

Nuclear Energy, Uranium, and the Future of Data Centers

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POVZETEK: Raziskava se osredotoča na ekonomske možnosti uporabe nuklearnih energij, srednje zelo značilne električne energije, za podatkovne centra. Nuklearna energija je posebno koristna za podatkovne centra, ki potrebujejo visok uporabniški obseg, nizko-karbone električno energijo v vsakem urah, omejen prostor in predvisne dolžnosti. Ta raziskava razvija model za oceno nuklearnih energij, ki odlično razlikuje ceno električne energije od vrednosti nenehnosti, karbone lastnosti, časa do energije in integracije v sistem. Raziskava se koncentrija na pet različnih pristopov do nuklearnih energij: obstoječi elektrane, upečenje in povprečje, nove velike elektrane, mali modularni ali mikroelektrani in nuklearna-izmenjalniško zbirno mrežno kombinacijo. Praktična vrednost raziskave je, da podatkovne centra bi morala plačati dodatno nenehno in pravilno razdeljeno čisto energijsko kapaciteto, ko je to najpoučnejši način, kako zadovoljiti celoten paket električnih storitev, ki jih potrebujejo.

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KLJUČNE UGOTOVITVE:

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POMEN ZA TRGOVANJE: Raziskava je pomembna za podatkovne centra, ki potrebujejo nenehno in čisto električno energijo. Raziskava razvija model za oceno nuklearnih energij, ki odlično razlikuje ceno električne energije od vrednosti nenehnosti, karbone lastnosti, časa do energije in integracije v sistem. To je pomembno za odločitev, ali je nuklearna energija najpoučnejši način, kako zadovoljiti celoten paket električnih storitev, ki jih potrebujejo podatkovni centri.

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Abstract

Artificial intelligence is converting data centers from ordinary commercial buildings into large, continuous, and strategically important electricity loads. This paper asks when nuclear power, fueled primarily by uranium, is an economically appropriate source of electricity for data centers. The argument is conditional rather than categorical. Nuclear energy is especially valuable when a data center requires high utilization, low-carbon electricity in every hour, limited land, predictable long-run operating costs, and protection from grid congestion or fuel-price volatility. Yet nuclear power also presents large capital requirements, long development and licensing periods, outage concentration, water and siting constraints, fuel-cycle dependencies, and unresolved allocation questions concerning grid costs and public risk. The paper develops a reliability-adjusted clean-power framework that separates the price of electricity from the value of firmness, carbon attributes, time to power, and system integration. It compares five procurement pathways: existing-plant contracts, uprates and restarts, new large reactors, small modular or microreactors, and nuclear-renewable-storage portfolios. Recent agreements involving Google, Microsoft, Amazon, and Meta demonstrate demand for nuclear attributes but do not yet prove that new nuclear construction is universally cost competitive. The analysis implies that data centers should not simply be “powered by uranium.” They should pay for additional, reliable, and appropriately allocated clean capacity when nuclear is the least-cost way to satisfy the full bundle of electricity services they require.

Keywords: data centers; artificial intelligence; nuclear energy; uranium; electricity markets; power purchase agreements; reliability; infrastructure finance

JEL classifications: Q40; Q42; L86; G31; L94

1 Introduction

The rapid construction of artificial-intelligence infrastructure has changed the economics of electricity demand. A traditional data center was already a large customer, but modern AI campuses can be planned at hundreds of megawatts and may seek gigawatt-scale interconnections. Their servers operate continuously, their revenue depends on availability, and their location is often constrained by fiber, latency, land, water, tax incentives, and access to transmission. The result is an unusually concentrated load whose private value can be high even when the surrounding grid has little spare capacity.

This demand arrives while electricity systems are replacing aging generation, expanding transmission, electrifying transportation and buildings, and attempting to reduce carbon emissions. The International Energy Agency estimates that data centers used roughly 415 terawatt-hours of electricity globally in 2024 and projects about 945 terawatt-hours in its 2030 base case (IEA, 2025). The national share may remain manageable, but the local consequences can be substantial because projects cluster in a limited number of regions and because data centers can be built faster than major generation and transmission assets.

