# Xcel Just Transition Solicitation (JTS), Phase 1, 2024
# Colorado PUC Docket No. 24A-0442E

**2 July 2025 Comment by Amory B. Lovins, Stanford University, ablovins@stanford.edu**

***Qualifications***

Some third-party opinions may provide useful context for younger readers unfamiliar with my work since the 1970s, prefacing my specific qualifications most relevant to this Proceeding (summarized in Attachment A). *Newsweek* called me "one of the western world's most influential energy thinkers"; Dr. Alvin Weinberg, former Director of Oak Ridge National Laboratory, "surely the most articulate writer on energy in the whole world today"; *Car* magazine, the 22nd most powerful person in the global automotive industry. Dr. John Ahearne, then Vice President of Resources for the Future, said "Amory Lovins has done more to assemble and advance understanding of [energy] efficiency opportunities than any other single person."

In 1994, the editor of the *Electricity Journal* wrote, "No advocate has had a greater influence on the changing orientation of US utilities toward energy efficiency — even the terms we use to talk about it — than Amory Lovins. Lovins's projections for the savings to be mined … have always challenged what many in the industry saw as practicable. His vision of the equivalency and even superiority of energy efficiency to conventional power supply has in large measure prevailed." In 2002, an independent analysis found that by taking efficient end-use seriously, my 1976 *Foreign Affairs* paper had offered the literature's only accurate foresight on US energy use in 2000—a few percent above actual. As the *Economist* concurred in 2008, that *Foreign Affairs* article — reframing the energy problem around end-use and least cost, emphasizing efficiency, renewables, and distributed solutions—was "ruthlessly attacked by the energy industry and the political establishment, and [its] … proposal for an alternative 'soft path'…was dismissed… But history has proved him right."

In March 2013, *Public Utilities Fortnightly* editor Michael Burr built a nine-page feature, including my retrospective, around my 1984 speech to NARUC. Burr said that speech "makes remarkable reading today, in part because it was so prescient; much of what Lovins predicted has indeed come to pass. However, what's even more remarkable is that the article actually still applies today, almost three decades later. With some editing—changing some details—it still presents a solid analysis of industry trends that are playing out right now." In 2016, *Public Utilities Fortnightly*'s Michael Mitnick named me one of ten "Lions and luminaries who led the changes in utilities," and *Power Engineering International* singled out my accurate foresight among 16 experts they'd asked in 1996 to predict electricity futures.

***General conclusions***

I'm sorry I was traveling on your Public Comment Hearing dates. In this independent personal Comment, I endorse, concur with, and reinforce the excellent Answer Testimony of David A. Schlissel, filed as Hearing Exhibit 1701 in this Proceeding. This Comment emphasizes where his conclusions were particularly conservative. Though without full immersion in the hearing record, I hope these selective but often broad and contextual observations will help the Commission.

This Proceeding deals almost exclusively with electricity supplies, but supply-side resources cannot be validly considered in isolation from demand-side resources. Efficient and timely end-use, which I'll call "negawatts" and "flexiwatts" respectively, are both extremely large low-cost resources—far larger than generally supposed. For example, end-use energy efficiency across all sectors and nearly all end-uses in the global economy could be approximately quintupled by systematically applying "integrative design"—optimizing buildings, factories, and vehicles as whole systems for multiple benefits, not as piles of isolated parts for single benefits. (That quintupling does *not* include the further two- to three-fold gain in primary energy efficiency that automatically results from replacing fossil and nuclear fuels with primary renewable electricity such as solar and windpower.) At historically reasonable speed, global end-use efficiency could be quintupled by roughly 2060, or tripled by about 2040. Similar considerations apply to the United States. In round numbers, I have no reason to think Colorado must or would differ markedly from the national average, though of course many details vary between and within states.

I've omitted here a blizzard of hyperlinks in order not overburden Commissioners and Staff. The easiest introduction to my views on end-use efficiency potential starts at 08:30 of a 2 June 2025 Stanford Energy Seminar, backed by a peer-reviewed foundational paper and two others. Scores of others (many in peer-reviewed journals) are available, including 2021 surveys of how innovation in design and business models can profitably decarbonize "harder-to-abate" sectors.

A sound utility regulatory process will compete or compare negawatts and flexiwatts against marginal W and Wh of supply, then pursue best buys first. Boundary conditions like reliability, resilience, health, safety, security, justice, and informed public acceptance are vital, but negawatts and flexiwatts can generally meet those goals better too. Neither kind of demand-side resource appears in Exh. 101's Base Plan graph (p 61): most of the solution space that should be at the core of any least-cost integrated resource plan appears to be a formulaic minor detail.

Beyond the following two sections, on AI data centers and on demand more broadly, I won't further pursue demand-side arguments in this supply-side proceeding, but their scarcity in the Plan implies that the supply-side emphasis of this Proceeding lacks essential context. Rebalancing that portfolio would make Mr. Schlissel's conclusions and recommendations even more compelling.

***Data center loads***

In 2003 in San Jose, I led the industry's first workshop on efficient data center design. It found very large opportunities, but today's are even larger, as summarized next. I'm referring not just to PUE (the ratio of a data center's total to its server loads, measuring cooling and other noncomputational overheads), which can now reach 1.02, but to every aspect of design, software, operations, applications, business models, and AI prospects.

New data centers are forecasted to account for *62% of Xcel Energy's Base Case electric energy growth and 72% of peak demand growth* through the RAP (Exh. 101, p 36). Color me skeptical. My 10 May 2025 essay "Artificial Intelligence Meets Natural Stupidity: Managing the Risks," posted 15 May 2025, documents many reasons why the same day's *Utility Dive* posting found that ˜80–90% of proposed US data centers are unlikely to be built. My essay's Abstract reads:

Future electricity needs for artificial intelligence (AI) are wildly uncertain—shaped by unproven concepts, disputed performance, limited trust, volatile markets, unpredictable adoption, and technical efficiency that quadruples roughly each year. Yet a speculative surge is driving massive investment in data centers and new electricity supplies, risking a 12-figure overbuild. Avoiding an electricity bubble requires clear-eyed analysis, disciplined planning, and using markets to allocate risks fairly to potential beneficiaries.

A cautionary history: In 1999, the US coal industry claimed that information technology would need half the nation's electricity by 2020, so a strong economy required far more coal-fired power stations. Such claims were spectacularly wrong but widely believed, even by top officials. Hundreds of unneeded power plants were built, hurting investors. Despite that costly lesson, similar dynamics are now unfolding again.

In 2023–24, artificial intelligence (AI) was suddenly hailed as the vital foundation of the next economy. Big Tech giants, aided by 36 states' subsidies [proposed but not yet adopted in Colorado], are investing a trillion dollars in data centers for AI services. Forecasted electricity use soared, but actual national use hasn't. In 2023, US grid electricity fell; in 2024 it rose 2%, the fourth-fastest rate in the past decade, as data centers' share (little from AI) crept up from 4.4% to 4.5%. Electricity growth was real in a few hotspots, but was widely misreported as a national trend. Worldwide, only about 5% of 2024 electricity growth powered new data centers; 5–10% is expected to 2030.

The known unknowables about markets for AI and AI's need for power may create a new electricity bubble with hundreds of billions of dollars of overbuilding. Hundreds of new data centers, each drawing the power of a small city, have been proposed, but many will never be built, and not all built are certain to thrive.

