WilderShares, LLC

## Q1 WilderHill® Quarterly Report: ECO, NEX, H2X, WNX Indexes, March 31, 2025

The Clean Energy Index® (ECO) began Q1 at 43.23, and ended Q1 at 33.10, down -23%; its low so far this year was also March 31st at 33. Despite hopes that inflation might slow, Fed pivot, it has persisted and hit this interest-rate-sensitive theme hard. When rate cuts didn't arrive, clean energy so the ECO Index® touched last year's low in the Fall. Then late last year ECO briefly gained some with -- or perhaps bit due to(?) the president's re-election to a 2nd term; we'd seen that in their 1st term from 2017 to 2020, this ECO theme moved dramatically. Or looking back last few years, ECO gained +58% in 2019. Remarkably it rose +203% in 2020, about the best performance of any Fund, anywhere. Unsurprisingly perhaps, after such gains, it fell by -30% in 2021, -46% in 2022, -22% in 2023, -30% in 2024. Thus big declines followed big gains. Seen broadly persisting inflation, perhaps too trade war, even recession -- also threaten to undo a soft landing, overshadow decarbonization that might favor renewables ahead.

ECO's passive theme is risky & can fall hard. From up in 270's in 2021, to down in the 30's in 2025, clean energy's story and hence ECO plummeted well over ~4/5ths. ECO Index®, Global NEX, Hydrogen H2X, Wind WNX can & do at times 'drop like a rock'. Jumps true, crashes too. Our mission is to capture & track this volatile story so crashes are expected. Strong moves down, or up pervade not only in wind & solar, but across clean energy; it's always been so.

Despite big falls, clean energy is not alone, and long-term is doing 'better' than natural gas, a key competitor for generating electric power. For the past 10 years a tracker for the NEX, the 1st Global clean energy theme and live since 2006, was down some -18%. And well-known original ECO capturing clean energy in US listings since 2004, was down -44%. For comparison, an independent Index for a natural gas theme (is not ours, given that we focus instead only on clean themes) -- fell mightily: it was down a very big -90% past 10 years!

As clean energy and so passive ECO fell into 30s, valuations discounted, some asked if this theme might possibly be troughing ahead? *Impossible to say!* And any inflection(?) would only be after a long downturn. Plus, so much in equity markets can be, & is counterintuitive. Clean energy very surprisingly rose hard this president's 1st term; their 2nd term will no doubt differ. Clearly too this 2nd term began much differently, falling very hard this time to start 2025. Or just perhaps 'all of the above' energy strategies may become a rising tide lifting all boats, renewables too, for energy abundance. Solar conceivably, is helped as the cheapest energy -- rather than on any climate or clean aspects. Or not, & recent declines carry on! That said, we emphasize *past performance is no indication of future results.* And inflation, chaos, trade wars may be impactful ahead -- volatility possibly heading other direction.

In sum ECO & NEX, H2X, WNX capture facets of clean energy. As energy that once was mainly fossil fuels, taken from deep down underground and burned -- increasingly is from sunlight & breezes, freely given from up above towards heavens. Here's ECO to late in quarter:


*Source: NYSE.com*

Let's look briefly 1st at what components were *the Most Down / and most up, in* early 2025 -- this year to last day of Q1 (March 31). At 4 volatile Indexes: US-listed pure plays in ECO; in *global* clean energy thus mainly components on exchanges outside of US in NEX; and 2 global themes, hydrogen economy H2X, and wind energy/grid WNX. Thus 1st up is ECO. Jan 1st to end Q1, three Components in ECO most *down* were in *carbon to sustainable fuels (-84%); *energy storage (-69%); and *battery storage (-68%). As to two in ECO most *up,* one was in *EVs and it is China-based (+67%); and one is in *US rare earth mining (+66%). An independent ECO tracker was down about -24% year to date (YTD) so declining most of these 4 WilderHill themes.

At global new energy NEX, 3 components most down YTD to last day Q1 2025, were in *solar as service (-90%); *battery materials and management (-75%); fuel cells & green electrolyzers, in UK (-68%). Most up, was in *hydro, wind, solar farms being bought out (+69%); *EVs, China-based, and name also in ECO (+67%); and carbon capture (+47%). Year to date, an NEX tracker was down noticeably less than ECO, yet was still significantly off by -10%. At global hydrogen H2X, the most down to last day Q1 included in *composite cylinders to store hydrogen ($H_2$) based in UK (-55%); *maker of *fuel cells (-37%); and *fuel cells used in buses, EVs (-32%). Up the most included for *fuel cells/$H_2$ in heavy-duty vehicles based in China (+37%); and *energy systems, engineering based in Europe (+31%). Year to date to the last day Q1 2025, this H2X tracker was also down less than ECO and was rather nearer the NEX at off -11%.

At global WNX for wind & grid, components most down YTD to last day Q1 2025 included in *Silicon carbide SiC chips (-61%); *power cables and distribution based in Japan (-26%); and *wind farms, hydro, solar, based in Iberia (-23%). Most up included a *large wind turbine maker based in Europe (+26%); and *renewable energy producer, Spain based. Year to date to last day of Q1 2025, WNX tracker was down the least of these 4 at -4%; hence WNX did 'best' YTD followed by H2X, NEX; as ECO trailed. In the US a re-elected president started their 2nd term vocally opposed to wind power. Yet globally, wind installations are growing: eg, 2023's record wind was up by +50% over 2022. Cumulative global wind capacity hit 1,021 GW, a bit like say ~1,000 nuclear reactors (though wind is intermittent). Yet on climate & $CO_2$ budgets, for the world to stay under <2.7 degrees F/ 1.5 C of heating, it was far from enough. Still, this narrow wind basket Not having had in Q1 2025 deeper-falling themes, like solar, EVs, $H_2$, fuel cells -- maybe helped WNX to stay nearer to nil, a relative 'winner' of these 4 all down here.

A curious fact seen 2021-2024 was that even as global clean energy installations grew, fast -- its equities, sank. Yet we've seen too that with once-costliest clean energy growing swiftly, it's now the *Very Cheapest, thus lowest-priced vs. traditional coal, natural gas, or nuclear -- *and though Intermittent, with storage it will become bit more firm ahead. In 2010, levelized cost of energy (LCOE) for onshore wind was a pricey $0.11/kWh, or a big 23% higher than coal/ gas @ $0.09. Yet by 2024 onshore wind cost was 67% better/ lower then at just $0.03 -- vs. fossils @$0.10. Utility-scale solar fell more in costs from a nosebleed $0.46 in 2010, or a 400% costlier than traditional gas/coal -- to $0.04 in 2024, 56% *less* than fossils. Battery storage costs are falling too; storage will be key ahead for a needed, firmer solar/wind.

As noted with ECO down in 30s, some have asked whether such low valuations may possibly mean some troughing ahead, given deep-discounted levels? *It's impossible to say!* And a sheer coincidental steadiness of declines seen in 2021-2023, has ended for that period, at least(?). A 2025 high for Q1 did come early-on, with 49.04 intraday (47.29 close) seen on January 7th -- nadir was late Q1 on last day March 31 at 32.18 intraday (33.10 close), so a steady fall maybe resumed(?). What's ahead for this story shall be interesting indeed. As all clean energy, so equities here (no surprise!) go on moving as always, in surprising, unpredictable ways.

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An unpredictability may be seen in ways applied clean energy is growing. Some places, that do Not shout at all about any heavy 'climate focus' per se, like North Dakota, Idaho, Texas -- are growing their renewables quickly & making electricity now at the *cheapest US rates!* They're also 'move fast, build things' places with big increasing power by wind, hydro, solar. Meanwhile, places one may have expected to be #1 for renewables capacity, like California, Hawaii, or United Kingdom often have *the Costliest* electricity, lag in renewables growth too. We'll address the reasons ahead. These can include over-reliance on priciest imported natural gas /LNG, even on oil for firm baseload, which in turn sets volatile, high rates there.