Nuclear energy has therefore returned to corporate energy strategy. Google contracted with Kairos Power for a sequence of advanced reactors totaling up to 500 megawatts. Microsoft entered a twenty-year agreement supporting the planned restart of the 835-megawatt Crane Clean Energy Center. Amazon backed an initial 320-megawatt small-modular-reactor project with Energy Northwest and X-energy, and Meta contracted for the output of the Clinton Clean Energy Center. These transactions

are important market signals. They show that technology firms value firm, carbon-free output enough to sign long contracts and support development, preservation, or restart of nuclear assets.

The transactions do not establish that every data center should be attached to a nuclear plant. Existing reactors, restarts, uprates, new large reactors, small modular reactors, and microreactors have different costs, risks, and schedules. A virtual power-purchase agreement also does not physically route each electron from a reactor to a server. Electricity normally enters a common grid, while contracts allocate payments, energy, capacity, and environmental attributes. True behind-the-meter configurations raise additional questions about transmission charges, backup service, public reliability obligations, and whether other customers bear costs created by the new load.

This paper contributes a finance-oriented framework for evaluating nuclear-data-center combinations. The key insight is that the decision cannot be made from levelized cost of electricity alone. A data center buys a bundle: energy, capacity, hourly firmness, voltage quality, interconnection speed, carbon attributes, fuel security, and insurance against interruption. Nuclear power can command a premium when it supplies this bundle more effectively than alternatives. Its weakness is that the premium may be outweighed by construction delay, capital-cost risk, regulatory uncertainty, or concentrated outage exposure.

The paper proceeds as follows. Section 2 clarifies the relationship among uranium, nuclear power, and data-center electricity use. Section 3 develops the economic case for firm clean power. Section 4 presents a reliability-adjusted valuation framework. Section 5 compares procurement pathways. Section 6 reviews recent corporate agreements. Sections 7 and 8 examine the uranium fuel cycle and the principal risks. Section 9 discusses finance and policy design. Section 10 proposes testable hypotheses and an empirical research agenda. Section 11 concludes.

2 Uranium Nuclear Power and Data Center Load

2.1 Uranium is fuel not electricity

A data center cannot literally be powered by uranium. Uranium is a primary fuel. After mining, conversion, enrichment, and fabrication, uranium fuel is used in a licensed reactor. Fission releases heat, the heat produces steam or another working fluid, and a turbine-generator produces electricity. The data center consumes electricity delivered through a grid connection or a dedicated electrical system. This distinction matters because mining and fuel security, reactor ownership, grid delivery, environmental attributes, and data-center operations are separate markets with separate risks.

The nuclear fuel cycle also means that “domestic nuclear power” is not automatically equivalent to a completely domestic supply chain. Uranium can be mined in one country, converted in another, enriched elsewhere, fabricated into fuel, and used for several years before discharge. Fuel costs are a smaller share of nuclear generation costs than fuel costs are for gas generation, which reduces short-run exposure to commodity-price shocks. Nevertheless, conversion and enrichment capacity, transport, geopolitical concentration, inventories, and fuel qualification can constrain deployment, particularly for advanced reactors requiring fuels not yet available at commercial scale.

2.2 The relevant data center load

The engineering requirement begins with load rather than annual electricity consumption. Let L denote contracted IT load in megawatts, u the average utilization rate, and PUE the power usage effectiveness ratio. If L is defined as IT load, annual facility electricity demand is:

$$E = 8,760 \times L \times u \times PUE$$

For illustration, a 100-megawatt facility load operating at 95 percent utilization consumes approximately 832 gigawatt-hours per year when L already includes cooling and other overhead. If 100 megawatts refers only to IT equipment and PUE equals 1.2, annual facility use rises to roughly 999 gigawatt-hours. The distinction is material: ambiguous use of “megawatts” can understate both interconnection needs and procurement cost.

