Economic Analysis of First- and Nth-of-a-Kind Micromodular Reactors Co-Sited with Nuclear Fuel Cycle Facilities in the United States

An account-level cost and 50-year viability framework for MMR co-siting

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Enrichment plants need stable power — co-siting economics are unproven

- **NFC facilities (esp. enrichment) are electricity-intensive** — exposed to price volatility and grid instability
- **MMRs (5–25 MWe) offer dedicated on-site power** inside the existing security perimeter, matching enrichment demand

Gap 1

No cross-vendor, account-level FOAK→NOAK cost framework for U.S. MMRs

Gap 2

No 50-year financial viability analysis at a named NFC facility

A standardized, account-level method makes 7 vendors comparable

Cost estimation

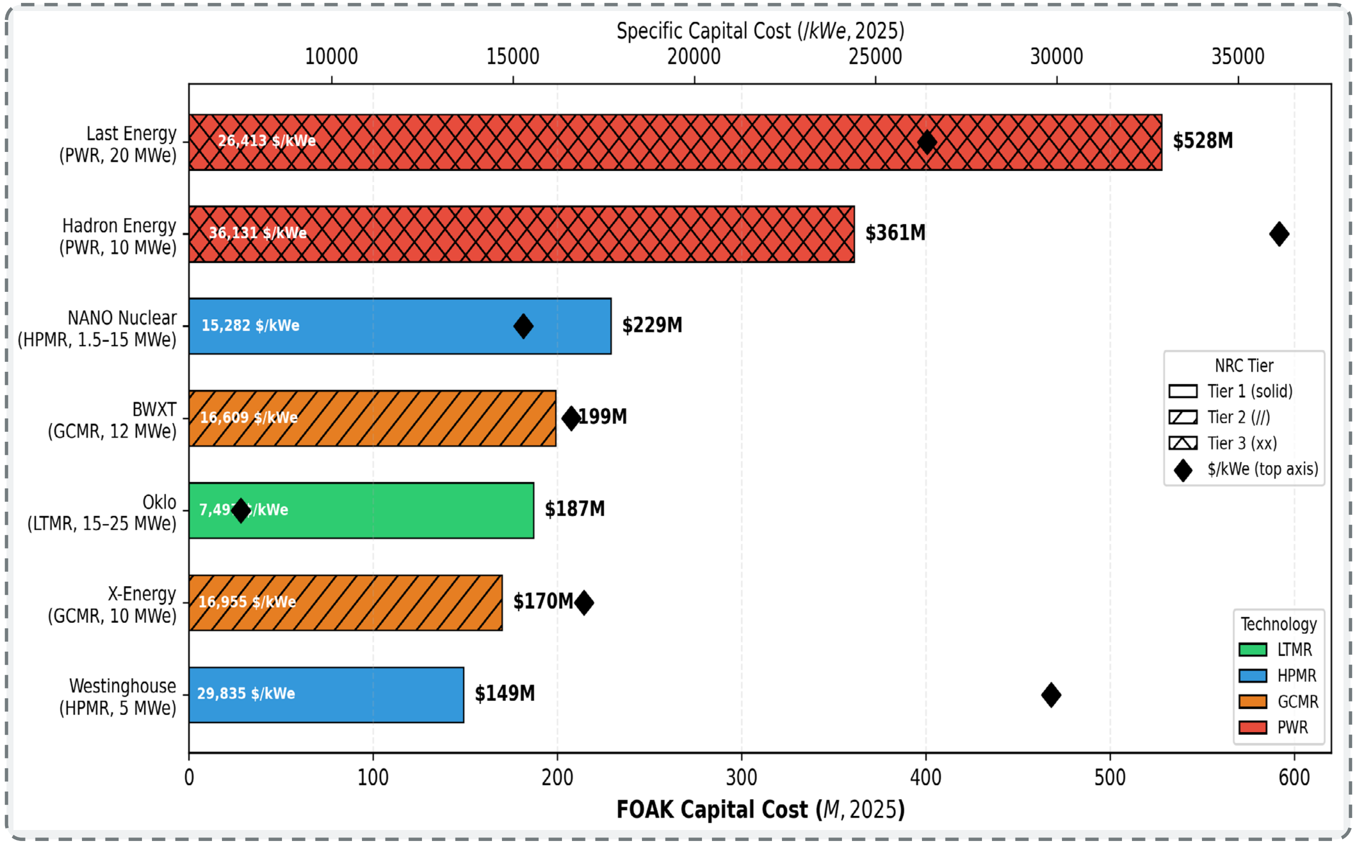
- MOUSE (INL): 82 cost accounts, 15 categories
- Power-law scaling (n = 0.60 below 30 MWt)
- 7 vendors · 4 technology families
- 3 U.S. NRC tiers (ADAMS engagement)