While renewables can make the lowest-cost power, wholesale electricity at attractive rates, that hasn't directly translated to greater $ profitability, or better margins. Plus, clean energy equities in Q1 2025, saw tough moments, including in solar. For instance as a big US solar name plummeted March 3rd, its headlines were " … Sinks As Company Warns It Might Go Out of Business", " … Plummets 60% Amid Solar Industry Challenges". It was Not a US maker of solar modules (as discussed ahead -- the US, Germany, Japan had once led, but past 2 decades manufacturing went to China); rather it was in 'energy as service' with low-cost China panels. If this US residential solar name that plummeted -65% that day was bit of bellwether for troubles in the rooftop solar flock, one could look briefly at what confronted it in 2025.

One factor that stood out was it had just *Issued a 'Going Concern' Letter. If a company may not have capital to survive a coming year, it must issue such Letter: obviously a huge red flag! While uncertain early 2025 *how* cuts may soon unfold to 2022 Inflation Reduction Act, this IRA was likely to be 'decimated' by new president/congress. ('Decimated' perhaps too weak: this referred in ancient Roman times to horrible deaths of 1 of every 10 soldiers; in early 2025 likely rollbacks to IRA contemplated were larger than a 10% figure). This firm paid dealers less-frequently; so on loss of confidence, concern over how it will obtain funds, manage capital flows, grow solar rooftops, it fell dramatically on March 3rd. Or, later, on March 28th a US maker of silicon carbide (SiC) chips important in renewables, and EVs, plummeted -52%. On losses, and comment an expected $750 million in grants & $1 billion in tax credits under a recent CHIPS act signed by last president & considered a major victory for US chipmaking -- might not be forthcoming under a new president and congress that took office 2025.

Of interest in a fast-moving energy-scene 2025, was politics (a topic we mainly seek to avoid). Seemed almost like the 1st concern of either *Costs/Reliability of energy -- or *Climate Risk -- was rifting into opposed camps. Those concerned 1st over energy's high costs, & reliability -- maybe, were perhaps less-concerned over climate risks; even though solar/wind is now the cheapest energy unlike at start of decade. Or, those more concerned over climate/and $CO_2$ -- maybe were less worried over costs of transition. Though decarbonizing requires big spends near-term (yet decarbonizing fast reduces energy costs); means buying goods from coal-intensive China; plus how to ensure critical, firm, reliable power given intermittency of renewables (though this could be better addressed with greater energy storage and grid).

Arguably both camps contain some truths yet were more polarized than ever, more than at decade's start. Consider importantly then: the very 2 cheapest-electricity-US states both rely heavily on renewables. Note too that America's own renewables-giant, Texas, boasts the most renewables in US by far + it also has cheap electricity: not in spite of, nor, with -- but *because of* its massive wind & solar often dominating its grid. Renewables can/do equal = lower costs. We know too the 2024 election will be impactful. Given clean energy has many facets, let's glance at 3 big themes in a chart next, from just before, to after November's red wave.

As seen here, below, all 3 major clean energy themes have fallen, hard. After Nov. 5th 2024 election and a red wave, all 3 ended far down in this Chart, roughly down -20% to down -30%. This shows from 2 months before election (from Sept 1st) -- to a few Quarters afterwards that 1) *Clean energy's pure plays on US exchanges **ECO tracker (blue)** from a Sept. 2024 low saw a brief post-election dip, a Jan. peak; and after it fell hard: it ends this period at down some -20%. Two other major clean themes both fell out of the gate, here from right after election as seen in 2) *Global clean energy thus exchanges mainly outside US in NEX tracker (light blue) at -25%; and 3) an excellent (not ours) **Solar-only** global theme fallen too from election (in red), -29%. Lastly we show a global *just-'cleanish' theme ('not so clean' as has fossil fuels & nuclear -- so Not one of our's) with many large caps **in purple, also off -23%:**

**Sept. 2024 to end of March/ end Q1 2025, 3 major clean energy themes; plus 4th theme**:


*Source: YahooFinance*

As above shows, differing facets of clean energy (not-so-clean alternatives too) all fell hard, from late 2024 to end Q1 2025. Despite the fact that 2024 the world added record 700 GW of new renewables, 25% above a prior year, & 22nd year of expansion, this theme still fell hard. Was bit curious to see too, that over 2021-2024 as renewables capacities were fast growing -- equities here fell; then, on re-electing pro-fossil fuel president who opposes clean energy -- equities in ECO at first, *rose a bit*. Fascinating. Maybe was a bit understandable! We will discuss in pages ahead. Stepping back, looking at this president's 1st term 2017-2020, rate-sensitive renewables enjoy *falling* rates; 10-year Treasuries then fell to just 0.5% in 2020. After that, from 2021, as rates rose to 4.5% late 2024, green equities plummeted. Shale oil, by contrast, can return value upfront; investors may see their $$ back in 5 years or less, so higher interest rates can be less onerous for the fossil fuels -- than for renewables. Still past 10 years, fossil fuels fell hard too; natural gas plummeted far more than clean energy.

Practically-speaking, the world and especially China, was adding gigawatts (GW) of solar PV mid-2020s, more than all other energy combined, any year in history! China in 2024 added 45% more PV, a record, reached 885 GW capacity, 6x the US! Yet on overcapacity, lack of profits, China as discussed ahead was also 'exporting deflation'. China lately announced post-2025, it will move from heavily-subsidized new energy rates, to instead more market-based rates. For less 'irrational competition'. Big changes may be ahead. As solar's growth goes on. Since 2005 annual global PV growth averaged +44%/year to 2024. More new capacity globally came online every 3 days, late 2024 -- than existed in world 2005. Yet that's mainly in China, which has long had the most reliable, consistent support, for clean new energy. What of the rest of world, as hugely varied energy stories unfold? These latter 2020's will be fascinating -- with wildly differing stories seen across multiple states, regions, countries.

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As 2025 marked ½ way point in this decade, start of latter 2020s, we're seeing big changes. Globally, energy discussions have shifted of late. From big concerns back in 2020 first over: ***How Clean*** is an electricity source -- to now: ***How Cheap, Firm, & Reliable*** is it today. We'll discuss all ahead, but a brief example is eg Norway's ample low-cost hydropower made it a winner in 2025 with about the Cheapest, yet Firm /stable, & Reliable electricity in the OECD. Meanwhile, it's Exporting its own far pricier, fossil fuels natural gas & oil to other nations.

Yet, electric cables linking Norway to the UK, mean Norway's own local rates can skyrocket -- if there's No wind; UK price spikes impacting a *hydropower* exporting nation. Norway's 2025 elections may mean it renegotiates contracts on 'price infection': late '24 rates near a connector in Rogaland, Norway leapt from <6 cents, to briefly >$1 USD (13 kr)/kilowatt-hour (kWh)! Or in a domestic matter, Sweden has ample hydro in its north too: but a poor national grid has meant population centers in distant south often pay far higher electricity rates.

Opposite of Norway's very low-cost electricity, thanks to its surplus renewables & baseload -- is losing UK with about priciest industrial electricity rates: 46 cents per kilowatt-hour. UK's years of falling demand plus its cheaper wind were a pincer for the traditional baseload gas -- much capacity was lost. De facto bans on & erratic support for wind; its permitting & pricing thickets, put its grid in a bad way. Rates there set nationally by pricey natural gas, and sadly it imports gas/power if intermittent winds don't blow. (Raising rates in Norway too near connectors). Or take Australia's aged coal-fired fleet, today on 'wrong-side of cost-curves' with coal that's unreliable and costly. In past, UK & Oz had once relied on cheap coal, natural gas for power. But now the fossil fuels are expensive. It's a whole-new world. One where the Cheapest Electricity today is made by renewables: hydro, wind, solar. Crucial next will be to strengthen grids everywhere. To grow energy storage. Lots of appropriate low-$CO_2$ baseload, and solving locally for an inherent intermittency of cheap, less-firm renewable energies.