Nonetheless, in the name of powering them, a US energy emergency was declared to speed, favor, and further subsidize rapid expansion of gas, coal, and nuclear plants already rejected in the marketplace; the emergency is apparently that they can't compete. They're also far too slow: gas turbines are sold out for 6+ years, and nuclear annual global net capacity additions now match just two days of renewable growth.

The market winners—solar, wind, and storage—are adding 93% of new US and 95% of world capacity in 2025, but are officially dismissed (along with efficient and timely use) as unreliable, even as the Pentagon's critical missions deploy them and private industry selects them for the most critical applications, including data centers. New federal rules are also stalling queued-up renewables and storage totaling more than total US generating capacity. They're ready to go, and far faster and cheaper than the favored options.

A grounded view of AI's status and prospects can help policymakers and investors avoid repeating past mistakes. The International Energy Agency expects renewables to raise world electricity supply 10–20 times more than data centers raise demand. Even lower AI-driven demand would free more renewables to displace fossil fuels sooner. However, an offsetting risk is little noticed: AI's most valuable technical uses include finding and extracting more oil and gas at lower cost. If AI boosts fossil fuel production more than it saves energy economy-wide, it could worsen emission threats. This hidden dynamic needs urgent scrutiny.

In the electricity sector, especially around emerging data hubs, AI growth poses risks including unreliable grids and load forecasts, stranded assets, weakened utility finances and credit, and cost burdens unfairly shifted onto other electricity users. State-level utility regulators can manage this by requiring developers to guarantee power payments, backed by bonds or insurance that can market-price the risk of default.

In the near term, smarter grid strategies can support data center growth without overbuilding. These include improving demand flexibility, enabling other users' efficiency gains, and co-locating new data centers with clean energy at underused gas plants. Just those "Power Couples," combining clean supply with flexible demand, can deliver fast, cheap, clean, reliable power to support AI progress on a solid foundation.

As AI evolves, the stakes for energy policy are high. Lost bets on electricity demand could waste major investments, lock in unneeded fuel infrastructure, and derail health and environmental progress. But disciplined foresight can support innovation while avoiding previous errors. Smart regulation, accurate risk pricing and allocation, and market-led investment in proven, least-cost solutions can ensure that the AI era advances not just technological progress but also resilience, economic stability, and global responsibility.

I strongly encourage Commissioners to read that 23-page essay. Let me amplify five points it documents:

1. Developers and speculators have strong incentives to propose, and request power supplies for, data centers that are often duplicative “phantom” projects. For example, Microsoft’s former VP of Energy says fewer than a fifth of data center load requests to AEP are likely to prove real. Most US data center proposals, especially for AI, appear to be of this evanescent sort, risking a bandwagon in seriously overbuilding generation and grid capacity. (That’s a broad nationwide impression. For comparison, the Company’s base forecast, Exh. 106 p 12, includes 1.9 GW or 31% of customers’ 6.2 GW of New Economic Development Load requests.) Such bubbles stranded hundreds of unneeded power plants in the early 2000s. This Commission is responsible for ensuring that such data center/AI bubbles don’t put power suppliers, their customers, or the public purse at risk again.
2. The hardware/software/system-architecture efficiency of converting electricity into AI services is roughly quadrupling each year, so an AI data center would need to quadruple its AI sales each year (assuming constant unit price, though declining price is more plausible) to sustain its AI revenues over the decades needed to repay power-supply investments. The limited, specialized technical applications that can justify AI seem much smaller than are needed to repay current AI investments. Fundamental weaknesses and uncertainties in AI’s business models and revenue prospects make its ultimate ability to repay its data center investments highly speculative. The basic causes of risk to the power supplier, just mentioned in items 1–2 and elaborated in my essay, are not removed by the Company’s attempt to assign a probability to the success of any large-load project. The Company believes its “80%-probability” projects will get built, but cannot be sure they’ll thrive for decades thereafter in the face of big AI’s rising and multiple market headwinds.
3. Lest the nonzero risks to full reimbursement of utility investments for powering proposed data centers fall instead on other customers, I recommend that such large loads be powered under full take-or-pay contracts to prevent any cost-shifting, *and backed by suitable bonding or insurance* to guard against throwaway subsidiaries structured to shield Big Tech’s assets from project failure. The default risk would then be priced not by parties to the transaction but by independent capital-market risk-management experts, and the risk would be paid for by the developer who hopes to profit from the project. The cost of such a bond or insurance policy will be small if the risk is truly as small as proponents claim. If the risk isn’t so small, then keeping it with the profits and away from other customers is conservative and prudent. Announcing that policy could deter speculative proposals.
4. Where a developer can provide such safeguards for the public interest and satisfy other public-policy requirements, grid-aware computing that optimizes operational timing (as in EPRI’s DCFlex program) to make the load slightly more flexible and optimize computational tasks’ location can change new data centers from a grid burden to a grid asset. This can usually enable far faster service to new data centers than could be achieved by adding thermal resources. Important Nicholas School (Duke University) and supporting analyses showed in early 2025 that predictable and very small load flexibility—even a small fraction of 1%—*could power essentially all forecasted US data center load growth using only utilities’ existing generators.* This approach promoted by Verrus and NVIDIA-backed Emerald AI could quickly resolve hyperscalers’ time-to-market concerns, and could render obsolete and wasteful the bespoke project-driven resource-addition strategy inherent in the Company’s Plan. Moreover, where there’s a little-used existing gas plant, the “Power Couple” layout summarized in my AI essay could enable renewables-plus-storage clusters to run a data center quickly, affordably, and reliably. Furthermore, an

overwhelming amount of further flexibility in using existing utility sets could come from stronger least-cost deployment of *non*-data center demand-side resources, reducing all customers' costs and risks. In short, the Company's add-thermal-resources strategy has already been displaced several times over. Now another powerful option has emerged:

5. The world's largest solar steel mill, sustaining upwards of a thousand jobs in Pueblo, is almost entirely powered by EVRAZ's 300-MW PV plant. Now, with bulk grid storage in 2024 averaging just $125/kWh (BNEF), *even data centers can now reliably and competitively operate on all-renewable power*, as Apple already does in four states. And *since PV plus batteries can now build roughly 4–7 times faster than a large data center, the power supply needn't be built until the data center is largely through construction.* That flipping of lead-times, making power supply much quicker rather than much slower to build than big data centers, *can eliminate the need for speculative utility asset additions* to be built in advance to enable the data center developer to commit capital and start building.

***An existence proof of competitive continuous solar data center power installable in months***

An early-2025 plant I inspected last week in Sparks, Nevada (Fig. ABL-1) illustrates the capabilities of this novel approach. By simply laying 20 $MW_{DC}$ of solar panels on the ground, equipped with Roomba-like automatic night cleaning, Redwood Energy has built and commissioned *in just four months* a modular, 12-$MW_{AC}$, *24/7/365* solar power station with 63 MWh of second-life-EV-battery storage for durations up to at least 48 hours. The battery array seamlessly integrates ˜800 EV packs varied sizes, types, chemistries, voltages, etc. Each battery can be hot-swapped for a fresher one whenever it ages out. This largest microgrid in North America is ultrareliably powering, around the clock, several MW of onsite Crusoe data centers containing roughly 2,000 GPUs (Fig. ABL-3). The microgrid's empirical all-in cost, fixed for decades to come, is *below the grid price of 8¢/kWh*. It's more reliable than the grid, so its grid link is for sale, not backup.