Annual energy equivalence is not hourly equivalence. A portfolio of wind or solar facilities can generate the same number of megawatt-hours over a year while failing to match the data center in individual hours. Storage, geographic diversification, transmission, demand flexibility, or firm generation must close the gap. Nuclear power is attractive because its output profile is closer to a continuous load. Yet a single reactor is not perfectly reliable. Planned refueling and unplanned outages require grid backup, redundant units, storage, or contractual replacement power.

3 Why Nuclear Power Can Fit Data Centers

3.1 Firm low carbon electricity

Nuclear plants combine high utilization with low direct operating emissions. In the United States, nuclear has historically recorded the highest average capacity factor among major generation technologies, commonly above 90 percent (EIA, 2025). High capacity factor is not the same as guaranteed availability, but it means that one unit of nameplate nuclear capacity produces far more annual energy than one unit of intermittent capacity. For a continuously operating data center, this reduces the amount of overbuilding required to obtain annual energy and makes hourly carbon matching easier.

The climate advantage depends on lifecycle accounting rather than the absence of a smokestack alone. Mining, enrichment, concrete, steel, plant construction, decommissioning, and waste management all create emissions. Assessments synthesized by the IPCC and NREL nevertheless place nuclear among low-lifecycle-emission electricity sources. The relevant comparison for a new data-center load is the marginal portfolio that would otherwise serve it, which may include gas generation, renewables, storage, transmission, and demand response.

3.2 Reliability has economic value

Data centers monetize computation, not electricity. An interruption can disrupt cloud services, financial transactions, logistics, communication, and AI training. The willingness to pay for reliable electricity therefore depends on lost contribution margin, service-level penalties, customer churn, hardware restart costs, and reputational damage. This creates a reliability premium that conventional energy comparisons often miss.

Nuclear plants can supply firm generation, but system reliability comes from portfolios. A large reactor is a large contingency: if it trips, hundreds of megawatts or more disappear at once. A data center paired with nuclear still needs the grid, batteries, diesel or gas backup, redundant feeds, or multiple generating modules. Small modular reactors may reduce outage concentration if modules can be maintained sequentially, but this benefit remains partly prospective until repeated commercial operation is demonstrated.

3.3 Land transmission and locational value

Electricity is location-specific. A low national average price does not create deliverable capacity at a congested substation. Existing nuclear sites can offer valuable infrastructure: grid interconnections, transmission corridors, water access, security boundaries, a skilled workforce, and communities familiar with energy facilities. The Department of Energy has estimated that existing and recently retired U.S. nuclear sites could potentially accommodate 60 to 95 gigawatts of new capacity (DOE, 2024b). Reusing such sites can reduce some development barriers, although it does not eliminate licensing, equipment, environmental, or transmission studies.

The relatively small land footprint of nuclear generation can be valuable near dense digital corridors. However, colocating a private load at a generator can shift costs and benefits across market participants. Regulators must determine whether the data center receives a private bypass of network charges while continuing to rely on the public grid for backup, balancing, and emergency support. Efficient policy should charge the data center for the services it uses and compensate it for verifiable services it provides.

3.4 Long duration contracting and capital formation

Nuclear projects are capital intensive and long lived; data centers are capital intensive but technologically shorter lived. This maturity mismatch creates both opportunity and risk. A creditworthy hyperscaler can sign a long-term contract that stabilizes reactor revenue, supports project finance, or prevents premature retirement. In return, the buyer may receive long-run price visibility and carbon-free attributes. The contract becomes an instrument for transforming uncertain merchant revenue into financeable cash flow.

The same contract can transfer excessive risk if it is poorly designed. A fixed-price buyer may bear inflation or delay through escalation clauses. A generator may promise output before licensing and construction are complete. A utility may socialize network upgrades. A community may absorb water, land, security, or decommissioning risks without adequate compensation. The central finance question is therefore not simply whether nuclear is economical, but who bears each tail risk.