Economic evaluation

- NOAK via Wright's Law (8–24% / doubling)
- 50-year LCOE and NPV (Eq. 3–4)
- 3 ITC levels: 0%, 30%, 50%
- 8% real discount rate; DOE-LPO financing

Non-LWR designs cost 57% less at FOAK

Technology class is the dominant cost driver (FOAK $149M–$528M)

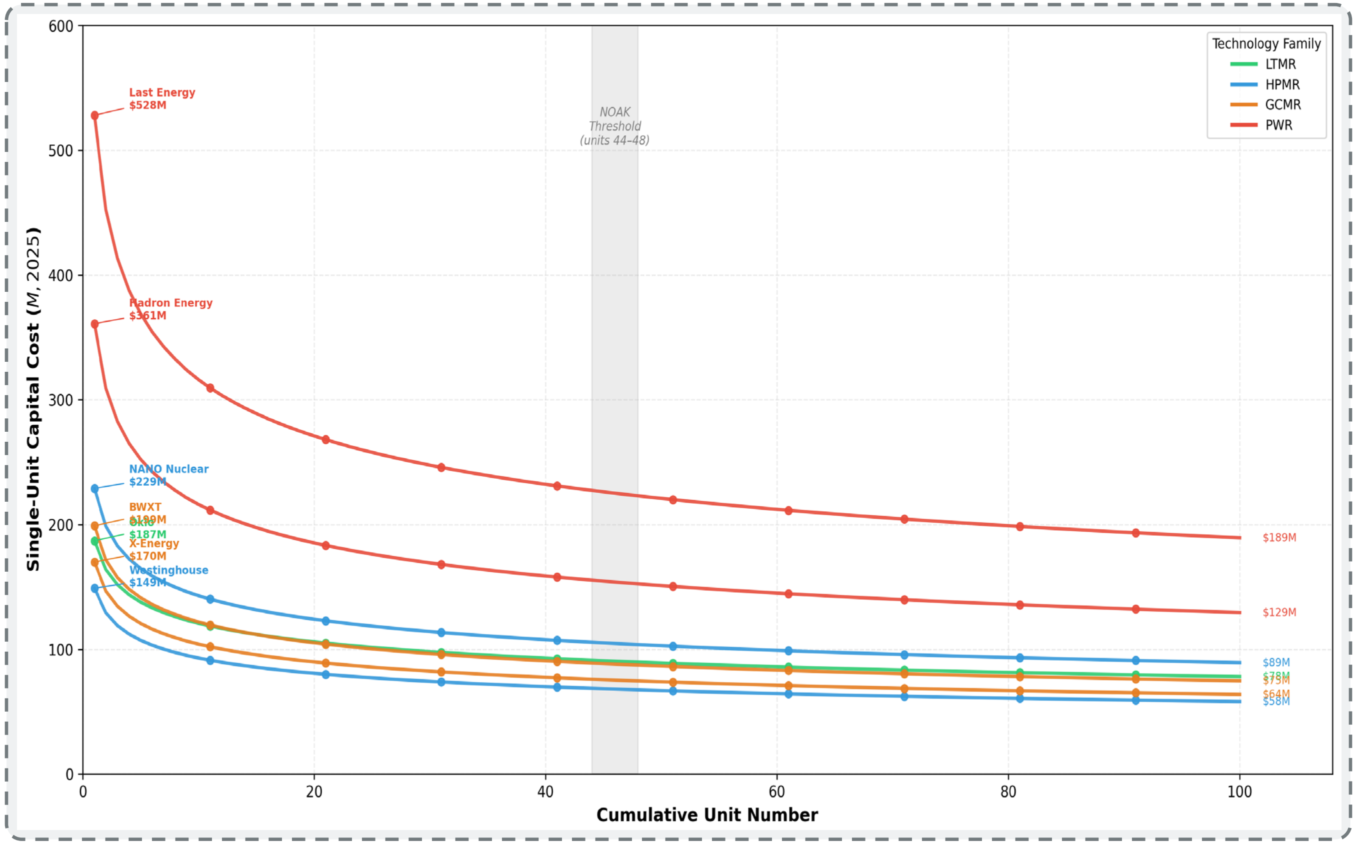


FOAK capital cost estimates (Table 3 / Fig. 1)

- **3.5× spread:** $149M (Westinghouse) → $528M (Last Energy)
- **Non-LWR $187M vs PWR $445M** — a 57% gap
- **Per-kWe 4.8×:** Oklo $7,497 → Hadron $36,131
- **Driver:** factory fabrication + simpler balance-of-plant

Learning cuts unit costs up to 64%

Regulatory Tier-1 adds $235M in fleet savings — as important as tech class



NOAK trajectories and NRC tier impact (Fig. 2 / Table 4)

- **Wright's Law:** unit 100 = $58–189M (44–64% below FOAK)
- **NOAK threshold at units 44–48**; 50-unit fleet saves $4.8B
- **Tier 1 saves $4.7M/unit** → $235M across 50 units
- **Early units lose money** but de-risk the whole fleet

Centrus's ACP is a ready-made co-siting testbed

Only domestic enrichment facility · sole U.S. HALEU source

- **Only U.S.-owned enrichment facility:** NRC SNM-2011
- **Sole domestic HALEU source:** outages carry supply-chain risk
- **Continuous centrifuge load:** restart magnifies losses (2011 precedent)
- **Brownfield edge:** perimeter, licensed area, workforce, emergency plans

Scenario A	Scenario B
21.7 MWe	**37.1 MWe**
3.8M SWU/yr	7.6M SWU/yr
$81k/hr outage*	$163k/hr outage*

~11 outage-hours/yr → $0.9M–$1.8M/yr in lost production

**assuming that no extra actions are/were taken*

Centrus American Centrifuge Plant, Piketon OH (Section 2.2)