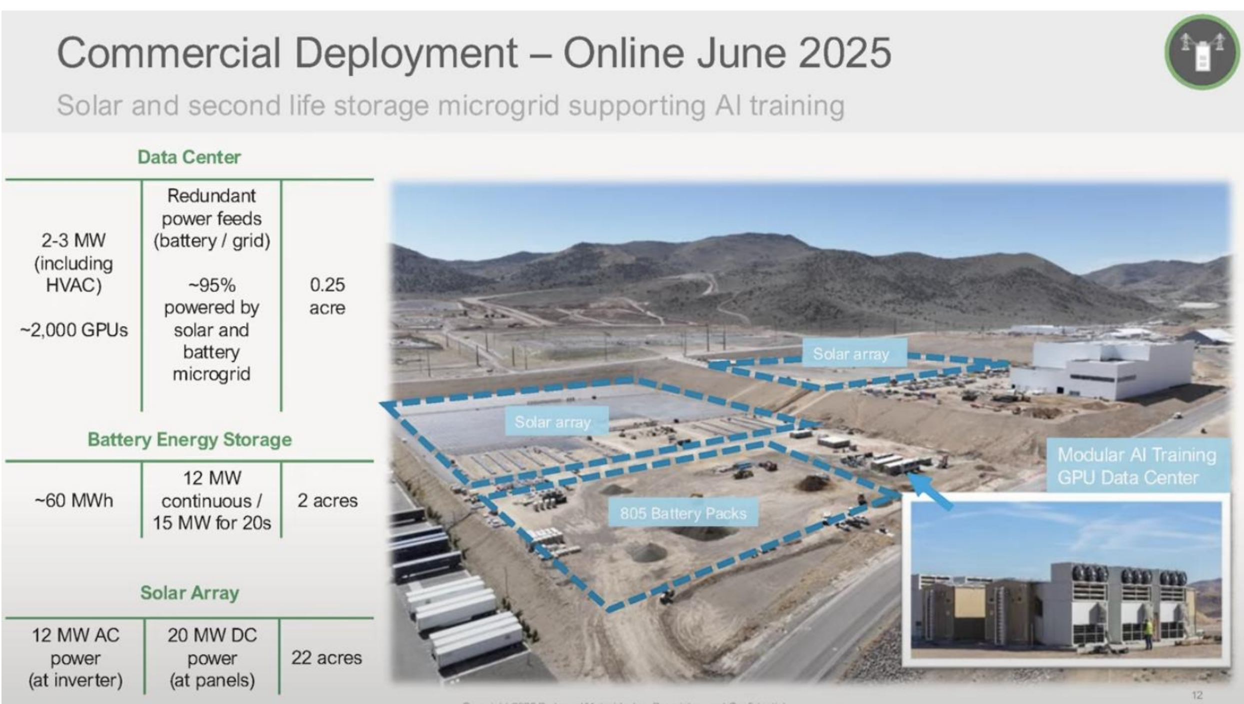

***Fig. ABL-1:*** *Redwood Energy's summary of its Sparks, Nevada 24/7/365 solar microgrid.*

Such a modular PV installation, scalable wherever there's land, is cheaper and more reliable than gas power. It's far faster even if new gas turbines were available timely. It's constant-price—unlike gas power, whose fuel-price volatility risk, last I looked, had a market value comparable to the Henry Hub gas price. It makes no noise, uses no water, needs no new critical minerals, and emits no carbon dioxide or methane. And it can be built far faster than a data center of any size: Redwood Energy is already engineering >100-$MW_{AC}$ clusters to add 20 GWh by 2028.

This ability to build many modules extremely quickly *makes large-load load forecasting nearly irrelevant*. Instead of speculating and arguing about when a large load will arrive and thrive, "Don't build it and they will come anyway" can add timely, competitive, IPP-or-utility PV+battery modules *after the data center is well under construction*. Whatever exists is possible.

Banking suitable solar sites could about eliminate the forecasting risks from data centers, because standalone, ultrareliable, 24/7/365 solar resources can now assuredly come "online on time with delivery certainty and price certainty" (Exh. 117, p 22). Redwood Energy's existence proof seems to me to supersede the traditional basic premises behind the Company's proposed resource portfolios. It also appears to invalidate the Company's assumption (Exh. 117 p 59:15–17) that a "no new gas" scenario is not realistic in Colorado. Gas plants now offer no advantage whatever.

Such modular solar microgrids would need little or no transmission buildout, depending on their degree of clustering, the scale of their loads, and their geographic location. Or if built and connected to existing transmission, line capacity could be radically increased, and losses about halved, through straightforward reconductoring with an advanced conductor (doubled- to tripled-ampacity, or more with forthcoming full dynamic loading) that eliminates the need for most new rights-of-way. I advise the maker of such an available product, and although I'm therefore not independent when discussing its product, I do think it worth the Commission's attention as a breakthrough option for quickly and cheaply enabling more inter- and intra-state power transfers.

***Grid stabilization***

Continuously and reliably matching variable renewable supply with varying demand—beyond the capability of traditional pumped hydro, compressed air, gravity, or similar bulk electrical storage—generally brings to mind electrochemical storage in large grid batteries or distributed behind-the-meter batteries. Both are valid, powerful, and profitable technical and business opportunities. However, *other* grid-balancing resources could largely or wholly replace stationary batteries, as illustrated conceptually (the real data are still being ascertained) by Fig. ABL-2. That chart's "negawatts" and "flexiwatts" blocks are about three times bigger than conventionally assumed. In hindsight, the "thermal storage" and "distributed electricity storage including EVs" blocks are considerably larger and probably cheaper than sketched in Fig. ABL-2. For example, RMI analyst Mark Dyson's hourly simulation two decades ago (graphed in Fig. ABL-3) showed that ERCOT could run on 100% renewables by combining modest negawatts (averaging a 10%/y real return as conservatively assessed by the National Academies), minor flexiwatts, ice-storage air-conditioning, and smart bidirectional EV V2G interactions, *but needing no bulk storage.* The economics would be excellent virtually anywhere at current prices, let alone future prices,.