4 A Reliability Adjusted Clean Power Framework

A data-center energy decision should minimize the present value of total service cost, not the posted price of electricity. For procurement portfolio j , define the reliability-adjusted cost per delivered megawatt-hour as:

$$RAC_j = (Energy_j + Capacity_j + Grid_j + Firming_j + Carbon_j + Delay_j + Risk_j - Flexibility_j) / \text{Delivered MWh}_j$$

Energy includes variable and contracted payments. Capacity reflects the cost of keeping dependable generation available. Grid includes interconnection, transmission, distribution, ancillary services, and backup obligations. Firming includes storage, redundant supply, and replacement power. Carbon includes compliance costs and the buyer’s shadow price of emissions. Delay converts time-to-power into lost project value. Risk is the certainty-equivalent cost of construction, regulatory, fuel, outage, and basis risk. Flexibility credits demand response, schedulable computing, heat reuse, and grid services.

Nuclear is preferred when its reliability-adjusted cost is below that of feasible alternatives and when the project satisfies financing, safety, environmental, and community constraints. This condition can hold even if nuclear has a higher standalone levelized cost, because the alternative may require storage, transmission, gas backup, carbon allowances, or a multiyear wait for interconnection. It can fail even when an existing plant offers low operating cost, because the load may be far from the plant, the contract may not add new clean supply, or a large outage may require expensive redundancy.

A complementary net-present-value expression makes the buyer’s decision explicit. Let B_t denote computing contribution margin enabled by electricity, A_t avoided outage losses, C_t carbon and compliance benefits, and X_t all energy, infrastructure, and risk-adjusted costs. The project is acceptable if:

$$NPV = -I_0 + \sum_{t=1}^T [(B_t + A_t + C_t - X_t) / (1 + r)^t] > 0$$

This formulation highlights the cost of delay. If a reactor becomes available in year seven while a gas-renewable portfolio is available in year two, five years of foregone computing margin can dominate a favorable operating-cost comparison. Existing nuclear, uprates, and restarts may therefore have greater near-term value than first-of-a-kind new reactors. Conversely, a long pipeline of modular projects may become attractive if standardized deployment shortens schedules and reduces cost dispersion.

Table 1. Technology fit for a continuously operating data center

Option	Primary strength	Principal limitation	Best use case
Existing nuclear contract	Firm low-carbon output with operating history	May provide limited additional capacity; basis and delivery risk	Long-term hedge and plant preservation
Uprate or restart	Uses existing site and grid assets	Engineering, licensing, refurbishment, and schedule risk	Regions with retired or underused nuclear infrastructure
New large reactor	Large block of firm low-carbon power	Very high capital exposure and long construction horizon	Multi-buyer or utility-scale expansion
SMR or microreactor	Modularity and potential siting flexibility	Limited commercial cost and operating record	Phased campuses after technology demonstration
Renewables plus storage	Fast deployment and low marginal cost in favorable regions	Hourly matching and long-duration firming can be costly	Flexible loads and regions with strong resources
Gas generation	Dispatchable and comparatively fast to build	Fuel-price and carbon exposure	Bridge supply or backup where permitted

5 Five Nuclear Procurement Pathways

5.1 Contracting with the existing fleet

The lowest-risk nuclear pathway is often a contract with an operating plant. The reactor has an operating record, a known location, trained staff, and an established interconnection. A long-term

corporate agreement can extend the economic life of a plant that might otherwise face weak merchant revenues. The benefit to the data center is stable access to carbon-free attributes and a hedge against fossil-fuel prices.

The principal criticism is additionality. If the reactor would have operated anyway, the contract may reallocate existing clean electricity rather than create new supply. This does not make the contract valueless: preventing retirement can avoid replacement by fossil generation. But the buyer should disclose whether the transaction preserves output, finances an uprate, extends a license, or simply transfers certificates. Hourly and locational matching should be reported separately from annual claims.

5.2 Uprates and restarts

Power uprates increase the output of existing units through equipment and operating changes. Restarts return retired capacity to service after refurbishment and regulatory approval. Both can exploit sunk infrastructure and may reach the market sooner than new construction. The Microsoft-supported Crane project illustrates the restart model: a long-term buyer helps underwrite a large block of capacity, while the operator remains responsible for licensing, refurbishment, and plant operations.

Restarts are not simple reversals of retirement. Components age, supply chains change, staff disperse, and new inspections or environmental reviews may be required. A financeable contract should contain milestone payments, delay remedies, performance tests, credit support, and a clear rule for replacement energy. The buyer should not advertise a commercial operation date as certain before regulatory approvals and technical work are complete.