A 30% ITC brings MMR power to grid parity

50-year LCOE vs the $86.3/MWh grid baseline, by ITC level

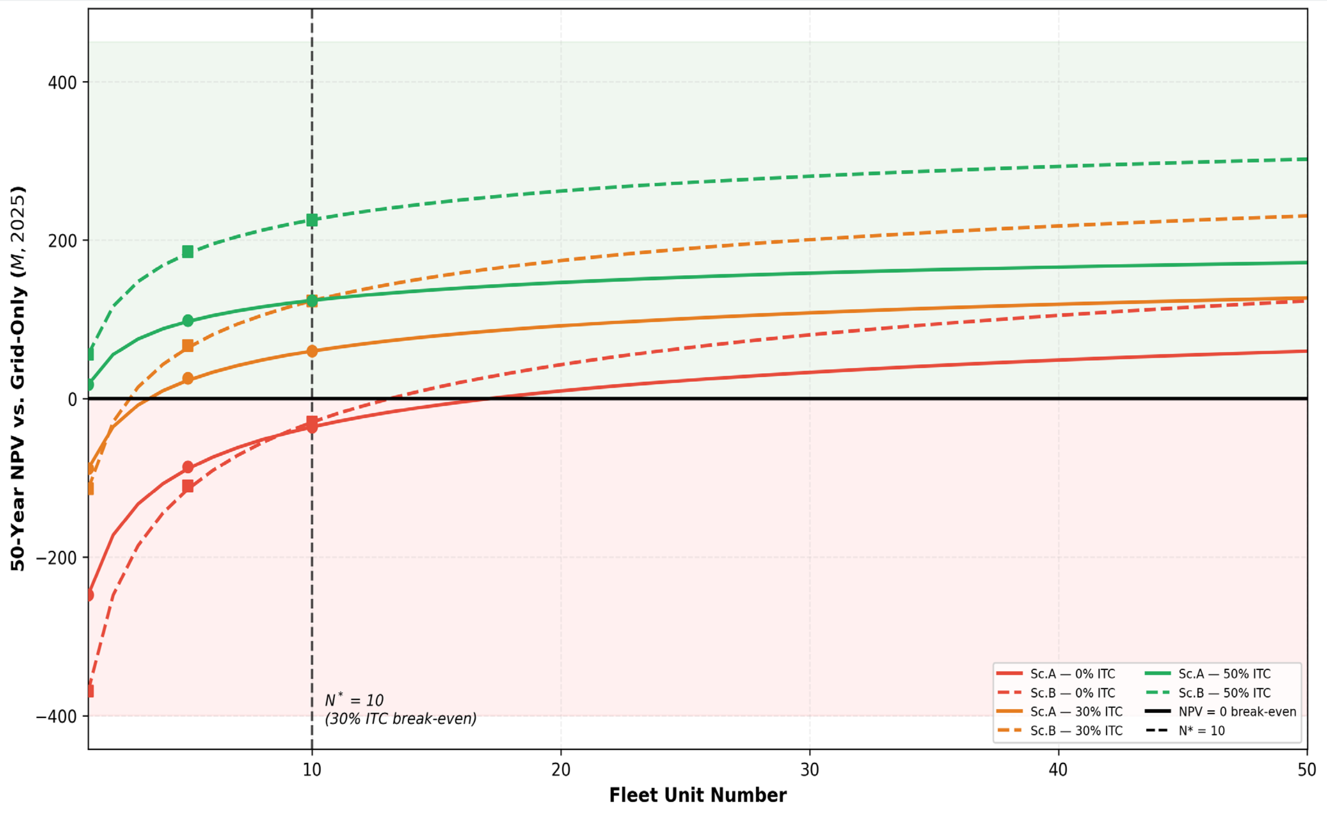
$137.5	$105.6	$84.4	$86.3
No ITC (59% above grid)	30% ITC → grid parity	50% ITC (below grid)	Grid baseline

All values in $/MWh.

- Grid escalates 3%/yr → $151 (Yr 20), $367 (Yr 50); the no-ITC MMR LCOE falls below grid by Year 20.
- Financing quirk: Unit 5 LCOE > Unit 1 (7% commercial vs 4% DOE); Unit 10 = $122.6 at 6%.

