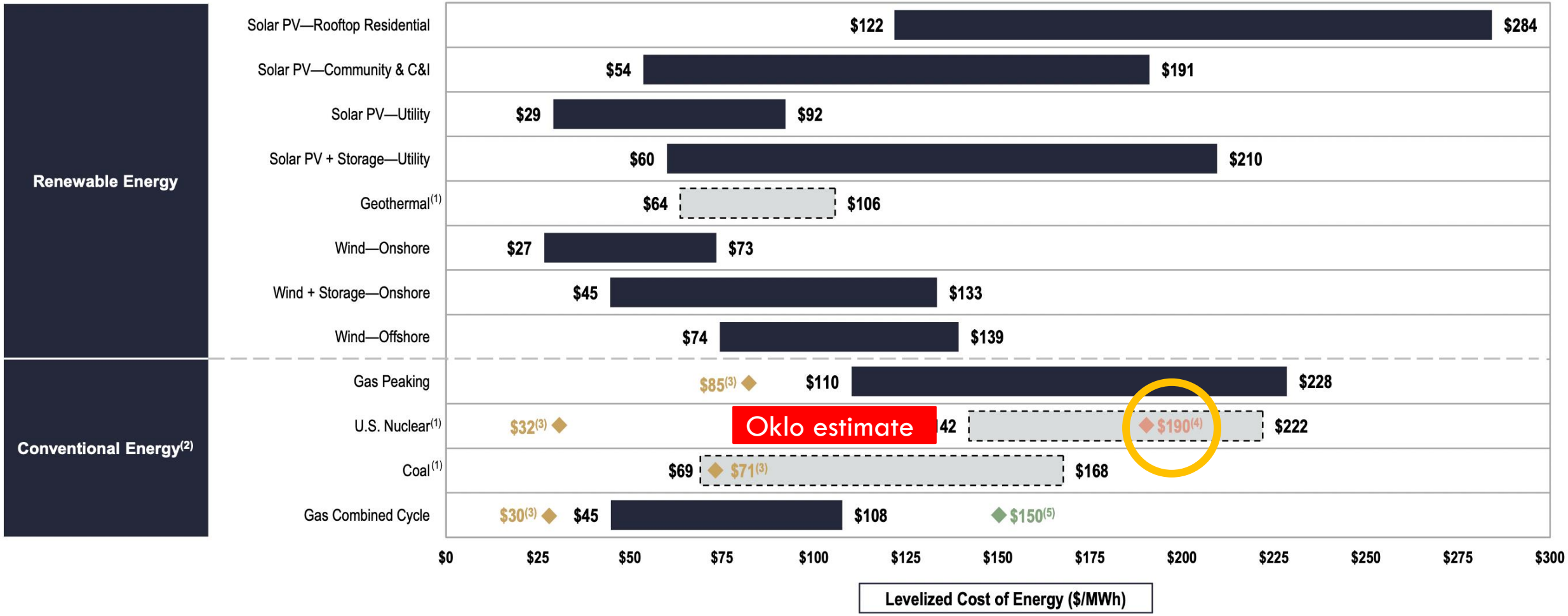
Proliferation and Security

Public Acceptance

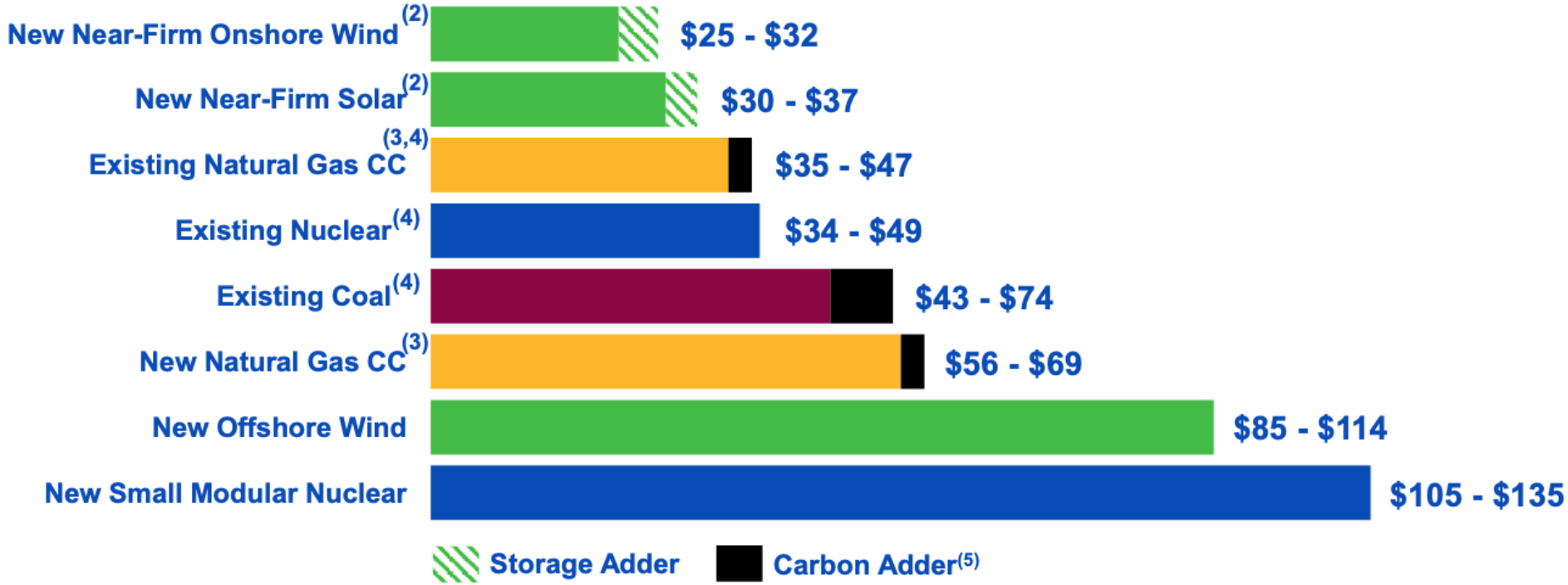


Levelized Cost of Energy Comparison—Version 17.0

Selected renewable energy generation technologies remain cost-competitive with conventional generation