5.3 New large reactors

Large reactors can support several data centers and the surrounding grid, but they expose investors to construction duration and cost-overflow risk. Their scale can exceed the needs or risk tolerance of one corporate buyer. A consortium structure may therefore be preferable: utilities, hyperscalers, industrial users, governments, and infrastructure investors can share output and risk. Standardized design, repeat builds, experienced project management, and credible completion guarantees are critical.

The strongest economic case arises where a region expects durable load growth, has supportive institutions, needs firm low-carbon power at system scale, and can reuse an established nuclear site. The weakest case is a bespoke first-of-a-kind plant justified by a single data-center forecast that may change before completion. Compute technology and location decisions can move faster than nuclear assets; contracts must address stranded-load risk.

5.4 Small modular reactors and microreactors

SMRs seek to replace some site construction with factory fabrication and repeated modules. Smaller increments may better match phased data-center growth and reduce the amount of capacity exposed to a single outage. Microreactors could serve remote or defense-related computing loads. These are promising design propositions, not yet universal commercial facts. Cost reductions depend on standardized orders, manufacturing learning, regulatory repetition, and a sufficient project pipeline.

The Google-Kairos and Amazon-X-energy agreements are economically significant because committed buyers can create an orderbook. Repetition is central: the first unit bears design, licensing, and supply-chain costs, while later units may benefit from learning. Yet first-of-a-kind schedules and

costs remain uncertain, and some advanced designs depend on specialized fuel. Data-center developers should value optionality but avoid assuming nth-of-a-kind economics for the first project.

5.5 Nuclear renewable storage portfolios

The practical choice is rarely nuclear versus renewables. Nuclear provides a firm low-carbon foundation; wind and solar can add low-marginal-cost energy; batteries can manage short-duration variation and ride-through; flexible computing can shift selected workloads; and the grid provides diversity. This portfolio reduces reliance on any single generator while improving hourly carbon performance.

A hybrid portfolio also improves asset utilization. During low data-center demand or high renewable output, nuclear electricity can serve the grid, produce hydrogen, support district heat, or supply other industrial loads. During grid stress, schedulable AI training can be reduced if contracts reward flexibility. Data centers should be treated not only as loads but also as potential participants in capacity, ancillary-service, and demand-response markets, subject to operational constraints.

6 Market Evidence from Corporate Agreements

Corporate nuclear agreements have moved from isolated announcements to a recognizable procurement strategy. Table 2 summarizes representative transactions. These agreements differ fundamentally: some preserve existing plants, some support restarts, and others aim to commercialize advanced reactors. Treating them as equivalent would obscure their effects on electricity supply and risk.

Table 2. Representative corporate nuclear energy agreements

Buyer and counterparty	Announced structure	Scale and timing	Economic interpretation
Google and Kairos Power	Multi-reactor advanced nuclear agreement	Up to 500 MW; first deployment targeted for 2030, followed by additions through 2035	Creates an orderbook and supports commercialization
Microsoft and Constellation	Twenty-year PPA supporting restart of Crane Clean Energy Center	Approximately 835 MW; developer target of 2028, subject to approvals	Uses corporate credit to support refurbishment and restored capacity
Amazon, Energy Northwest, and X-energy	Development and investment arrangement for modular reactors	Initial project of roughly 320 MW with expansion potential	Links phased data-center demand to modular deployment
Meta and Constellation	Twenty-year agreement for Clinton Clean Energy Center output	Existing 1,121 MW plant; agreement begins after current support expires	Supports continued operation and a proposed uprate

The agreements reveal four forms of value. First, corporate buyers are willing to contract for long duration, which reduces merchant-price risk. Second, they value hourly firmness and carbon-free attributes together. Third, large buyers can accelerate technology learning by supporting multiple units rather than a single demonstration. Fourth, nuclear procurement is becoming part of data-center location strategy, not merely a sustainability accounting exercise.