Two cheapest, 'winningest' US states for retail electricity 2025 were N. Dakota (11.31 cents), and Idaho (11.34 cents). Also a Washington state at a cheap 12.39 cents. All 3 thanks to ample renewables. N. Dakota turns 1st to its cheapest electricity sources, wind (36%) and hydro (4%); only after does it turn to dirty, stable yet costly baseload, lignite coal (55%), gas (5%). Idaho relies 1st on its cheap hydropower (43%) wind (15%) solar (6%) -- only after, does it turn to needed, costly yet key baseload gas for last 1/3rd. Washington state 1st gets 68% from hydro, 7% by intermittent wind; so 75% is from 2 cheapest resources. Only after those, does it turn to costly yet firm stable gas (13%), nuclear (8%), coal (3%). Both worldwide & in US, developed places with the cheapest electricity often rely first on their ample cheap renewables!

The costliest US state was Hawaii: 39.6 cents, or 3x cheapest states. The reason is clear; with No fossil resources of its own, in 2025 it still was importing & burning costly oil to meet huge 78% of its grid electricity demand. That high 39 cents was near the retail rate in 2024 in costly Germany. Meanwhile in mainland America, an average retail was a low 14.9 cents.

2nd worst, at 34 cents was California: its onerous regulations mean it can take decades(!) to add capacity. Has 3rd highest industrial baseload gas costs, big wildfire liabilities. Yet high California rates *were Not Due* to renewables: Texas has far more cheap wind power & growing faster. Little-regulated Texas is 2nd in solar too, growing it faster. Yet Texas' retail rates were a low 15 cents in 2025. Hence older conventional wisdom from long ago as to Cheapest sources (today, it's now renewables) -- and what is Costlier electricity (today, it's fossils gas, coal) -- like assuming fossils aren't subsidized (they all are!) should be sharpened latter 2020s.

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Texas makes the very most clean electricity in US & cheaply too: so much its 169,000 GWh of renewables-generation in 2024 surpassed most nations! By population, California is a bigger place, yet made 'only' 92,000 GWh. Industrial Texas has the most demand, and cheap Texas industrial electricity @ <7 cents, blew away California costing 3x more. On a good, yet not-unusual winter Texas day early 2025, wind/solar met 69% of electricity demand and growing. Of course, that solar works just daytimes, wind in breezes only! They're intermittent, yet are The Cheapest + often The Dominant sources nowadays for Texas' own electricity.

*But, importantly: 2/3rds of Texas *capacity* is still firm, dispatchable, non-renewables*. To see how Texas grid has evolved, in 2015, it had 251 natural-gas plants. These work-horses of dispatchable baseload can meet much demand. And yet 10 years later in 2025 on far greater electricity demand vs. 2015 -- it had a near-same 264 gas-plants. Since baseload must get cleaner, one sees why there's calls for eg small modular nuke reactors next decade. ***If,*** it can be made safer/better/cheaper than today's old, costly, not-secure, 2nd gen (2nd generation) nuclear technology. Gas is cheaper than nukes @'just' 7 - 9 cents, and it may be built faster than nukes (if the turbines/ parts are available) -- yet as noted, gas grew by a puny 6%.

How, why? The answer is, Renewables. Clean grew from 168 wind/solar farms there in 2015 -- to 652 wind / solar farms in Texas in 2025. Clean energy generating capacity grew 315%. Versus natural gas capacity 'growth', of just 6%. A key reason is: electricity made by solar/ wind is now THE Cheapest by far -- when sun is shining, wind blowing. A trick now is to pair the cheapest renewables, with cleaner/better baseload recognizing climate/$CO_2$. Streamline permitting. Improve grids. Expand both clean energy production / and storage greatly.

Economic allure of wind/solar is why a less-regulated, market-oriented Texas, grew as it has! In 2015, gas was key to Texas electricity; it has a great deal, loves its fracked gas (especially vs. far costlier gas in Europe, Asia). Plus, at times, Texas' gas can be 'cheap-ish'. *But even 'cheapish gas', is Not Free; very different from solar / wind as the 100% forever, free fuel -- especially given latter costs are dropping fast to now just 3 cents/kilowatt-hour, or less!* "Traditional energy", so coal, or natural gas, or 2nd gen nuclear, can't ever touch that.

As Texas' gas increasingly gets exported, interconnected to demand worldwide, US price for gas/LNG also is rising reflecting higher global prices fetched for product. A bit like Norway, where 'price infection' due to higher UK prices paid for electrons other side of a connector, drove up prices in Norway for its own power. As prices rise at one end, they fall other towards equilibrium. When US converted its own LNG terminals from Importing to instead Exporting -- US became the world's #1 LNG producer. Fast went from zero exports 2016, to 8 years later it supplied a massive 21% of global LNG. Of course, it drove US natural gas prices higher too -- while wind and especially solar became very cheapest energy, this chasm only growing.

Unsurprisingly traditional energy is fighting back, hard. At local, state, national, global levels. After a century making wealth, fossil fuels are enormously influential, among most-powerful of interests, and they're winning on many fronts. So, while they lost on costs, vs solar/wind latter 2020s loss widening, they can highlight eg renewables' intermittency, lack of firmness, poor dispatchability. If 'All of the above' energy strategies promoting all, that's fine & good. But, lately, efforts are directed at hobbling just, only, solar/wind. Attacks on renewables, on EVs, specifically aiming to halt clean energy. Sure, if one 'overlooks' climate, gas alone could be great! Subsidies just for it. Yet that of course, is a hugely risky 'IF!' And what we're seeing are new efforts, moves to slow, even halt just clean wind/solar alone in its tracks.

For example, Texas' legislature in 2025 was considering a bill (SB 388) to require at least 50% of new generation from 2026 must be dispatchable gas, coal, or nukes, only; though storage (of solar/wind) is normally dispatchable, this bill specifically excludes that. Fossils & nukes in falling behind on costs, are now asking less-regulated, pro-free markets Texas to put its thumb on scales -- against clean! Another bill would require that renewables alone, must get PUC Permits. And worse, while an oil well there now must be at least >200 ft from a property line; yet another new bill would make that setback be at least >3,000 ft for wind!

Besides state attempts to hobble just wind & solar, a 'surprising' idea 2025 was to try to make costly coal alone, far cheaper, by cutting its federal regulations. Even though coal would still be too costly: paring environmental/cost of carbon rules alone is Not enough. Yet to cut US rules, to allow more harms to human health, is a non-starter. Even in China with sparse health protections, coal has become pricey; at baseline USD 5.0 cents (RMB 0.38) it's more costly than renewables -- even in China! Plus, there's never been true 'clean coal'. We've seen too on some recent politics in America, fossil fuel camps energized, that an old -- yet still very wrong argument is being trotted-out too: it claims traditional US oil & gas are Unsubsidized; that only the renewables solar/wind are subsidized. *Yet that's just wrong too: all energy is in fact, subsidized.* Consider the tax breaks given just US oil & gas. Despite attempts to end these breaks in past, an enormous $35 billion in direct subsidies is ever-continuing.

Of 10 big tax favors given directly for US production, note just 2 huge subsidies to oil & gas. One for "intangible drilling costs" is a massive subsidy part of the US Tax Code since 1913; it has long let fossil firms annually write off 80% of costs of drilling, wages, surveys etc, even before producing oil. Another huge fossil subsidy in force for over a century is the "depletion allowance" till letting fossil firms deduct a big 15% of their taxable income today. In 2025 an already very profitable US oil & gas industry got $1.7 billion subsidies on intangible drilling costs that year alone; next 10 years they'll get subsidies from this break worth $9.7 billion. Further the depletion allowance gives $15.6 billion more in subsidies too. It's little wonder oil & gas companies spend millions on lobbying to preserve tax breaks; the subsidies are worth billions to them. But, hush, don't use that wretched word, 'subsidies'. Public relations efforts have long strived to portray oil/gas (even coal!) in a 'Marlboro Man' rough & tumble way.

One that takes its own risks, neither seeks/ nor gets government support. They've gone out of their way to avoid a 'subsidies' label for $$$ given them. But truth, is well, the truth. So yes: renewables also enjoy big subsidies; these have grown competitive with fossil subsidies; from 2016 to 2020 about 46% of US federal energy subsidies went to renewables. Yet this is just direct explicit subsidies. Consider too, the far bigger implicit subsidies to polluting fossil fuels when one also counts costs to human health, for clean-ups etc as they are far larger. IMF estimates they were *$7.1 Trillion* in 2022, or 7% of GDP. Or costs for US Military to keeping oil flowing in Strait of Hormuz between Iran/Oman; were it shut, oil prices may go over $300/barrel. Another example is a Price-Anderson Act limiting the US nuclear industry's liability to $10 Billion per radioactive catastrophe; without that, risks for current 2nd generation US nuclear would be too high, no new nuclear plants would get built.