technologies under certain circumstances



Estimated Costs of Generation Resources Late-2020s[1]
($/MWh)

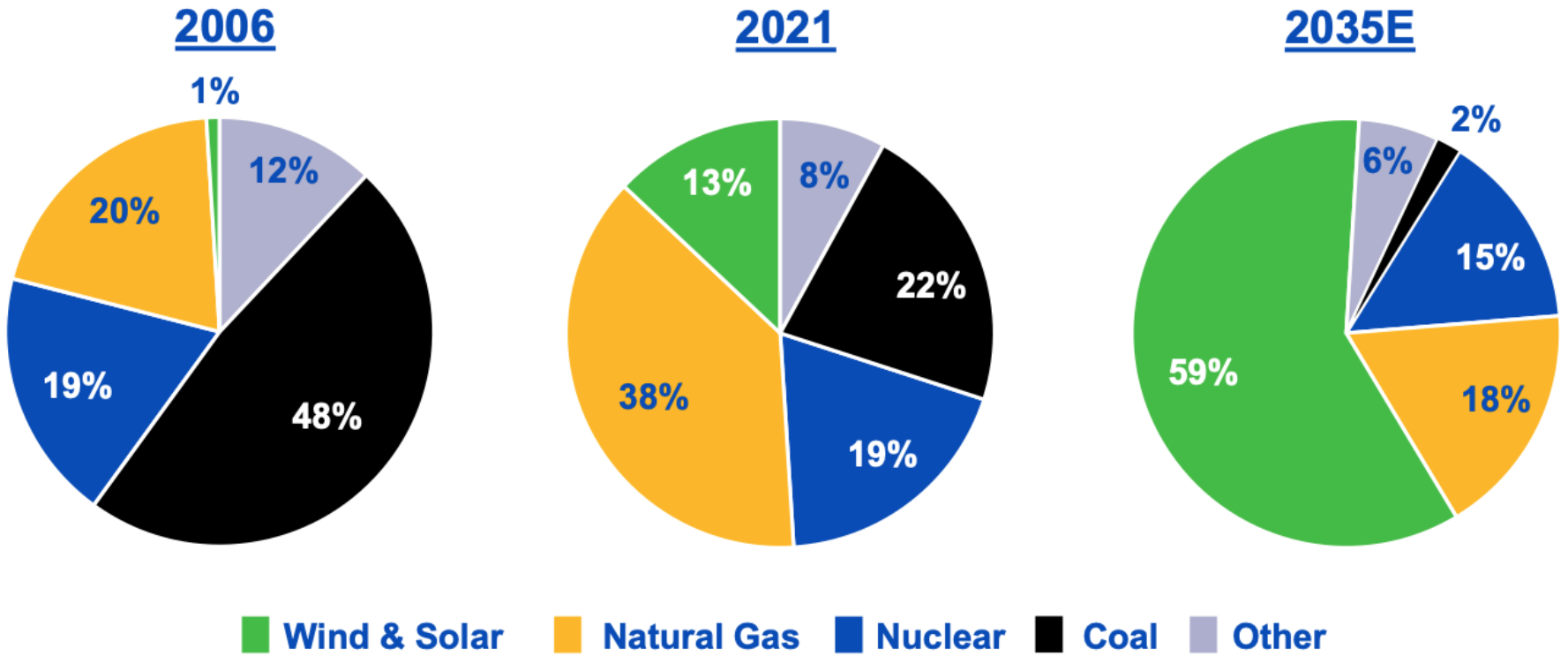


We expect further technology improvements and cost declines will extend the competitiveness of onshore renewables and storage