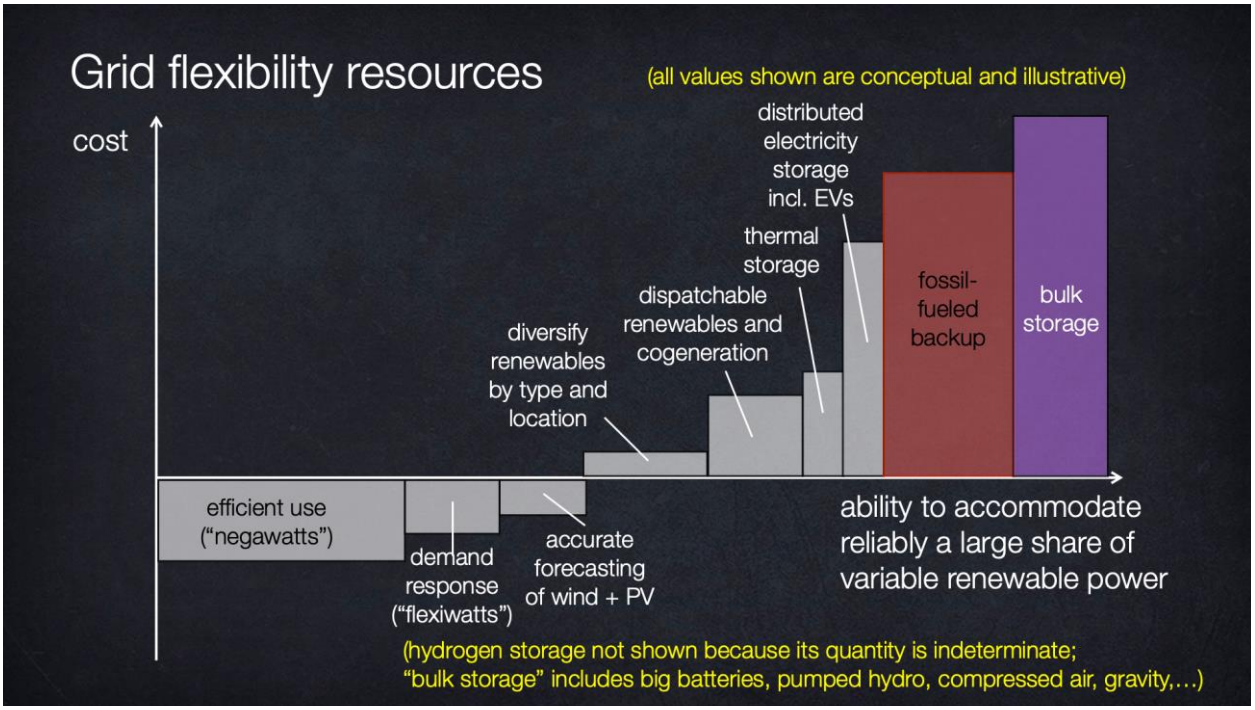


***Fig. ABL-2:*** *A qualitative notional supply curve of eight—with green molecules (yellow text), ten—carbon-free ways to keep the grid balanced as solar and wind output vary. Big batteries, part of the magenta block, are sliding left to intermediate cost, but though practical and profitable, they're not generally needed because the cheaper options further to the left are so big.*

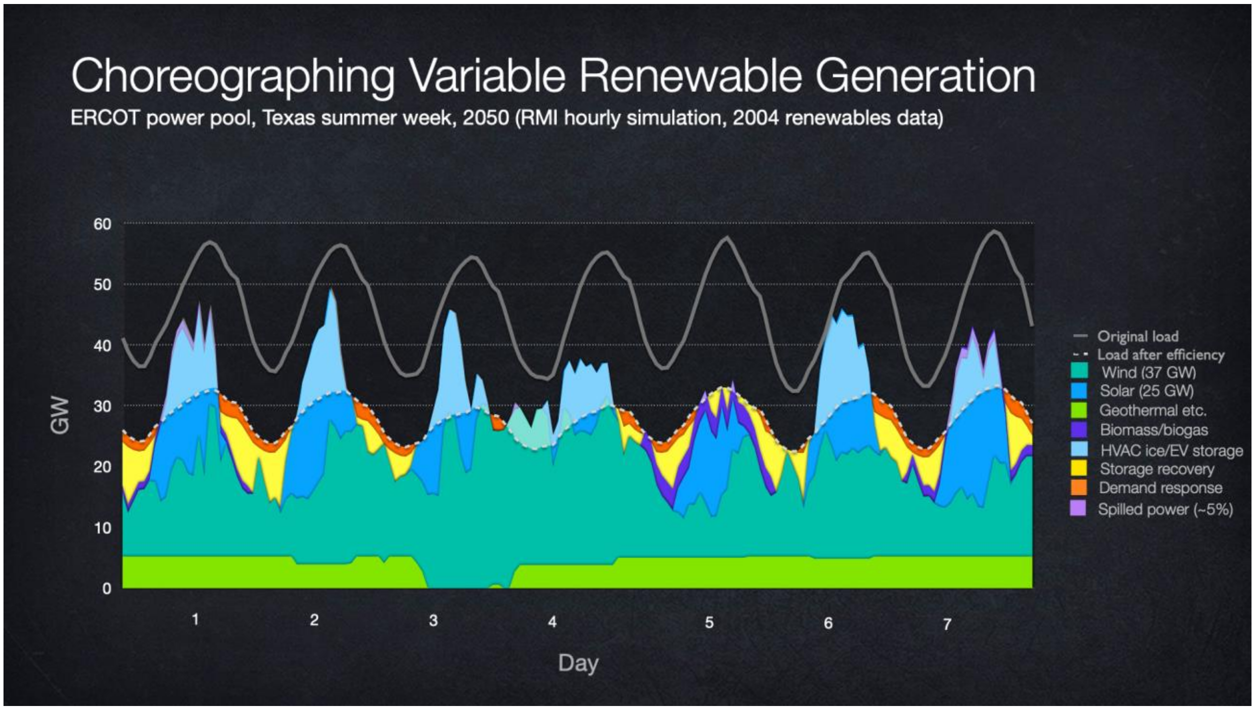


***Fig. ABL-3:*** *A typical 2050 ERCOT summer weekly loadshape, as forecast around (and scalable to recent demand levels and expectations), can be met entirely and year-round by e.g. ˜86% wind and PV, ˜14% dispatchable renewables, ice-storage air conditioning, and smart EV/grid interactions, using no bulk electrical storage. Many other balancing options are left unused.*

It's therefore not surprising that recent annual renewable fractions of electricity use include roughly 191% in Scotland, approaching 90% in Denmark, 72% in South Australia (running reliably on PVs, wind, and batteries with zero "baseload" capacity), 66% in Spain, 55% in Germany, and 46% in Portugal. Over a thousand peer-reviewed papers describe 100%-renewable power system designs, many in detail. And in case you were wondering, the official report on the 28 April 2025 Iberian blackout found that renewables weren't at fault, conventional generators failed, and batteries and grid-forming inverters could have prevented it. Stronger international links and synchronous inverters would also have helped, but the big issue was voltage rather than frequency stability, and the main causes were less technological than managerial and regulatory.

***Load forecasts and resource planning***

This Plan of Xcel Energy (used interchangeably with Public Service Company of Colorado) expects to acquire ˜12–14 GW of new supply-side resources (Exh. 101, pp 5 and 61) and an apparently far smaller amount of demand-side resources. The Company expects native peak load to rise from 7.2 GW in 2024 to 8.6 GW in 2030 (p 30, Exh. 117). (EIA says Colorado's statewide net summer capability in 2023 was 19.5 GW, of which 11.2 GW was utility-owned.) Xcel Energy's Base Case forecast abruptly raises long-stagnant electric energy growth to 7%/y through 2031 when Comanche retires; the Low Load forecast, to 2.8%/y. This dramatic shift, echoed by many US utilities' spurt to an estimated $212 billion of 2025 investment, is due mainly to projected data centers. Those projections, as I suggested, are fraught with great uncertainty and risk. The Commission should treat future electricity demand as not fate but choice, to be prudently exercised over a wide range—bearing in mind that the Company's allowed returns on capital investments incentivize forecasting high, promoting sales and load, and building rate base.