Thus it's important to state plainly, contrary to arguments lately in the 'oily' 2nd half 2020s -- that in fact All sources of energy -- oil, gas, coal, nuclear -- and clean renewables too, are ALL subsidized. And while we're clearing up energy misconceptions, distortions, let's stay with that. For example look at America's two lowest-priced-electricity winner states in 2025: what were their sources for electricity? Was electricity in the 2 very cheapest states, sourced purely from 'super-cheap' fossil fuels -- as the fossil interests might have one believe?

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Given messaging by fossil interests, one may think Cheapest-electricity-US states must get *All their power* purely from just natural gas, or coal -- not from renewables at all! And yet the cheapest state of all at just 11.31 cents/kWh in 2025, was windy North Dakota. Note it turns 1st to its least-cost source of power: wind. Wind power is 36% of its generating capacity, which had more than doubled 2016-2023. These gains were Not on any green ideals, nor climate-concerns, but because frankly its abundant winds make the cheapest power. Along with wind to 1st meet demand, it turns first also to another cheap source, hydropower for 4% more. Hence note its renewables often are its 2 cheapest sources of electricity. Only after that cheapest 40%, will it use its very biggest resource, dirty lignite coal, for another 55% of electricity generating capacity. Costliest of all, its own natural gas is lastly a final 5%.

Hence at America's lowest-priced state, 1) its cheapest wind costs are ½ or less than its coal, 2) its own lignite coal is abundant though costly on human health +environmental regulations -- yet important baseload mitigating intermittent wind/solar, with 3) all so cheap thanks to *renewables lowering fossils costs; also, it *does Not face big climate/or wildfire risks; *and a sparce population lets it export to other states & Canada. In sum, its renewables are now 1st big 40% of its power and growing -- while its own fossils only after are 60% and falling.

2nd lowest-priced Idaho was 11.34 cents per kWh. Does it get all electricity from fossil fuels? Again, No! For Idaho in 2023, its biggest source by far is hydro, 43%. Again, renewables are its Cheapest power. So, it turns 1st to low-cost 'water' (hydro), and wind for 15% more; hence 2 renewables + 6% solar are 65%, 2/3rds clean meeting demand. Wind/solar are intermittent, hydro stable but less than fully firm; thus, it turns after these to costlier, fossil firm power: natural gas notably 1/3rd in low-cost Idaho. A lesson again is abundant renewables are key to low-cost electricity. A 3rd very low-cost state, Washington was 12.39 cents retail in 2025: it gets 68% electricity from hydro, another 7% is from wind: hence 2 renewables make 75% of its supply. For important baseload it also gets 25% of electricity from firm but far more costly fossil gas (13%), nuclear (8%), coal (3%). Hence these 3 low-cost US states notably all rely very-heavily and sizably on renewables: wind, hydro. To include more solar ahead too.

*So why haven't cheapest renewables, already lowered retail costs greatly?* One big reason: 'margin pricing' mechanisms that commonly set electricity at higher costs. Take a UK (Great Britain), where marginal pricing means if *any* natural gas baseload is in the production mix -- true 98% of the time -- then that last most pricey gas, sets wholesale price nationwide. Even though costliest, last-used gas makes on average only 40% of UK mix (at times, just 10%). In producing electricity, cheapest sources (renewables) are used first. Then, next-cheapest, firm sources, etc. *But retail customers do Not see benefits of cheap solar/wind with almost no operating costs. Instead, a wholesale rate is set by last, and so the costliest source.*

Baseload thermal relies instead on heat/steam, whether from natural gas, coal, or nuclear -- and it's costliest now latter 2020s, vs. preferably cheaper (but intermittent) renewables. It is firm, yes. Yet nowadays it's oft cheaper to build a new wind, or solar farm, from scratch -- than to go on fueling an existing coal plant! As seen next in a gas-heavy UK soon, in 2030 (left) this price gap is tremendous. Traditional *Natural gas electricity at some 14 pence/kWh -- versus *Offshore wind, *Onshore wind, *Large-scale Solar at 1/3rd the price, costing only about 4 pence/kWh. Even rather pro-nuclear Nordic countries found 2025 that to add new nuclear plants (that can't even come online 'til latter 2030s soonest), is uneconomic: they've thus decided to extend life of their few existing plants. Renewables can make the cheapest wholesale power, yet on marginal pricing, retail consumers will not see that:

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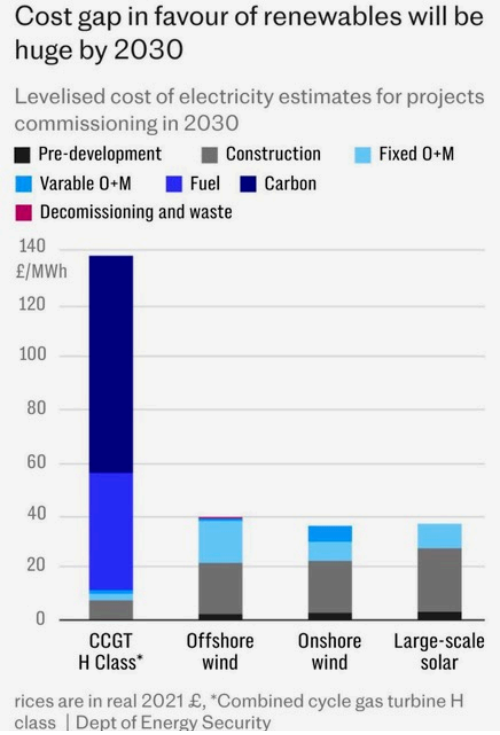
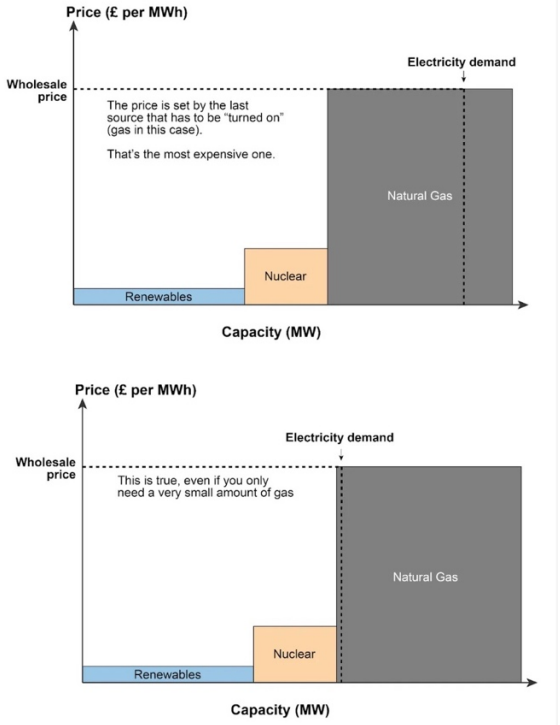



*Source: UK Dept of Energy Security*




*Source: Sustainability by Numbers.*

As seen left above, one core reason for high UK electric prices is its *Reliance on natural gas (often imported gas, that's even pricier). Burned in latest most efficient combined cycle gas turbine (CCGT) -- it will still be much costlier than is wind/solar, and the gap is widening. Meanwhile, if much gas is burned (right, top chart), marginal prices somewhat understandably are high; yet if gas meets only just a small bit of demand (right, bottom), electricity is still highly-priced 'without good reason'. Because the UK (unlike many places) also sets out one national price, highest demand places (like say London) set rates for rest of UK. Though wind farms in a north produce abundant cheap local power (negative wholesale pricing at times!). Thus, a shift in UK to local/regional pricing, could reduce rates for a good many citizens in many places there. Such a regional system would be more like say a US, where 50 diverse regions (the 50, US states) each have their own varied electricity production, and rates.