1) Energy Resources' internal estimates, based on current law
2) Near-firm assumes a 4-hour battery to achieve a roughly equivalent reliability during peak hours for comparison with dispatchable generation sources
3) Range assumes $4-5/MMBtu gas price
4) Represents all-in cash operating cost per MWh including fuel and ongoing capital expenditures
5) Reflects modest CO_2 cost consistent with existing state and regional CO_2 policies and IOU planning conventions

NEXTera ENERGY RESOURCES

U.S. Electricity Production by Fuel Type[1,2]



Estimated ~15% annual growth in renewables through 2035 in the power sector alone; additional opportunity from broader economy

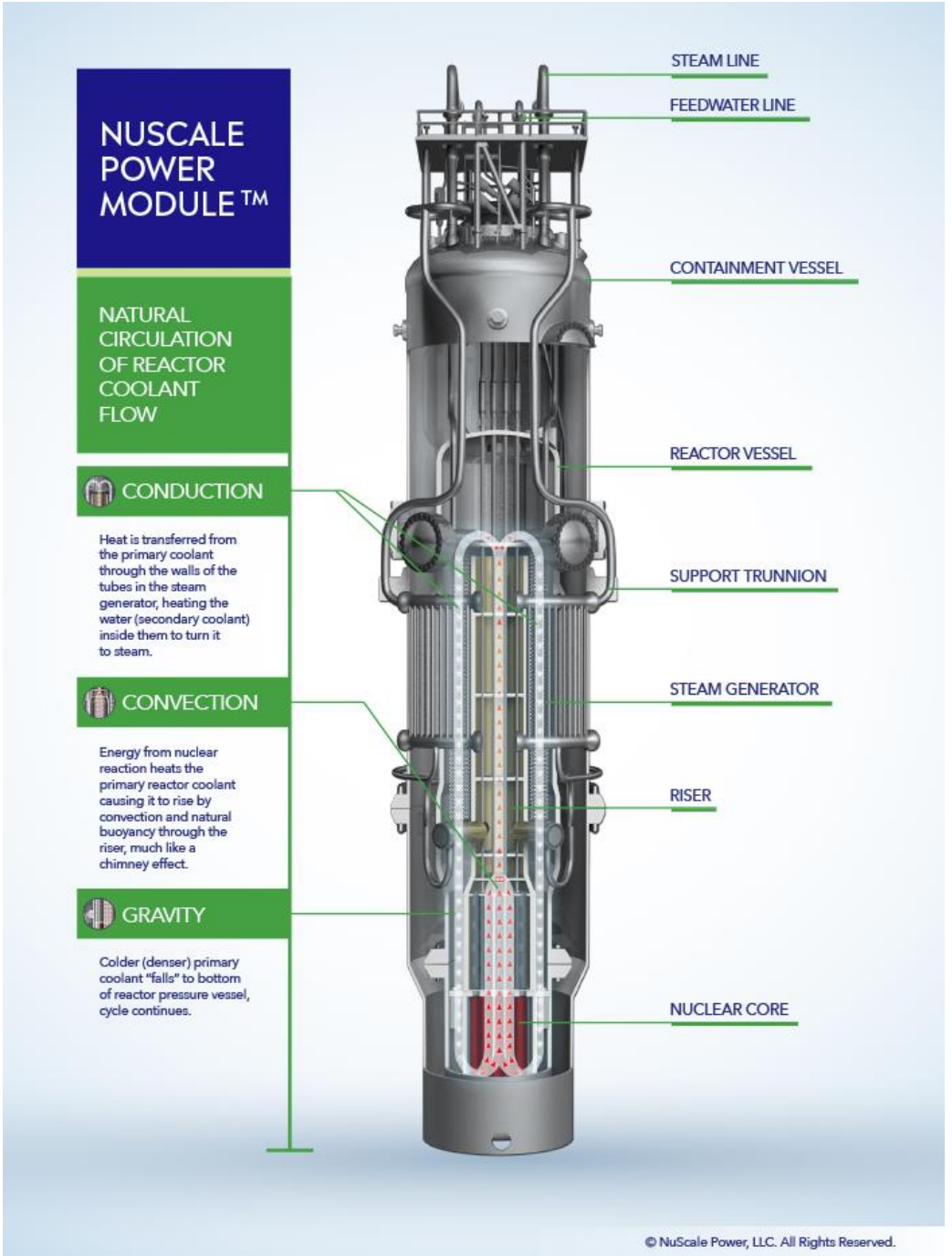
1) Source: U.S. Energy Information Administration (2006 and 2021); IHS 2021 Fast Transition Case (2035E)
2) Other includes hydroelectric, biofuels, geothermal, landfill gas, oil peakers and hydrogen