This is not the place to dig into the difference between Xcel Energy's forecasts or their updates, but a basic methodological issue jumps out: *Exhibit 101 doesn't establish that the Company has competed or compared demand-side against supply-side resources. Instead, it compares supply-side resources with each other.* That method can't yield a least-cost or least-risk strategy. It ignores the all-resources basis of integrated resource planning. Nor is Exh. 101's focus (pp 36–37) on the higher Base Case justified by its appeal to an ambiguous statement by Governor Polis, who does not and should not dictate the strategy of energy providers nor of this Commission.

Exh. 101 mentions energy efficiency once, in a single word on p 36, and implies that its energy effect is very small. In contrast, based on my half-century of experience worldwide, I think a rigorous analysis would reveal efficiency and demand-response opportunities ample to offset Xcel Energy's entire forecast growth in service demand—much of which, as I'll explain next, appears highly speculative in the sectors *other than* data centers—at lower cost than its proposed supply-side resources. That suspicion merits careful testing.

Having watched electric utilities and their customers suffer from widespread overforecasting and overbuilding for a half-century, I think the potential demand effects of new data centers, electrification of buildings and vehicles, and industrial expansion are highly uncertain. How much electricity the world will need in 2050 is uncertain to at least twofold and probably to fourfold or more. Facile, fatalistic assumptions can harm electric affordability, impacts, risks, and security.

A simple illustration of the need for caution is the 33-year history of Norway's electricity demand (Fig. ABL-4). While 28% of the 2024 car fleet was pure-electric and another 7% plug-in hybrid, 60% of the housing stock shifted by 2020 to tripled-efficiency heat pumps for space heating, and real GDP rose by 105% (1990–2023), total annual electricity use rose by a mere 24%.

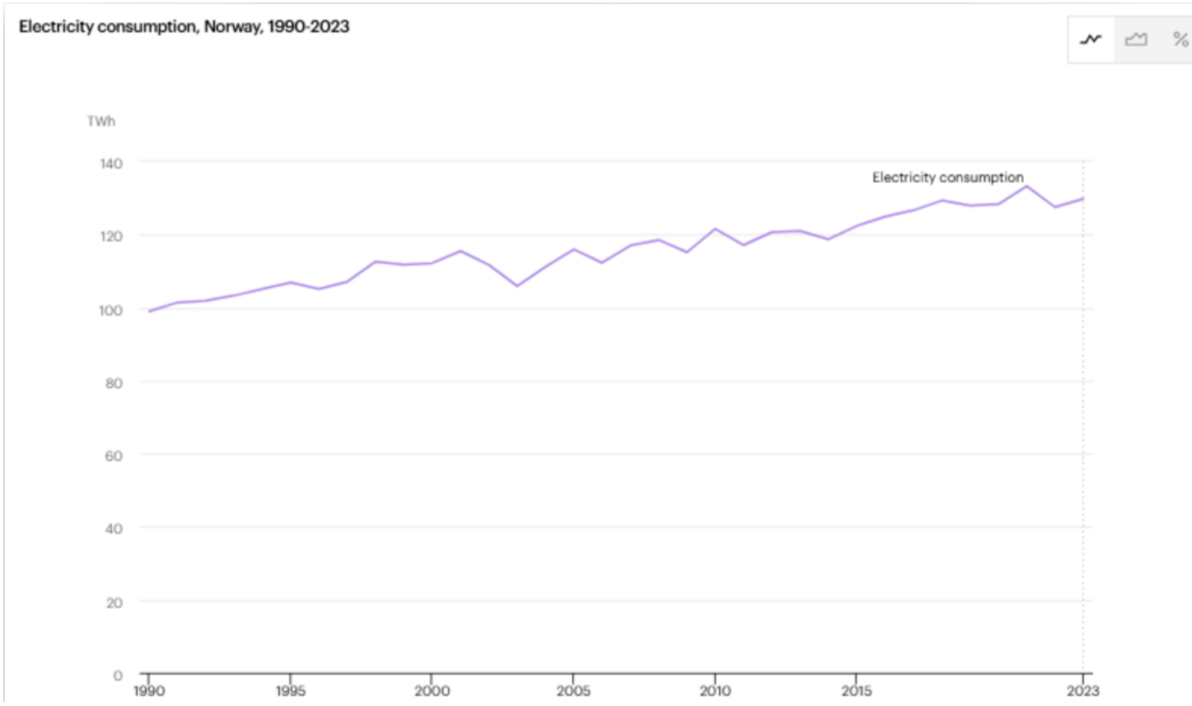

***Fig. ABL-4:*** *Norwegian electricity consumption, 1990–2023 (IEA data).*

Electrifying buildings *while making their shell and equipment far more efficient* is a common but often underestimated opportunity. For example, a Swiss fist-sized air-to-hot-water heat pump yields a COP of 6–15 (for 31–13K lift). It can therefore provide an extremely efficient worst-case space-heating backup for a net-zero or near-net-zero building envelope. My own 1983 house at 2200m/7100ft elevation, where outdoor temperatures used to drop to –44˚C/–47˚C, has no heating system; it's ˜99% passively heated, with the last 1–2% of heating active-solar. The house's central atrium has produced 83 passive-solar banana crops, and its ˜99% space-heating energy saving *reduced* total net construction cost. Saving also ˜99% of water-heating, ˜90% electricity, and ˜50% water yielded a ten-month overall payback in 1983. Nowadays the construction cost would almost certainly be below normal. Also of note, the Dutch *Energiesprong* superoutsulation technique can now cost-effectively retrofit many existing, especially masonry, buildings to net-zero performance in as little as a day—optionally without even disturbing the occupants.

Electric road vehicles can double or triple technical platform efficiency (by safely reduced mass, aerodynamic drag, rolling resistance, accessory loads, and powertrain losses) *before and in addition to* the major efficiency gains from electric powertrain. For example, my 2020 Society of Automotive Engineers paper documented automotive efficiency opportunities severalfold larger than officially recognized. Thus my popular, mass-produced carbon-fiber EV, a BMW *i3*, saves ˜300 kg of weight and quadruples overall efficiency to ˜124 mpge without compromise or higher cost. Strong competitive pressure may become overwhelming and flip the global auto industry if

China executes its reported strategy of switching flagship auto designs to ultralight carbon-fiber structures by 2030. I also showed in 2023 how autos could provide thermal comfort even in tropical climates with no air conditioner. As for heavy vehicles, Tesla's *Semi* truck is testing at 3–6 times the Class 8 diesel fleet's efficiency, about half due to non-electrification improvements (with some others left untapped for now). And aeronautical efficiency techniques are evolving so quickly that my grandsons may well be able to fly across the Pacific on all-PV-powered airliners, as surveyed in my 29 April 2025 Stanford aviation seminar available on request.

These transportation efficiency gains can offset a great deal of vehicle electrification and growth. At the same time, smart bidirectional grid connections, and business models that monetize most of the ˜21 services that parked vehicles can provide to the grid, can create major economic value. This can transform road vehicles' business models by adding immense dispatchable storage, plus ancillary services like frequency and voltage stabilization and fast grid regulation. These new assets, needing almost no utility investment, will become formidable competitors to grid batteries. They will grow very quickly to dwarf conventionally assumed grid-dedicated storage projects by an order of magnitude. The Company's expected 823,000 in-territory EVs in 2031 (Exh. 106 p 13) could plausibly correspond, at a nominal 50–100 kWh pack size, to ˜41–82 GWh of pack capacity parked ˜95% of the time, mostly at or near load centers. For comparison, Exh. 122 p 7's revised new-large-loads forecast for 2031 is 0.9 GW. P 13 shows an updated 2031 native peak forecast of 8.6 GW, which the parked cars could sustain for ˜4.5–9 hours a day. The 5 million EVs now on US roads have ˜350 GWh of battery capacity, rising by ˜150 GWh each year.