So, let's look next at US with 50 unique states, providing 'de facto, regional pricing'. There's lessons to be learned. Like, that cheapest-electricity states use abundant renewables. And the costlier states, use much gas. For all US, natural gas made up 43% of electricity on average in 2025. Even burned in the most-efficient, combined-cycle co-gen plants, gas is costlier than renewables; yet gas here too sets Retail rates. This is seminal. US electricity Retail rates are set by a last, 'most important' source. Note too diverse consumer retail rates in all 50 states are some places high, others low. While consumers paying retail, don't see (wholesale) prices at which wind, solar, hydro, actually produce. Plus, on needed grid stability, firm baseload has a big role. Given US is varied, let's look at other side of coin, at 2 Costliest electricity states. Very bottom of barrel, the priciest is Hawaii. Its 2025 cost was a nosebleed 39.6 cents/kWh -- over 3X that of a cheap, say North Dakota, Idaho, Washington state. Reasons for such sad and pricey results are clear and also pretty embarrassing for the state of Hawaii.

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Foremost is that Hawaii today has the Dirtiest most-fossil-fuel/oil-dependent grid in America. Utility PR tries mightily to avoid acknowledging this; certainly, doesn't fit in with chamber of commerce messaging of tropical clean island paradise. Yet most electricity there long is made by burning (goopy awful #2 bunker!) oil, even until-recently, imported coal(!). Most states long ago dropped oil for making electricity, after oil crises 1973/1978. Yet Hawaii burns oil (coal too until recently), hidden from tourists, pollution dissipated by ocean breezes.

Due to short-term thinking, decisions of long ago, Hawaii with No fossil fuels in 2025 was importing & burning a worst #2 bunker oil (yikes!) to meet 78% of grid demand for electricity. This, on islands blessed by abundant sun, winds, waves. Natural geothermal could be / should be making firm reliable baseload, renewables today meeting 100% of electric needs. Instead, utility PR stresses small growing renewables, says nothing of mainly burning the worst kinds of bunker oil. When Hawaii decided long ago imported fossil fuels would make electricity, the die was cast: rely on oil, coal; and with no cleaner neighboring states, it put itself in a corner. Instead, had Hawaii looked first to its own natural wind/ water/ sun/ geothermal (as had Washington state, Idaho, Norway), it might today be in a much better situation especially on reducing costs. Thus, it is now trying to grow renewables, grid, and storage much faster.

Next, a famous poster child for very high-electricity (and often other) costs, is California. It's often trotted out for misconception that its own high electricity rates, at 34 cents per kWh so 2nd worst in US, are due to its wind, solar, hydro. *But, that can't be right!* Texas makes far more wind power, growing far faster than California. Texas is a close 2nd in solar, growing faster too. Texas renewables make far more power than California -- yet Texas' electricity is far cheaper: just 15.6 cents in 2025! Thus in fact, *Texas' renewables keep costs down:* it's hard for the gas/nukes to compete. So, California's high costs can't be due to solar/wind.

Instead, more accurately, a few factors help explain California's 2nd worst prices including: *Heavy Regulations, *Slow/costly permitting. *Industrial Natural gas prices 3rd highest in US for still-needed baseload (so big question: how to transition from gas, as climate requires). *Its Huge wildfire costs. *Ratepayers subsidize rooftop PV, & low-income households; these arguably should be funded statewide. All push up retail rates, extraordinarily high -- vs eg, 3 bordering business-friendlier neighbor states: Oregon, Nevada, Arizona that charged in 2025 respectively 15, 13, 12 cents. As seen repeatedly, fact is clean hydro/ solar/ wind by contrast, can all be *deflationary;* they *reduce* costs. And while reasons for California's high costs are complex, these could be cut especially at its 3 big investor owned Utilities.

Those 3 Utilities aim to recoup costs of wildfires, gas accidents from ratepayers, while also providing big, sure 10% returns on equity to shareholders. California is vast geographically, but a very conservative Texas in 2023 had made by far the greatest Wind power: 115,000 gigawatt-hours (GWh). Other US wind power leaders are all conservative too: Iowa (42,000 GWh), Oklahoma (38,000 GWh), Kansas (27,000 GWh). As further evidence, of 12 states with greatest 'WWS' (Wind, Water/ hydro, Solar) percentages from Oct. 1, 2023 to Sept. 30, '24 -- six were among the 10 lowest-retail electricity price states early 2024. Low-priced states overlap on a map with abundant wind & hydro power. South Dakota, Montana, Iowa, got at times 110%, 87%, 79% of their electricity by clean energy, mainly wind, hydro. At other end, a costly Maine with instead high industrial natural gas price (in disaster recovery) -- had high electric rates. California with high industrial gas costs 2x the US average price, ratepayers subsidizing socially-sought-after goals (that should be addressed by bigger taxpayers pool), was maybe fated to have costlier rates than most states, with none of these traits.

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A California that in 2023 had got about ½, or 54% of its electricity by renewables, aimed for 90% renewables by 2035. But, that 2035 is still years away; mid-2020s costly natural gas was still a huge 39% of in-state generation. Given self-inflicted regulatory burdens, for it to fast replace baseload natural gas will surely be no easy task. It's complicated, no silver bullet. And so as we observe, a more accurate portrait is that US states with cheapest retail power, often rely heavily on ample renewables. Jan. 2025 retail costs were thus low in renewables-heavy states like Utah (11.4 cents), Arkansas (11.8 cents), Nebraska (12.1 cents). In wind-endowed-Midwestern states Kansas and Wyoming, we saw them enjoying price *declines*.

When a first hybrid car arrived, the Prius, critics long held it having 2 drivetrains (both one gasoline, & one electric) -- meant sure failure: either make a cheap gas engine car, or costly EV they cried. What they didn't foresee, was enjoying 'cheap/free onboard power off wasted braking energy' -- would more than make up for having 2 drivetrains. Today the new hybrid dual-power cars are growing faster than gas-engine cars. Similarly, critics today who bemoan solar/wind for being ever-intermittent, as needing backup fossils, perhaps don't yet see that plummeting renewables costs + ever-free fuel -- *may* more than overcome a price differential ahead. Solar/ wind might, not far-off, fall even more in wholesale costs to Under say just two pennies per kilowatt-hour. Fossil fuels, current 2nd generation nuclear *never* can do that!

2020s is seeing growing pains: 'curtailment' that shuts solar/wind if making more power than a grid can yet handle. Better grid/ more storage can solve much. In California late winter-early summer 2024, 100% of demand was met by green sources up to 10 hours, 98 of 116 days, a record. Zero blackouts. Solar output was up 31% vs 2023, wind up 8%. Battery capacity up 2x. But, what of baseload that's still vital today & necessary, during the other hours!??

Globally, wealthy places see bit of a similar conundrum. Those with ample renewables like a pretty stable Hydro, often have best/lowest electricity rates. Norway's 1,700 hydropower plants mainly in north form 88% of electricity production capacity; it also has 65 large wind farms too for 11% more electricity. Some 99% of demand thus met by cheapest sources: both renewables. Costlier, polluting thermal plants that must burn gas, coal, or biomass meet only 1.5%. From 1990s, it had long had healthy total domestic capacity surplus. Hence Norwegians long have enjoyed ample, reliable, firm, and very cheap clean domestic power.

But what of renewables' downsides. One issue lately, is pricing mechanisms. In Norway's case it long enjoyed cheap power and while it's Not in an EU, it is in Agreements to export 'surplus' power to Northern nations, UK, Germany, Denmark, if latter see low winds, inadequate power production. Norway has exported electrons via 1,400 megawatt (MW) undersea cable since 2021. A thing is lack of winds can make prices (vs. a normally far-pricier UK, or Germany with average retail rate of high 39 cents) -- spike here too, so local rates in southern Norway have skyrocketed at times near connector cables. Normally dear prices in UK, or in Europe, during low winds spike rates extraordinarily in Norway too, nearby export points. Sweden as well makes a cheap hydropower in its far north, while demand is mainly in its south; as an internal matter Gothenburg in its own south saw retail prices 2025 briefly go 190X that in north.