NEXTera ENERGY RESOURCES

NUSCALE IPWR

NuScale

- UAMPS ended the NuScale project in Idaho in November 2023
- Cost *estimates*
  - 2015, 12 modules for 600 MW, $3 billion
  - 2018, 12 modules for 720 MW, $4.2 billion
  - 2020 - $6.1 billion
  - 2023 - $9.3 billion
- January, 2024 - NuScale lays off 30% staff



THE TALE OF WESTINGHOUSE AP-1000

Does modularity work?

WHAT ABOUT FACTORY BUILT MODULES? THAT WILL SOLVE THE COST PROBLEM, WON'T IT?

Vogtle, Georgia

VC Summer, South Carolina

Abandoned, July 31, 2017

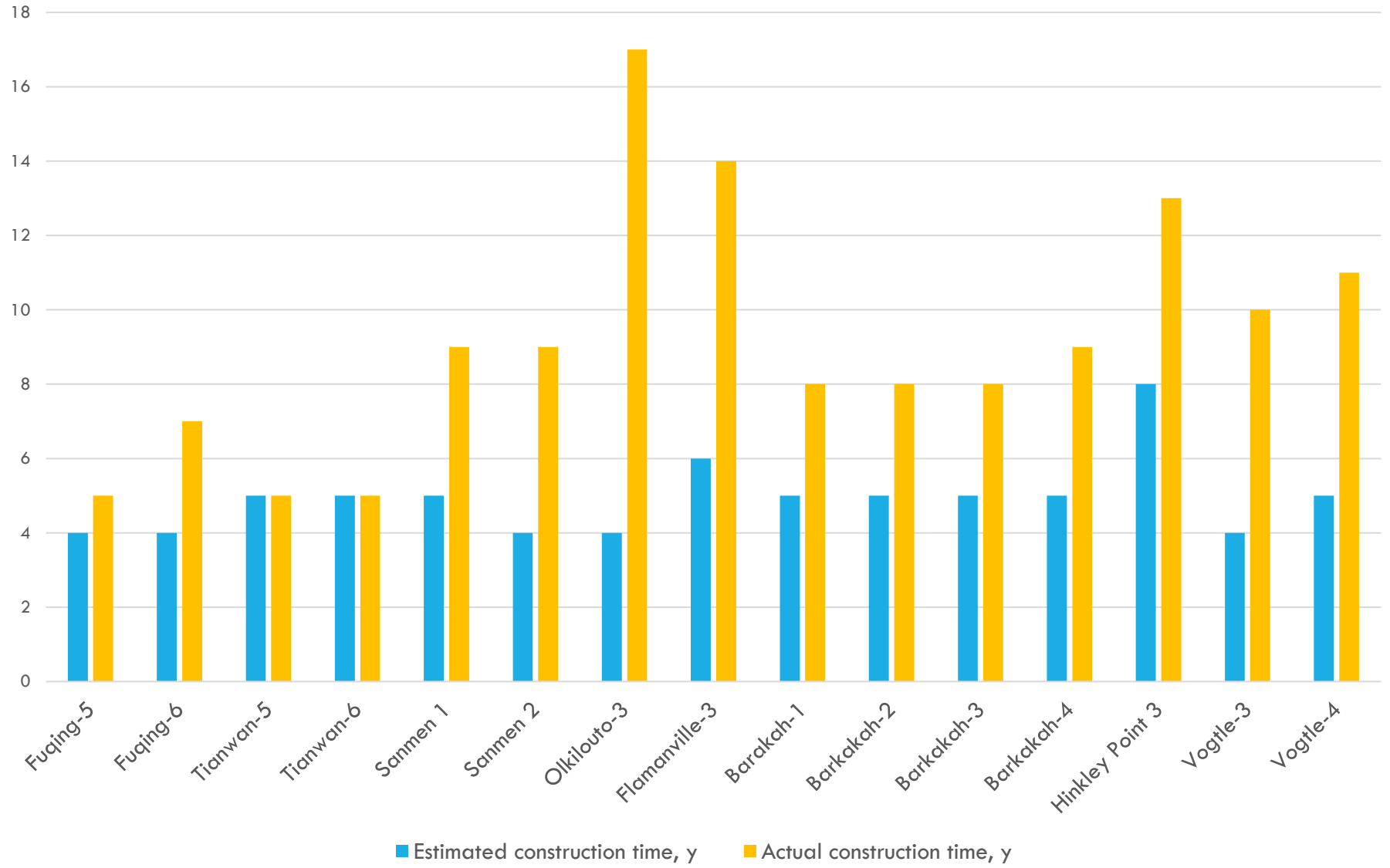
MODULAR FABRICATION EXPERIENCE IN US

Welding and Rewelding at Vogtle

Shaw Modular Solutions Plant, Lake Charles, LA

Westinghouse bankruptcy, March 2017

Expected vs Actual Construction Times, Recent New Builds



ECONOMICS CHALLENGES: CAPITAL COSTS

Actual current experience: huge cost overruns

AP-1000, Georgia, US

- 2 reactors, original estimate: $14 billion
- actual: >US$35 billion

- **EPR (European Power Reactor)**
  - **Finland**: 1 reactor, estimated cost 3 billion euro
    - Final cost 11 billion euro ($12 B)
  - **France**: 1 reactor, estimated cost 3.5 billion euro
    - Now, cost is 12.4+ billion euro ($13.4 B)
  - **UK** 2 reactors, estimated cost $20 billion
    - Now expected to cost $39-43 billion

SUPPLY CHAINS NOT ESTABLISHED

Many non-light water reactors require new exotic fuels

- No source of the more highly enriched uranium to feed into the fuel