They also reveal limits. Announced megawatts are not the same as operating megawatts. New projects remain subject to licensing, financing, supply-chain, community, and construction outcomes. Existing-plant contracts may not physically serve a particular campus. Public disclosures rarely reveal the full

strike price, escalation formula, guarantees, or network-cost allocation. The transactions are evidence of willingness to contract, not proof of social cost minimization.

7 Uranium Fuel Security and the Data Center Thesis

Uranium strengthens the nuclear value proposition through energy density and inventory. A reactor can store substantial fuel value on site and refuel at long intervals, limiting exposure to just-in-time pipeline delivery. The uranium price is only one component of the delivered fuel cost; conversion, enrichment, fabrication, transport, and inventory matter. Because fuel is a relatively small portion of total nuclear generation cost, a uranium-price increase generally has a smaller proportional effect on electricity cost than a comparable gas-price shock has on gas generation.

The conclusion should not be overstated. Rapid nuclear expansion can tighten uranium, conversion, enrichment, and specialized-fuel markets. Advanced reactors may require high-assay low-enriched uranium or proprietary fuel forms. Geopolitical dependence can migrate from fossil fuel to nuclear fuel services if procurement remains concentrated. A credible data-center nuclear strategy therefore includes diversified contracting, strategic inventories, transparent origin, recycling research where lawful and economical, and investment in domestic and allied fuel-cycle capacity.

Waste is a real intergenerational obligation. Used fuel remains highly radioactive and is stored initially in pools and later, where appropriate, in dry casks under regulatory requirements (NRC, 2024a). The physical volume is comparatively small relative to fossil waste streams, but duration and stewardship are demanding. Data-center buyers should not claim “waste-free” electricity. Long-term contracts can include contributions to decommissioning and waste-management funds, but public institutions remain central because the obligation can outlive both the data center and the corporate buyer.

8 Risks and Counterarguments

8.1 Cost and schedule

The largest objection to new nuclear is not fuel cost but capital delivery. Large projects have experienced high cost and schedule dispersion in several Western markets. Interest during construction compounds the problem: each year of delay increases financing cost while postponing revenue. Data-center demand forecasts can also be revised as chips become more efficient, workloads migrate, or business conditions change. A reactor designed around an aggressive load forecast can become oversized or stranded.

SMRs may improve modularity but do not repeal project finance. Factory investment requires volume; volume requires orders; orders require confidence in cost and licensing. Early units can be expensive. The appropriate claim is that standardization and repetition may reduce risk, not that small size guarantees low cost. Contracts should use independent engineering review, transparent milestone budgets, contingencies, and risk-sharing that preserves incentives to complete the project.

8.2 Water heat and climate exposure

Thermal power plants reject heat, and many nuclear designs use substantial cooling water. Data centers may also consume water directly or indirectly. Co-location can therefore concentrate water demand

and thermal stress, especially in hot or drought-prone regions. Dry cooling, hybrid cooling, wastewater use, air-cooled data centers, and heat reuse can reduce freshwater pressure but may raise cost or reduce efficiency. Site evaluation must consider watershed conditions rather than relying on a national average water-intensity number.

8.3 Safety security and governance

Nuclear safety and data-center cybersecurity are each high-consequence governance domains. Physical proximity does not justify integration of operational control systems. Reactor instrumentation and control, grid interfaces, and data-center networks require defense in depth and institutional separation. Emergency planning, security boundaries, cyber standards, workforce screening, and incident communication must remain under competent regulatory authority. Corporate demand cannot substitute for independent safety review.

8.4 Opportunity cost and crowding out

A nuclear contract may reserve scarce clean output for a wealthy private buyer while households and other industries face higher prices. Alternatively, a corporate contract may finance capacity that lowers system costs for everyone. The difference depends on additionality and cost allocation. Policymakers should ask whether the project adds generation, pays its interconnection and backup costs, improves or worsens system reliability, and shares tax and employment benefits with the host community.

There is also an opportunity cost to capital. Money committed to a delayed reactor cannot simultaneously finance transmission, efficiency, renewables, storage, or faster firm resources. The least-cost portfolio will vary by region. Nuclear should compete on reliability-adjusted system value, not receive an exemption from economic comparison; renewables should likewise be evaluated with the cost of hourly balancing and delivery rather than energy price alone.