Hence vs. an EU, Norway may soon revert to prior system, & so first satisfy its own demand -- rather than first sending electrons abroad. To do otherwise, risks new price spikes that deny upsides of its own hydro, stoking public anger. Indeed 2 political parties in Norway had made it a focus of Fall 2025 elections. They may renegotiate rates in future, or even one day sever links that send power to UK & Europe; this was a leading factor in 2025 campaigns.

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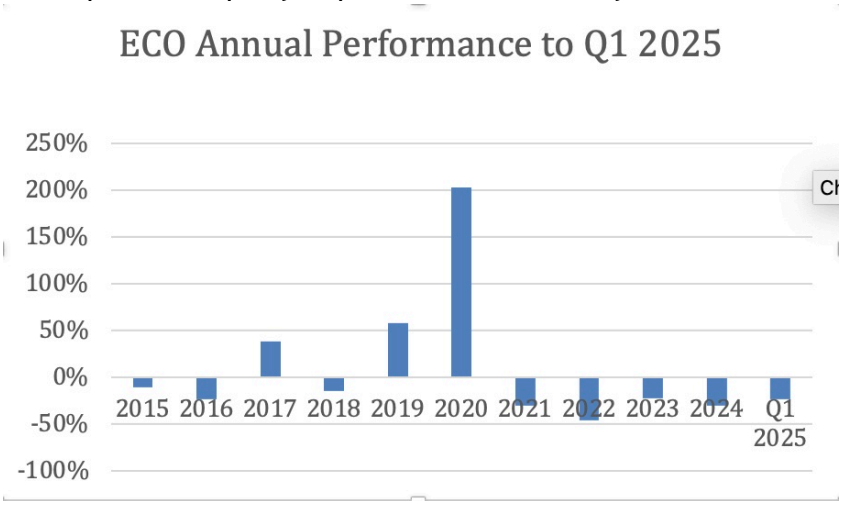
It's easy to see why a nation's sovereignty, high power costs, & choices can be pivotal in an election. Norway's ruling coalition collapsed early 2025 on fury as once-cheap rates jumped. Meanwhile fears at other end of cable, in UK, are maybe blackouts ahead, no laughing matter. In 2025 a sizable 4% of UK electricity was Norway's hydro: it may be pared back one day. Times of no North Sea wind, UK rates jump, so prices some Norwegians pay for home-grown electricity: recently those jumped 20-fold in Norway in just 1 week. In 2025 a 12,000 turbines UK wind fleet on a brief windless/gloomy 'dunkelflaute' (dark doldrums) spell saw collapsed output; instead of making 10 GW like a typical day, fell to just 120 MW, 0.5% of normal output. Was like just 30 turbines on a windy day -- when those can make a huge 23 GW very cheaply! Thus, consider the impacts both sides of connectors. Especially in an increasingly-energy-starved, sadly rather de-industrialized, and with now-sparser / costlier-baseload UK.

Hence UK's situation is far different from energy-exporting Norway, that's long has made its hydro electricity cheaply while selling far pricier oil & gas to UK, Europe. The UK instead is scarily *Importing* even more fossil fuels+ electricity. In 2019 the UK imported £19 billion/year worth of energy, fuels too; by 2024 it was £41 billion/year. Norway as UK's key electricity supplier, sent USD $1 billion of electrons 2024; UK imports electrons too from France (USD $865M), Netherlands (USD $980M). Every year since a France/UK connector opened 1986, UK has imported electricity from France where industrial power costs are less, 'just' 16 cents. (A brief exception was in 2022 when France saw issues in its nuclear fleet, but since then the UK has resumed being net energy Importer). Natural gas still makes much UK domestic electricity and UK gets 41% of that gas from Norway, a good/nearer gas source than Qatar where UK sources 14% of gas. But a point is the UK today is problematically not in electricity surplus, nor is it in any broader domestic energy (fuels too) surplus by any means.

If all nations in a region normally are mainly healthily energy-positive, cheap power at all, connectors help promote stability. But instead, UK has higher/worse industrial electric rates than costly Europe! And it imports much natural gas. After century+ of coal to meet electricity demand, by 2023 gas was making 33% of its electricity -- coal & oil each down to <1%. Thus, coal there today (thankfully) hasn't generated so little since in 1757. But something has got to give. With UK support for wind in fits & starts, highly uneven -- plus after its long-falls in energy demand -- its gas-baseload capacity today is down hard. As its 2$^{nd}$ generation nuclear plants have proven wildly costly, maintenance far worse than expected: it's no France. As we see, energy is Not Simple, it's a complicated topic -- like how to get baseload! Yet there's smarter paths now that will make sense regardless: build resilient energy grids. Add much more energy storage for firmness. Grow renewables too since apart from cleanest/ they are also nearly-always cheapest. More dispatchable domestic sources. Streamline permitting. And solve locally for appropriate low-carbon baseload – all this can drive down energy prices.

Meanwhile, some old paths make little sense today. Take Australia's coal: its national market operator had to issue 144 'Lack of Reserve' Alarms in Q4 2024, highest number ever. As customers trimmed demand, it likely means higher electricity rates ahead. Many alarms were sounded at 2 aged power stations, Bayswater, & Eraring, on coal's growing unreliability to fuel old plants; a station ran only 4 weeks, a last 5 months! Another station had a catastrophic explosion. On coal's rising issues, electricity rates Q4 2024 for national market shot up to AUD $88/MWh -- up by 83% in late 2024 vs a year prior. So, coal-fired electricity that was dirty, had by 2025 grown also unreliable, & too expensive. Let's return now to clean energy. To equities in the US, and issues in 2020s that lately maybe impacted themes. Especially given some surprising results the past decade, regarding politics and a clean energy theme.

It may be worth glancing back a moment, for any political correlation to this theme. At mid-decade 2025, a look back at ECO's annual returns last 10 years is small food for thought. As expected, we do see clean energy / hence ECO Index has been *very* volatile. That volatility no surprise, as it is an emerging theme. Yet the *direction* of annual moves is maybe *not* what one may have expected, if anticipating maybe say directional correlations as between ECO -- with president/party in power each of these years. Below is ECO from 2015 + Q1 2025:

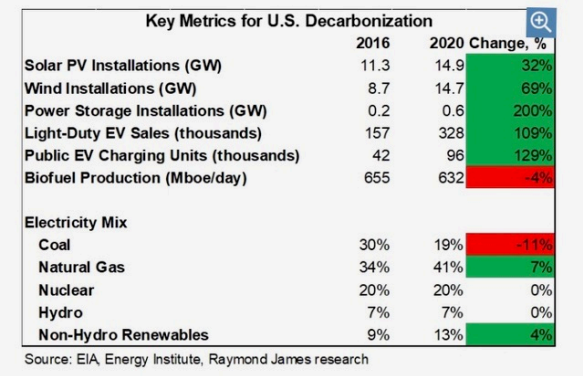



This 2nd point on direction is notably counterintuitive: Not what one may have expected each of 10 years. No correlation! Yet what surprises is that with a *conservative* president in office this clean energy theme/ hence ECO, *rose* sizably. 2017-2020 in a conservative's 1st term, this clean theme strongly *gained*. Tallying annual gains/losses each of these 4 years, it was surprisingly *up* a large net +284%; as up +38% in 2017, down -15% in 2018, up +58% in 2019, up big +203 in 2020. Again, no correlation. Still, remarkably, gains under a conservative leader famously opposed to 'green new deal', action on climate & carbon. A 2nd term + differing inflation these 2 eras may be very impactful ahead, with different look. As this president was re-elected to a 2nd term for 2025 to 2028, let's watch and see what happens here ahead.

Inversely, maybe unexpected too, is under a *liberal* president who supported climate action, this same clean energy theme captured by ECO, *fell very sizably* 4 years 2021 through 2024 by a net total -128% (tallying -30%, -46%, -22%, -30%). Not what one might have predicted! Counter to conventional wisdom yet in 10 years clean energy *rose* in conservative president -- and *fell hard* under a liberal -- opposite direction of assumptions, no correlation. But, looking at 'just' a past 10 years through 2024, was perhaps too short-ish a time horizon.