NPV turns positive at Unit 10

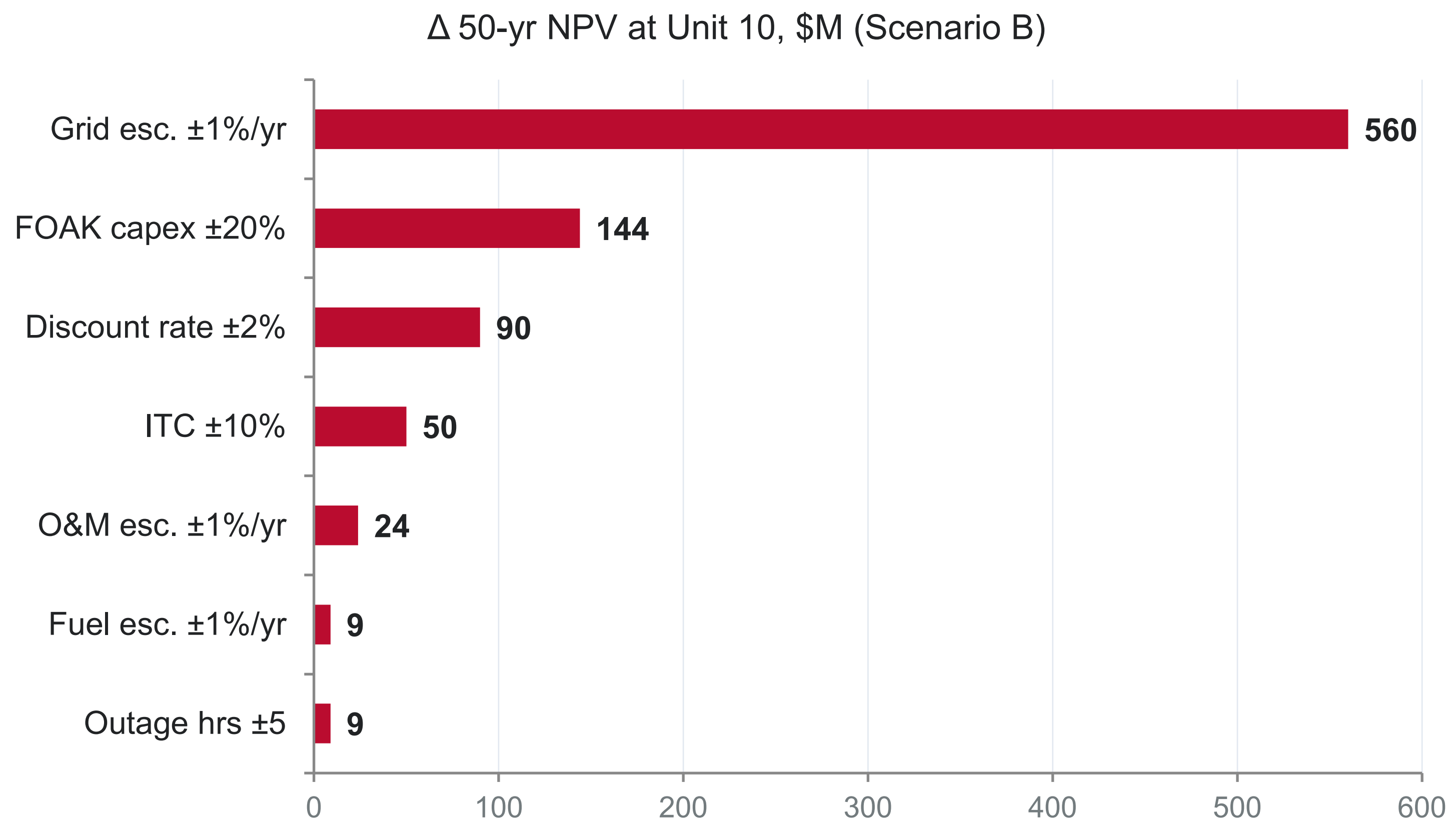
Commercial break-even within a decade — N* = 10 at a 30% ITC



50-year NPV and sensitivity, 8% discount (Fig. 3 / Tables 5–6)

- **Unit 1 needs ≥50% ITC** (Sc. B); Unit 5 positive at 30%
- **Unit 10 = commercial break-even** (N* = 10, 30% ITC)
- **50-yr advantage $1.75B → $2.65B** (Sc. A → B)
- **$1 ITC at Unit 1 → $3–5 saved**; capex + grid escalation dominate

Capital cost and grid escalation dominate the economics



One-at-a-time sensitivity, Δ NPV at Unit 10 (Table 6)

- **Grid escalation is the top lever**: ±1%/yr → ±$280–560M
- **FOAK capex second**: ±20% → ±$72–144M
- **Robust to O&M, fuel, outage** (< ±$25M each)
- **8% discount (inverse)** is why the 30% ITC is needed early

Conclusions

MMR co-siting is commercially viable within a decade (under the assumption of 1 deployment per year)

1. **First reproducible account-level FOAK→NOAK framework** — 7 vendors, MOUSE + Wright's Law
2. **57% non-LWR cost gap; Tier-1 maturity worth $235M** — as important as technology class
3. **N* = 10 at 30% ITC → government-to-private transition** — $1.75B–$2.65B 50-yr advantage
4. **Next:**
   i. **other NFC stages + a couple with the co-siting risk PSA** (companion paper)
   ii. **other coupling scenarios (e.g., NFC stages + datacenters + MMRs)**
   iii. **perform uncertainty analysis on the parameters of the economic model**
   iv. **use of real economic data as soon as they become publicly available**

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