8.5 Moral hazard and public guarantees

Government support may be justified by learning spillovers, energy security, carbon reduction, and the option value of a diversified technology portfolio. But guarantees can create moral hazard if developers retain upside while taxpayers absorb overruns. Support should be conditional on standardized designs, verified milestones, cost transparency, private risk capital, and public benefits. Corporate buyers that create the load should provide meaningful offtake commitments rather than rely solely on regulated customers.

9 Finance Contracting and Policy Design

A sound nuclear-data-center contract should allocate at least seven risks: construction cost, completion date, operating performance, fuel supply, market-price basis, carbon-attribute delivery, and stranded load. It should also specify grid services, backup rights, transmission charges, curtailment, decommissioning obligations, and community benefits.

Table 3. Suggested risk allocation

Risk	Party best able to manage it	Illustrative contractual mechanism
Design and construction performance	Developer and engineering consortium	Milestones, performance guarantees, contingency sharing, independent engineer

Risk	Party best able to manage it	Illustrative contractual mechanism
Load growth and technology migration	Data-center buyer	Minimum offtake, phased capacity, assignment rights, termination payment
Licensing and public approvals	Shared; developer leads	Conditions precedent, long-stop date, transparent public engagement
Fuel availability	Generator and fuel suppliers	Diversified suppliers, inventory requirements, indexed bands
Grid and basis risk	Buyer, utility, and market operator	Defined delivery point, congestion formula, backup tariff
Operating outage risk	Generator with buyer redundancy	Availability guarantee, replacement energy, modular redundancy
Decommissioning and waste	Generator under public regulation	Funded trust, statutory compliance, periodic adequacy review

Policy should be technology-neutral about outcomes but not blind to attributes. Market rules can separately price energy, capacity, ancillary services, carbon, and locational reliability. Clean-energy tariffs can allow a corporate buyer to fund new resources without shifting costs to nonparticipating customers. Standardized interconnection studies and clear co-location rules can reduce uncertainty while preserving fair network charges.

Permitting reform should improve process quality and predictability, not weaken safety. Parallel reviews, early site permits, standardized reactor designs, pre-application engagement, and adequate agency staffing can shorten avoidable delay. Existing and retired nuclear sites deserve priority analysis because they may already possess transmission, industrial zoning, workforce, and community experience. The Department of Energy’s estimate of 60 to 95 gigawatts of potential new capacity at existing and recently retired sites illustrates the scale of this option, though site-specific feasibility must still be established.

Data-center policy should also require transparency. Developers should disclose expected load by phase, annual and peak consumption, PUE and water metrics, generation additions, backup technologies, hourly carbon matching, and allocated grid-upgrade costs. Nuclear counterparties should disclose project status, licensing milestones, fuel assumptions, waste and decommissioning arrangements, and whether claimed output is new, preserved, or reallocated. Transparent categories would improve research and reduce exaggerated claims on both sides of the debate.

10 Testable Hypotheses and Research Design

The framework yields hypotheses suitable for empirical testing. First, proximity to operating or retired nuclear sites should shorten time-to-power for data-center projects when usable interconnection capacity exists. Second, long-term nuclear contracts should reduce the sensitivity of data-center operating margins to natural-gas and wholesale-electricity price shocks. Third, announcements involving existing-plant preservation should have different market effects from announcements involving first-of-a-kind construction because completion and additionality differ. Fourth, jurisdictions with clear co-location and clean-tariff rules should attract more data-center investment, conditional on fiber, taxes, labor, climate, and electricity prices.

A state- or balancing-authority panel could combine data-center capacity, interconnection queues, generator characteristics, congestion prices, fuel mix, transmission additions, water stress, and regulatory policy. A difference-in-differences design could study nuclear-contract announcements or plant-restart decisions, but treatment timing is endogenous: buyers choose places with expected

growth and available infrastructure. Plausible strategies include event studies around regulatory decisions, synthetic controls for plant regions, and instruments based on historical nuclear siting interacted with exogenous national AI-demand shocks. Any instrument must satisfy the exclusion restriction; historical siting can affect modern industry through channels other than nuclear availability.