Supposing maybe a fluke on just 1 presidential term each side, we can note a prior ~10 years too from 2005. Here we see annually in 2005 - 2008, a conservative president's 2nd term ended near nil if tallying 4 years (+4% in 2005, +5% in 2006, +58% in 2007, a big -70% in 2008). Waters were muddied a bit by the Great Recession in 2008, that dropped all very hard; consider if it hadn't been for 4th harsh year 2008 with all globally down, we see a previous also conservative president would have shown (again surprisingly) large net *gains* in clean energy's theme/ so ECO in their own 2nd term in office. Lastly, in a prior liberal president's 2 terms 2009 to 2016, we saw a net -40% *loss* tallying up 8 years (+28% in 2009, -5% 2010, -51% 2011, -19% 2012, +57% 2013, -17% 2014, -11% 2015, -22% 2016). Hence 20 years to end of 2024 do *Not* reflect directional expectations, if one assumed green losses for a conservative, gains for a liberal. Facts were quite opposite! Resists making accurate predictions, *ex ante*. Importantly too, the higher inflation, chaos seen ongoing 2025, may also mean much different result ahead.

*Doubtless their 2nd term will turn out far differently from 1st term.* And, that 2nd term certainly began very differently, with equity returns (hard down!!) vs. their first. Yet as this president had a 1st, full 4 years term 2017-2020, one can ask: Did decarbonizing/clean energy equity growth, pause then or slow? No! Both in rhetoric & actions, this president long has *favored* fossil fuels: oil, natural gas, carbon-laden coal, & nuclear -- and has strongly *opposed* renewables, especially wind, solar and decarbonizing. In 2025 this President pledged to try & "have a policy where no new windmills are being built". Notably, however, we see too that despite it all, clean energy installations & equities both grew in 2017-2020. Solar installations were up then 32%, nascent power storage was up 200%; wind installs up 69%, EV sales up 109%, EV charger installs up 129% (latter 3 off miniscule base). Only biofuels were down then, and it owed much to overall demand destruction that punished all fuels in Covid-19:



| Key Metrics for U.S. Decarbonization | 2016 | 2020 | Change, % |
|---|---|---|---|
| Solar PV Installations (GW) | 11.3 | 14.9 | 32% |
| Wind Installations (GW) | 8.7 | 14.7 | 69% |
| Power Storage Installations (GW) | 0.2 | 0.6 | 200% |
| Light-Duty EV Sales (thousands) | 157 | 328 | 109% |
| Public EV Charging Units (thousands) | 42 | 96 | 129% |
| Biofuel Production (Mboe/day) | 655 | 632 | -4% |
| | | | |
| Electricity Mix | | | |
| Coal | 30% | 19% | -11% |
| Natural Gas | 34% | 41% | 7% |
| Nuclear | 20% | 20% | 0% |
| Hydro | 7% | 7% | 0% |
| Non-Hydro Renewables | 9% | 13% | 4% |

Source: EIA, Energy Institute, Raymond James research

Note too above, that America's electricity mix start of 2017 had been about even at 30% coal, 30% natural gas, 20% nuclear. Yet by end of the president's 1st term, coal in 2020 was down hard to 19%, as natural gas was up near 40%. Nuclear, that is so *very* expensive in the west -- and big hydro not as susceptible to growth, both were static, at 20%, and 7% respectively. Coal was hammered those 4 years yet not primarily by renewables, but by plunging costs for competing natural gas thanks to US fracking. Start of that decade in 2010, a Utility executive might reasonably have aimed to add coal. End of that decade, 2019, their fiduciary duty made coal relatively a bad bet. Not as being #1 dirty/polluting, but acutely it became too costly vis-à-vis an also firm, 'less-dirty', more flexible, cheaper natural gas-fired electricity.

So importantly, decarbonization did Not pause in 1st term, 2017-2020. Nor, might it in 2025-2028(??): for still critical too are innumerable state-level policies, private-sector goals etc all advancing green energy. No doubt renewables will be hit very hard (but maybe geothermal, biofuels). Yet crucial today too is better economics now of green power. The US States reflect this: rock-ribbed conservative Texas outpaces liberal blue California in renewables. Ruby-red conservative Iowa, Oklahoma, Kansas, lead on wind by %. Liberal Oregon by contrast did not start wind offshore. Globally, one expects liberal Europe to lead; instead, start/ stop policies are a problem. As an anything-but liberal, 'coaly-China' is the world's clear solar/ wind/ EVs etc manufacturing Leader -- even with supply chains saturated, profits squeezed.

On 2022 IRA roll-out, 2/3rds of $$ at 1st went to conservative states, bit harder to undo all. Yet Big Cuts are certain: can mean hundreds of billions $$ taken off EV funding, DOE Loans, PTC/ITC credits phased out. It's understood: Elections & 2024 Red Wave Have Consequences! 53 GOP Senate seats yet 2 moderates mellowed reconciliation a bit. House-lead thin. That said, GOP members who in 2024 supported IRA, may accede to 'one big beautiful bill' in 2025. Still, US oil executives who'd enjoyed world-record production 2024, may Not want so greatly a popular 'Drill, Baby, Drill!!' which could mean an oversupply, and lower fossil fuel prices -- so much as to ensure ongoing demand for their product, fewer regulations, less taxes.

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Control of Congress is vital; of a House where spending bills originate -- & of Senate with tall 60 votes needed (50 on reconciliation). Much nitty-gritty is determined here. And regardless of the 2024 red wave, not all clean energy means partisan battles; good ideas can be agreed-on despite politics. For instance: yes, more grid capacity is vital for more solar, wind, battery storage -- just as it is to add more natural gas & coal power, plus more nuclear too -- so note, grids can be bettered without new poles, pylons. Extant cables are often made of heavy steel cores surrounded by thin aluminum conducting electrons. Replacing old wires with light carbon fiber core & thick conductor wires can carry more power: this is 'reconductoring'. In California, a widespread switch to such cables could better transmission capacity some 4-fold by 2035. Or importantly, just streamlining Permitting for all, could be very Big Deal.

Still, so much controversial, political. Should a US president in their 2nd term go faster on US battery making? Mining? Today rare earth elements, + graphite, magnesium etc come from mainly China (so under threat if conflicts arise over Taiwan); heavy rare earths from Myanmar; cobalt mainly from DR Congo: all insecure. So military & strategic need for certain minerals probably is paramount, and yet their roles crucial too, given many new energy applications -- should these soon be sourced in US? Processed, too? Or, can come mainly from allies?

Also, directly on point given the president's vocal, longstanding opposition to offshore wind, should it now be halted in all US? Even offshore the states desiring it like California? Should renewables be slowed, even though US is in transition from near-zero energy demand growth past 20 years -- to voracious new demand especially places hosting new AI /data centers, building clean energy manufacturing? How big to go in an US, or in EU, on tariffs on the EVs, & on PV from China? Go fast past 2nd gen -- to newer 4th generation nuclear? Fights brew even on niche hydrogen ($H_2$). Europe 2020s was drafting rules so green $H_2$ has nexus to renewables, to guarantee green $H_2$ is made when sun shines, wind blows on 'additional' green-electrons. While in a US, even Exxon, Chevron, American Petroleum Institute, co-signed a letter in 2025 lobbying to save IRA 45V tax credits on 'blue' $H_2$ if made by (their) natural gas. $H_2$ is still very niche; just 16 million tons made in US in 2024. $H_2$ by gas is much cheaper @$1.50/ kilogram -- than a green $H_2$ costing 3x that: no one wants $H_2$ at such high cost!