Second-life batteries, another vast and fast-growing resource, can provide profitable grid or microgrid storage for typically ˜3–5 years after they retire from autos, then yield pure feedstocks to displace the critical-minerals needs of battery manufacturing. Redwood Materials, which has ˜90% of the US lithium-ion battery-recycling market, announced on 27 June 2025 that it expects US battery-related recycling to support ˜142 GWh/y of battery manufacturing in 2030, 270 in 2035, 505 in 2040, 808 in 2056, and 1,011 in 2050. That's half or more of what grid-scale storage is widely projected to need. Colorado should get its share of this second-life-battery bonanza, and its EV leadership may justify building Redwood-style recycling facilities in-state.

I cannot opine specifically on the efficiency potential of the "Strategic Economic Development" new loads included in the Company's updated Base Load Forecast (Exh. 117, p 33) because their nature is Highly Confidential. However, my experience suggests that building those facilities right the first time could greatly reduce their electricity needs. RMI's latest $60+ billion worth of industrial redesigns in 20+ sectors, new and retrofit, typically found ˜30–60% energy savings in retrofits with paybacks generally around 2–3 years, and in newbuild projects, ˜40–90+% savings with nearly always *reduced* capital cost (Fig. ABL-5, on the next page).

Such large practical savings are consistent with decades of uniquely deep analysis I led at RMI, summarized in a joint *Scientific American* article with EPRI ("Efficient Use of Electricity," Sep. 1990, pp 64–74). For example, as that article summarized, and as my team detailed in the encyclopedic *The State of the Art: Drivepower* (RMI/COMPETITEK, 1989), motors use half the world's electricity—even more in industry—but 35 retrofittable improvements to drivesystems, between the retail meter and the input shaft of the driven machine, could save around half the drivesystem energy with a 16-month payback at a 5¢/kWh rate. (Some of those savings have since been achieved, but the potential has meanwhile expanded, potentially by a comparable amount.)

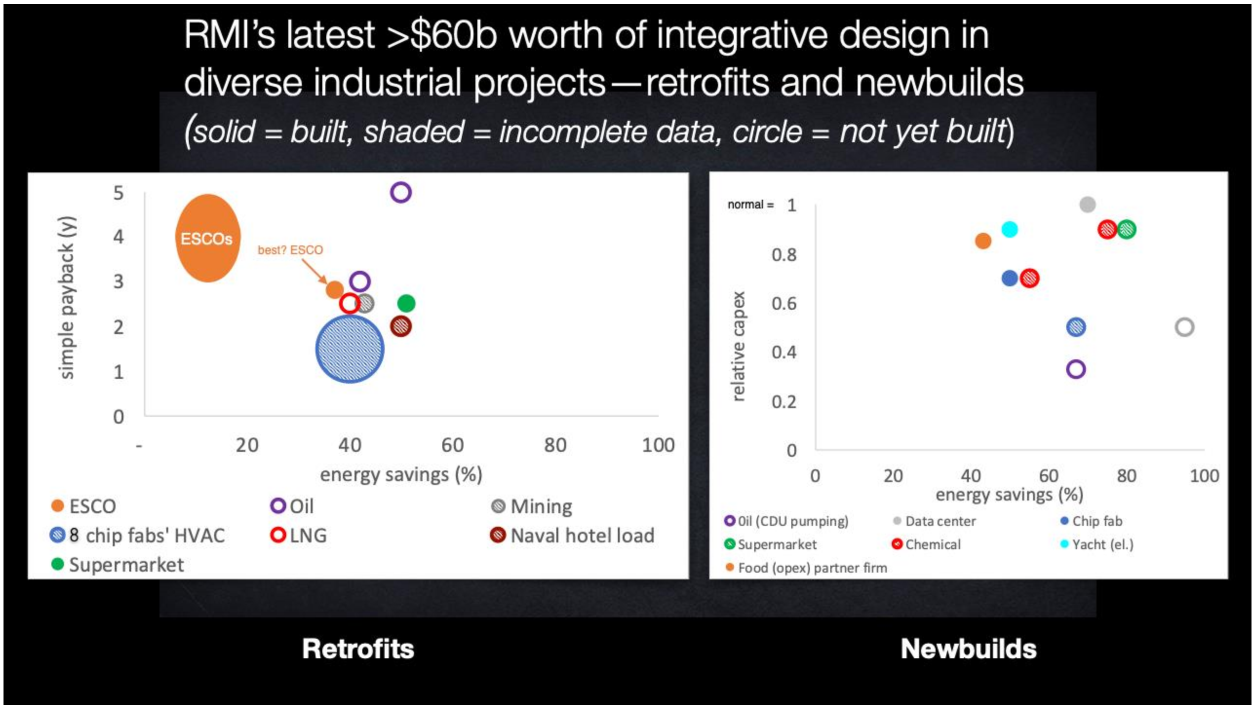


***Fig. ABL-5:*** *Very large empirical industrial energy savings (RMI data except for ESCOs). Similarly, the "best ESCO" firm, Ireland-based* Crowley Carbon *(not graphed here), now typically achieves newbuild savings around 50–60% across similarly diverse industrial sectors.*

That example doesn't count often-larger *downstream* savings. For example, half the world's motor torque runs pumps and fans. Making their pipes and ducts fat, short, and straight rather than skinny, long, and crooked typically saves ˜80–90+% of friction, hence of pump and fan energy (97% in my house), while reducing whole-system capital cost. If everyone did this, it could save a fifth of the world's electricity—or a third if the 35 drivesystem improvements (7 bought, 28 as free byproducts) are also included while the motors are being downsized by ˜5–10-fold. This isn't yet in any official forecast or model, because it's not a technology; it's a *design* method.

These opportunities illustrate the powerful "integrative design" approach to advanced energy efficiency that I teach at Stanford, summarized in the 2 June 2025 seminar cited on p 2 above. Such dramatic savings are most readily achieved with new loads, and should be favored by authentic least-cost integrated resource planning. Yet the Company's efficiency efforts do not appear to envisage, analyze, foster, or reward them, preferring the conventional and incremental measure-by-measure approach of "dis-integrated design." I therefore place little credence in the Company's projections of new or old demand. In my opinion, inferring comparably large but underscoped efficiency opportunities in industry, transport, and buildings, achievable least-cost levels of native electric energy and peak demand—forecasted to rise by 25 TWh/y and 3 GW in 2023–31 (Exh. 106)—need to be rethought from scratch. Fortunately, as we've seen, this Proceeding needn't wait for nor depend on such demand-side reanalysis, because meanwhile, supply-side revolutions have probably made accurate load forecasting unnecessary (pp 5–6 above).

***Nuclear power***

Nuclear power has no business case or operational need in any civilian application I know of, as I've summarized and elaborated elsewhere. Large reactors like the AP1000 are hopelessly uncompetitive; so-called Small Modular Reactors, if built, would be even worse. I invite the Commission's attention to short basic references on SMRs' economics (also here and here), safety, waste, proliferation risks (also here, here, and here), and lack of enough facial credibility to warrant serious assessment.