At the project level, researchers could estimate whether long contracts lower the weighted average cost of capital or improve debt capacity. Contract prices are often confidential, so bond spreads, credit ratings, equity event returns, capital expenditures, and announced capacity may serve as outcomes. A structural model could value the option to delay a data center, phase reactor modules, or switch procurement pathways. The key state variables would include compute demand, interconnection delay, natural-gas prices, carbon policy, reactor completion probability, and the speed of hardware efficiency improvement.

A second research design should examine distributional effects. County-level employment and tax revenue can be compared with electricity rates, water withdrawals, grid investment, and household reliability. The relevant counterfactual is not “no data center” in isolation but the next-best use of the site, electricity, water, and public incentives. Separating private gains from system and community effects would move the debate beyond simple claims that nuclear-powered data centers are either universally beneficial or inherently extractive.

11 Discussion

The phrase “nuclear-powered data center” can describe three different arrangements. In an accounting arrangement, the buyer purchases energy and carbon attributes from a distant plant while using the ordinary grid. In a locational arrangement, the data center and reactor are in the same market region and the contract supports deliverable supply. In a physical arrangement, the facilities are colocated or connected behind the meter, while still requiring rules for backup and grid interaction. Policy and research should identify which arrangement applies.

The distinction between existing and new nuclear is equally important. Existing nuclear can provide near-term firm clean energy, but merely reallocating its output does not solve aggregate scarcity. Preventing retirement may be additional if the counterfactual is closure and fossil replacement. Upgrades and restarts add or restore output with less greenfield development. New reactors offer the largest long-run expansion but also carry the greatest completion risk. A credible strategy uses a ladder: preserve safe existing units, pursue economical upgrades and restarts, demonstrate advanced designs, and scale only after cost and schedule evidence improves.

Nuclear energy also should not become an excuse for inefficient computing. The lowest-cost megawatt is often the one not required. Better chips, workload scheduling, server utilization, efficient cooling, heat recovery, and transparent PUE and water-use metrics reduce the generation and grid investment needed. Efficiency and nuclear supply are complements: reducing waste makes scarce firm clean electricity available for more valuable computation and for other customers.

Finally, the corporate nuclear trend can reshape capital markets. Hyperscaler contracts may create a new class of infrastructure cash flows linking digital demand with energy assets. Investors will need to price reactor technology, licensing, fuel supply, buyer credit, basis risk, and load obsolescence together. Securities backed by long-term nuclear offtake could attract pension, insurance, infrastructure, and

project-finance capital, but only if risk disclosure is substantially better than ordinary promotional announcements.

12 Conclusion

Nuclear power offers a strong match for some data centers because it can provide firm, low-carbon electricity with high utilization, limited land requirements, and relatively low exposure to short-run fuel-price volatility. Uranium contributes to this value as an energy-dense and storable fuel, but uranium is only one element in a regulated chain of mining, conversion, enrichment, fabrication, generation, grid delivery, waste management, and decommissioning.

The correct policy is not to require every data center to be powered by nuclear energy. It is to make large digital loads responsible for the full electricity bundle they demand and to allow nuclear power to compete on that basis. Existing-plant agreements, uprates, and carefully evaluated restarts can provide near-term value. New large reactors and SMRs may support long-run growth, but their economics depend on construction discipline, standardized deployment, licensing performance, fuel availability, and fair risk allocation. Renewable energy, storage, transmission, flexible computing, and efficiency remain essential components of the portfolio.

The central conclusion is therefore conditional but actionable: nuclear energy is most compelling for data centers when it is additional or preserves capacity that would otherwise retire, is deliverable where the load occurs, arrives within the project's economic window, allocates grid and tail risks transparently, protects safety and community interests, and has a lower reliability-adjusted total cost than feasible alternatives. Under those conditions, long-term data-center demand can finance clean firm capacity and nuclear power can enable digital growth without making fossil generation the default marginal response.

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