- No existing fuel fabrication facilities

No supply chains for reactor parts

Still no plans for the waste in the US

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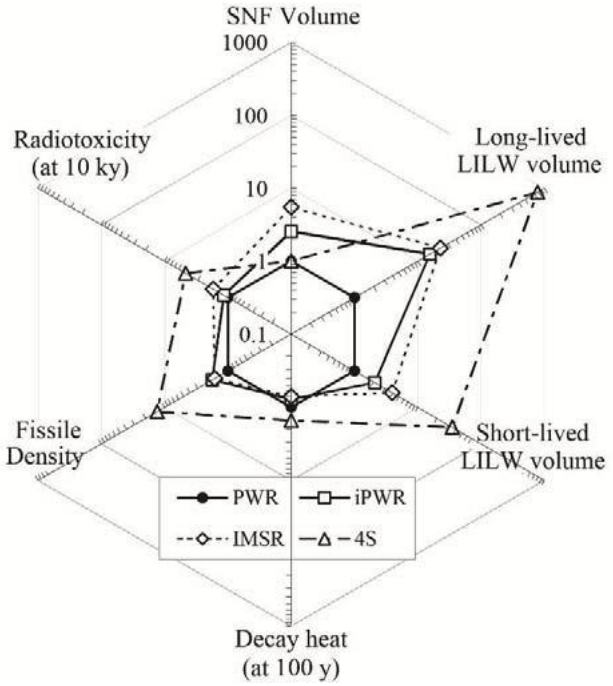
WASTE IMPACT FROM DIFFERENT DESIGNS

SMRs do not improve, and may make worse, the nuclear waste problem

Krall, Macfarlane & Ewing, 2022



These reactors will produce more LILW per kW generated and may produce more spent fuel by volume per kW

Some advanced reactors have exotic fuels

- Requires processing = additional costs

HIGH UNCERTAINTY AND RISK

Actual costs of reactors are unknowable at this time – because these reactors do not exist

- Cost of plant
- Cost of fuel
- Cost of waste

Length of build uncertain

Supply chains not established yet

It will take at least 20 years or longer to sort this out

CONCLUSIONS

Biggest challenge for SMRs right now: they don't exist

SMRs will not be commercially available in large numbers until after 2050 (NAS, 2022)

At that time, they will have to compete with other energy sources (renewables)

Bottom line: Nuclear power will not be a growth industry for the next 20 years.

Not a near-term solution for climate change

SMALL MODULAR REACTORS: <300 MW

Light Water Reactors

Sodium-Cooled Fast Reactors (and Lead-Cooled)

High-Temperature Graphite Reactors

Molten Salt Reactors

Heat Pipes

TRISO fuel for HTGRs, courtesy DOE.