As of April 2025, solar power outproduces nuclear power worldwide; windpower's output is even larger; and efficiency is bigger than both. US cumulative energy savings from the 65% lower primary energy intensity achieved in 1975–2024 are 27 times the total increase in US renewable energy supply of all kinds. Nuclear power is and will remain a minor distraction, not worth the Commission's or Company's attention. It's a future technology whose time has passed.

SMRs fall at the first hurdle—economics—due to simple arithmetic. Their output would initially cost about twice as much per kWh as a big reactor's (Exh. 1701, p 61:1–18), or more; a big new reactor's output is about 3–8 (Lazard) or 5–13 (Bloomberg New Energy Finance) times costlier than that of PVs or windpower; and by the time enough SMRs could be built and run to decide whether to build a factory to seek their claimed scaling economies from mass production, renewables are set to get another twofold cheaper. The product of those three terms—in round numbers, 2 times 3–13 times 2—is about 12–52. That's far more than mass production could deliver.

Some might object that these LCOE comparisons don't count system firming costs. However, I think the evidence (e.g. from Germany and Texas) shows that achieving equivalently firm power raises backup costs more for thermal plants than for variable renewable portfolios, because the thermal plants' forced outages tend to be bigger, longer, sharper, and far less predictable. The 8,766 h/y Redwood Energy solar plant described above is also a convincing rebuttal: any new plant with a steam cycle, even without equivalent firming, would be hard pressed to compete with <8¢/kWh busbar cost, and the solar power is delivered right to the onsite data center, not from far away via the grid, avoiding typically several more ¢/kWh of grid costs and losses.

I concur with Mr. Schlissel's judicious, current, and cogent nuclear assessment (Exh. 1701), but would emphasize two points:

- Multiple clustered SMRs are less safe than their individual units, because an accident in one could make it impossible for operators to observe, protect, run, fix, or maintain the others (as happened at Fukushima).
- Any new resource that costs more than the cheapest marginal resource—which is typically efficient use or modern renewables or their synergistic combination, optionally with storage as needed—*will displace less fossil fuel per dollar, thereby making climate change worse*. The same is true of *slower*-to-deploy resources. Nuclear power is both costlier *and* slower than renewables (or efficiency), so it's doubly harmful to climate protection. This "climate opportunity cost" should be explicit in analysis and policymaking.

### *Hydrogen*

Having written in 2003 what was for many years the industry-standard white paper on hydrogen, I retain an interest in its subsequent evolution. While hydrogen has some attractive features and could be useful in some process-heat applications, it is vulnerable to competition from combinations of solar heat, thermal storage, better processes, and more-efficient end-uses (such as smarter structural design, which could save about half the world's steel and cement). As noted on p 4, while longhaul aviation using liquid-hydrogen cryoplanes could work well (subject to fueling infrastructure), emergent superefficient aircraft now look more likely to go all-electric.

Mr. Schlissel (Exh. 1701, p 110:13–15) rightly said it's illogical to turn SMR electricity into green hydrogen: better to use the electricity directly. Though more-efficient lab-scale photolysis and electrophotolysis have lately been demonstrated, electrolyzing water and then using the hydrogen is inherently inefficient (132:17–19). Combining the costliest electricity with the costliest energy carrier is unwise. Where electrolytic hydrogen is justified, wind or solar should power it.

It's often possible to retrofit metal pipes for hydrogen safety by adding internal liners resistant to hydrogen diffusion, such as metal-film-coated composites (hinted at for retrofit in Exh. 1701, p 128:23, as for new pipes at p 128:17). However, that detail of a potential partial solution to the challenges of transmitting hydrogen in old metal pipes designed for fossil methane doesn't in any way change Mr. Schlissel's (pp 125–128) or my conclusions about the unpromising economics of hydrogen, especially when delivered by pipe (or tank truck) rather than made onsite.

### *A toolkit for designing just transitions*

The vital just-transition dimension of this Proceeding reminds me of useful history. RMI's first major project, starting in 1983, was the Pioneer Project in nearby Carbondale, Colorado—the prototype for the Economic Renewal Project. Its analytic and organizing processes and tools allowed citizens of what are now called "just transition communities" to design and achieve a bottom-up sustainable local economy, particularly in distressed extractive- or declining-industry communities in the Intermountain West. This highly effective effort was the foundation for Carbondale's transition from a dying coal-mining town to what is now the most vibrant and cohesive community in the Roaring Fork Valley. RMI then spread this effort effectively to more than 20 communities in seven countries. Some written materials are online, and a summary was published in 1997. The workbooks and casebooks could be usefully updated. In my opinion, some version of the Economic Renewal process could be valuable in Pueblo today. Its leader for two decades, ten-year Pitkin County Commissioner Michael Kinsley, has retired from RMI but remains active and is my neighbor in Old Snowmass. A Colorado effort to reassemble and update these valuable tools from the 1980s and 1990s could, I believe, yield strong dividends in Pueblo and similar just transition communities.

### *Conclusion*

Xcel Energy's case for new thermal resources, mainly to power proposed data centers and other large users being wooed by rate discounts, is outdated and unconvincing. It doesn't even seem to reflect the basic principle of competing or comparing all practical demand- and supply-side resources, then comparing portfolios of the best buys for least system cost, lowest emissions, greatest reliability and resilience, and other goals—in this case, especially the broad benefit to just transition communities.

Not having engaged with the Company or Commission for many years, I was frankly dismayed to see the quality of this Plan and its apparent underlying information. Neither is atypical of the industry, but neither meets the moment or reflects the modernity and sophistication that Coloradans deserve and expect. I'm sad to see this, and would like to help get it improved.

Some of the content of this Comment may astonish the Commission, Staff, and Company. In my longstanding spirit of respectful collaboration, I'd like to ensure that any questions can be adequately addressed and thoughts exchanged to improve mutual understanding and support better decisions. I would therefore be honored to offer the Commission and Company *pro bono* an informal but substantial informational technical discussion, in person or virtually. If logistics permit, meeting at some of the world's most efficient and delightful buildings, in Old Snowmass and/or Basalt, could better focus engineering understanding of the value of integrative design. If this suggestion is of interest, please contact me at ablovins@stanford.edu.

Thank you for your kind consideration. I hope this Comment stimulates and supports your deliberations. With respectful best wishes—

Amory B. Lovins, Adjunct Professor (2020–24), Lecturer (2025– )
Department of Civil and Environmental Engineering, Stanford University
Precourt Scholar, Precourt Institute for Energy, Stanford University
Cofounder and Chairman Emeritus, RMI (founded in 1982 as Rocky Mountain Institute)
1739 Snowmass Creek Rd, [Old] Snowmass CO 81654
970 948 2280

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***Appendix A: Qualifications—details***

Originally an experimental physicist, I have built a half-century of expertise in energy efficiency, renewable energy, grid integration, and energy's links to security, economy, environment, and development. I'm an all-renewable, auto-islandable customer and Holy Cross member (served wholesale by Xcel Energy), and a third-generation Coloradan with a 35-year gap. Since 1982 I've lived in Old Snowmass on the Western Slope, where I'm a passive-solar banana farmer in my home and office. It's one of the world's most efficient buildings—a noted owner-builder project for which I did the conceptual and energy design—and it incubated RMI during 1982–2000. It also influenced the design of RMI's nearby Basalt Innovation Center, which uses about one-ninth the normal amount of energy, with excellent comfort, esthetics, and economics.

In 1982 I cofounded Rocky Mountain Institute (now RMI)—an independent nonprofit organization that is transforming the energy system to secure a clean, prosperous future for all. I became RMI's CEO 2002–07 and Chief Scientist 2007–19, and remain its Chairman Emeritus, a 43-year Trustee, and an independent contractor. RMI's more

than 650 staff work in 62 countries to speed the energy transition. RMI, like me, is scrupulously apolitical, nonpartisan, and transideological.
A Harvard and Oxford dropout, I became an Oxford don and have taught at ten other universities. In 2020 I became half-time Adjunct Professor of Civil and Environmental Engineering at Stanford (retitled Lecturer when I joined Stanford's faculty in 2025). My course "Integrative Design for Radical Energy Efficiency" posts lectures and materials at efficiencyhub.stanford.edu.

As a hands-on practitioner, I have led the superefficient redesign of more than $60 billion worth of industrial facilities in 20+ sectors, scores of buildings, and various land and sea vehicles. My "integrative design" techniques often make very large energy savings cheaper than small ones.
I have briefed more than 30 heads of state, and for a half-century have advised major firms and governments in over 70 countries on advanced energy efficiency and strategy.

I have authored 32 books and more than 900 papers, spanning many disciplines but chiefly on energy. My 1999 business book *Natural Capitalism* (1999) with Paul Hawken remains a business-school best-seller. *Small Is Profitable: The Hidden Economic Benefits of Making Electrical Resources the Right Size* was an *Economist* 2002 Book of the Year. My Pentagon-cosponsored 2004 synthesis *Winning the Oil Endgame* roadmapped how to eliminate U.S. oil use by 2040 and revitalize the economy, led by business for profit. My 2011 *Reinventing Fire* synthesis expanded that agenda to include coal and save $5 trillion, and so far is on track in the marketplace. (These four flagship books had respectively 2, 6, 4, and 60 coauthors.)

This energy work was recognized by the Blue Planet, Volvo, Zayed, Onassis, Nissan, Shingo, and Mitchell Prizes, MacArthur and Ashoka Fellowships, twelve honorary doctorates, the Heinz, Lindbergh, Right Livelihood, National Design, and World Technology Awards, and Germany's Officer's Cross of the Order of Merit—its highest civilian honor for public service. I am an honorary US architect and a Swedish engineering academician, and was a 2011–18 member of the National Petroleum Council. In 2009, *Time* named me one of the world's 100 most influential people, and *Foreign Policy*, one of the 100 top global thinkers. Stanford University's 2023 Scopus-citation-based analysis listed me among the top 2% of world scientists. Bloomberg New Energy Finance founder Michael Liebreich calls me "the Einstein of energy efficiency."

My work has particularly focused on making the electricity system efficient, diverse, distributed, renewable, and resilient. Building on my 1976 *Foreign Affairs* article's end-use/least-cost reframing of the energy problem, since 1980 I've laid most of the conceptual, analytic, and often technical foundations of modern least-cost electricity strategy and efficiency. I led and wrote RMI's 1986–92 COMPETITEK *State of the Art* volumes (six volumes, 2,509 pages, 5,135 notes)—then and still the most detailed synthesis of electric end-use efficiency potential. These were later condensed, improved, and updated by the spinoff firm E SOURCE, which serves more than 350 North American utilities. I co-founded and -led PG&E's pioneering Advanced Customer Technology Test for Maximum Energy Efficiency ($ACT^2$), which confirmed my hypothesis that integrative design could make big savings cheaper than small savings. These and many other elements of RMI's work underlie today's multibillion-dollar negawatt industry. The highly controversial shift to distributed, modular, and renewable generation that I foresaw in 1976 now provides about 95% of global and 93% of US capacity additions.

My clients have included the US Congress, 13 state and five foreign governments, dozens of major firms, major real-estate developers, and more than 100 electric and gas utilities. I taught at Camp NARUC for about a decade, and have addressed such groups as the National Academies, Association of Energy Engineers, seven DOE National Laboratories, UK Royal Academy of Engineering, National Science Foundation, Council of Scientific Society Presidents, ASHRAE, Institution of Electrical Engineers, Edison Electric Institute, Electric Power Research Institute and its Japan counterpart CRIEPI, NARUC (keynoting two Annual Meetings), American Gas Association, American Petroleum Institute, American Association of Petroleum Geologists, Urban Land Institute, Industrial Development Research Council, CoreNet, American Institute of Architects, American Physical Society, Highlands Forum, World Energy Conference, Goldman Sachs, Merrill Lynch, JPMorgan, Morgan Stanley, Swiss Re, Allen & Co., Bloomberg New Energy Finance, News Corporation, Council on Competitiveness, CSIS, Hoover and Brookings Institutions, Council on Foreign Relations, Conference Board, Keidanren, World Economic Forum, World Bank, International Monetary Fund, Royal Society, and Royal Society of Arts.

The terms, concepts, and practices I invented, developed, and spread since 1980 include: negawatts, buying them whenever they're cheaper than megawatts, providing the right amount and quantity of energy to do each end-use task at least cost, having utilities finance efficient end-use and be rewarded for best buys first (as by "decoupling and shared savings" reforms), recovering abandoned-plant costs by savings costing less than short-run marginal generation, competitive all-resource auctions, integrative design, the equity value of efficiency, the invalidity of rebound concerns, 20-odd ways to make markets in saved electricity, competing efficiency against not just generation but also grid assets, integrating variable renewables without much or any need for bulk storage, halving PVs' balance-of-system cost (underlying DOE's SunShot initiative) and then repeating that twice more, revealing the advantages of regional/local rather than remote generation and the vulnerability of big grids (and how to make them resilient by netted islandable microgrids and distributed generation), least-cost climate protection, the >200 hidden benefits of distributed resources, the utility "death spiral," the fatal flaws of California's restructuring (both before and after the fact), distributed and renewable power's mission value for the US Department of Defense, the falsity of claims about electricity use by the Internet (1999) and probably AI (2025), nuclear power's dismal economics and prospects, why its opportunity cost makes climate change worse, why natural gas's price volatility makes fracked gas far costlier than it looks, lessons from impressive Asian and European renewable energy revolutions, grid/vehicle integration, business-model integrations, and bidirectional value tariffs. Such thought and practice leadership is implicated in most of electricity's important trends and innovations since 1976—well-known to old-timers but in the misty past for two later generations of regulators and operators.

I also have a deep background and history in energy/security issues. I wrote the definitive unclassified book on the vulnerability and resilient design of energy critical infrastructure (the Pentagon-cosponsored *Brittle Power: Energy Strategy for National Security*), served on two Defense Science Board task forces and the Department of Energy's senior advisory board, and in 2011–17 was Professor of Practice at the Naval Postgraduate School. A 62-year student of nuclear issues, I have written several books on proliferation and other issues related to nuclear power, and many papers in such places as *Foreign Affairs*, *Foreign Policy*, *Nature*, *Science*, *Annual Review* *of Energy,* and *Bulletin of the Atomic Scientists*. I look forward to this opportunity to learn from the Commission, Staff, and Company.