Regardless in 2025 EVs/PV made outside of China -- or green $H_2$, e-methane made anyplace -- were mostly too pricey. Some ideas are now closer: fossil-players may soon claim to make 'clean $H_2$' even from gas-fired electricity, on RECs (renewable energy credits) by solar/wind distant places, times. Conservatives support this. Favor 'all of the above' energy strategies thanks to abundant, cheap US shale gas; worry far less about climate risk. Or, many will support 'big Ag' dairy RNG (renewable natural gas) from agriculture, renewable natural gas from landfills or wastes. Yes, avoiding methane spills one way to help limit greenhouse gases. Capture carbon permanently, mineralized as rock. Unsurprisingly France pushes for turquoise 'low-carbon $H_2$' from waste heat in its ample nuclear fleet. Many, many further debates will lay ahead. And incentives matter. For instance 45X MPTC (Manufacturing Production Tax Credit) in a 2022 IRA just possibly could help US-made solar PV to become globally-even, cheap. Say on a 5.25 cents Wdc solar tax credit for possibly 60% cost reductions in US solar. Conceivably for 4 million new US solar/wind jobs. And yet we know better, as a 2022 IRA was being cut way back in 2025 -- even though we need all the energy we now can get. In short, uncertainty reigns across clean energy, so no surprise to see such volatility in clean energy stocks. To surely predict what will happen ahead regardless of election outcomes, or indeed anything else, and so like equities in general, is an ever-Impossible task. Still, some review & analysis here can be useful.

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Take level & direction of Fed Rates, since these influence clean energy's theme. Look at Federal Reserve Economic Data (FRED) for US Fed Funds Effective Rates 2020-2024. From Fed Rate of 1.55% in Jan. 2020, it dropped to (a free money!!) just 0.09% in Dec. 2020. Such low rates boosted longer-cycle renewables: Thanks, Central Banks+ no inflation! But afterwards -- rates leapt from a 0.08% in Jan. 2022 -- to once-normal yet felt high 5%+ by 2024. We saw clean equity's falls, not surprising on that spike. The central banks did have to head off inflation; it just was, they'd responded much too late to a gathering inflation. It resulted in a few years with some of the fastest interest rate increases seen, in well, nearly-ever.

Let consider interest rates further as they mean a lot to clean energy's (& equities) theme. Short-term rates, set by the Fed / Federal Reserve, get headlines. But important too are the 10-Year Treasury bonds, so-called 'notes' (as briefer in duration vs. eg, 30 year bonds): these move differently, instead on market sentiments: yet they also mean a lot. In 2020 the key '10-years' remarkably had sat at <1.0% as ECO jumped +203%. But afterwards from 2021, the 10-year notes then *rose* next 4 years. As Fed finally eased short-term rates bit late 2024, 10-year Treasuries did *not* respond the same: they at 1st rose! To psychologically key 4.50%. If goes past >5.00% ahead, then that could make far riskier equities harder to justify. But/or, if falls back well under <4.0%, that may help re-ignite animal spirits, renew interest in potential returns in these volatile themes. see eg, https://finance.yahoo.com/quote/%5ETNX

So, year 2024 that ended with ECO well down, elongated big steady falls of 2021, '22, '23. Charts were ugly in clean … & all energy. Yet looking back to try divine a bit what's ahead -- is of little weight, trying to see forward! Just some musing, playing with numbers. Finding coincidences by looking back on joys of ample data over 20+ years. There's no way to surmise from just these past data, what may yet be ahead. One might only glance at such a thin-gruel bit of the past, and then try to guess (and be typically quite wrong!) about the future.

Confounding all too is that impressive pace by which renewables are now being installed, records being set for new $$$ going into wind, solar, grid, etc. Global low-carbon investing had hit $1.77 Trillion in 2023, up 17% from 2022. How can this theme's own stocks so plummet, go down for years, again over 2024, as clean energy grows globally?! We'll look at that curious fact ahead. Just brief mention here, is that as margins compress, as new energy prices fall -- profits have been hit hard. Meanwhile, long-planning China 'ignored' overcapacity fears via unshaken policy support; it has aimed for ever greater market share, ever-lower prices + full employment. Unlike in the West, where seeing some near-term profits is a prerequisite.

US & Europe projects pushed out too by interconnection/ transmission (IX/TX) chokepoints. Demand is very strong, and grid growth has not been enough. 2023/2024, 5-year load forecasts grew 450% from 23 GW to 128 GW; interconnection approvals were seen to grow ~5x in 2025, good, yet not fast enough. Other issues vex a west: Start/Stop inconsistent policy support like moving from US IRA tax breaks in 2024 -- to slashes in 2025 (unlike China). Ongoing scarcities in the west like of say, high voltage transformers, poor grid capacity, lack of domestic lithium, minerals, processing, US wind incentives in IRA axed 2025, etc etc. We discuss thorny factors ahead as maybe some diverse reasons green energy stocks had dropped hard of late.

Even with IRA slashed from 2025, a few policies are notable. Safe Harbor provisions in IRA may allow tax breaks, if work began before law is changed, or incur 5% of costs; that goes on 4 years and can boost sales. Or, this sector may decline not only on repeal of favorable IRA -- but also simply on pure economics, bearishness, sector declines, poor prospects here.

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Broadly, at least 15+ factors were perhaps at play in clean energy's bearishness 2021-2024. *Debts were up sharply in US, Europe, China; *Inflation rose in a west: as *Interest rates & so costs of credit jumped, *Hopes of margin expansion/profits in PV, wind, EVs were thus dashed. *Funding & IRA Rules needed 'yesterday' were slow to come from agencies. From *2023, 100+ US residential solar installers went bankrupt, 6-fold prior 3 years, US residential solar installs fell ~15% in 2024, California was down some 40%-50%. *China's big Overcapacity in solar, wind, EVs etc was sticky, bubble fears; as *Some supply chains clogged despite hits to demand for new EVs, wind, on high costs. *Big-Cap stocks did better than Mid, Smaller-caps here, and *Speculative disruptors faced poor sentiments: *100+ SPACs since 2020 also diluted investing. *Ongoing China/vs. Western Tensions threatened to decouple a strategic green trade ahead. *The new House Speaker & then US president 2025 meant massive IRA funding cuts. Finally, some *Exhaustion given scientists repeated dire warnings of climate crisis now.

On the other hand, realpolitik here is that 'move fast & build things' leaders Texas, and China (now designing solar PV for space!) -- are way-out-performing California, and Hawaii (the 2 costliest power rates in US!) for renewables. Latter 2 places shout about: clean & climate, but relative 'Build Absolutely Nothing Anywhere Near Anybody' (BANANAs) policies, mean far less renewables get built. Decarbonizing is arguably better served by a liberalism more like a mid-20th century when 'many-things-got-built, fast' -- rather than a 21st century BANANA. Or, vs. a UK where de facto onshore wind bans, poor grid, mean costly power. Instead, the UK could build more (domestic) wind: note in 2025, there were zero Chinese turbines sold there. UK-based workers then made blades at a Siemens plant in Hull; on Isle of Wight at a Vestas plant, some blades were exported. Both JDR of Britain, Sumitomo of Japan built high-voltage cables factories for offshore wind. SEah of South Korea put up a steel plant for offshore towers. No Chinese turbines sold, or factories there yet – the UK could be doing more.

Against flood of China's overcapacity in PV, EVs, etc, its property bubble bust, Beijing does aim for yet more capacity but lacks a domestic demand to sop up all green 'emerging future industries'. Overcapacity can hit profits; in 2024 fully 25% of mainland China listed firms were unprofitable -- vs. just 7% decade prior. All that, as China sought to ramp fast its Exports in search of demand. So it has been exporting a deflation that hit profits everywhere. Let's look at wind's global troubles, as just 1 facet here. In 2023 a big wind name made headlines as it abandoned contracts to develop 2 wind farms off New Jersey, US. Why might such 'failure' be bit 'ok'? Well, big wind manufacturers were *losing* $$ on each enormous offshore turbine delivered. A contract to supply turbines in a deal for 1st New Jersey wind farm was negotiated 3 years prior. It was then stuck delivering units, after wind prices jumped 40%. Thus a $1.5 billion deal obligating new turbines/towers, put it deeper into a hole. Ending that contract, ironically, might help reduce huge $6 billion backlog. Hopefully to help address overcapacity; a need for wind businesses-to-realize commercial profits was rising undeniably. First step, if digging oneself in a hole, is to stop digging! As one conglomerate narrowed losses, a bottoming(?) far out ahead seemed maybe possible(?). Q3 2023 losses did slow to -7.6%, off scarier -26% year before. That emblematic firm took $500 million charge to repair & maintain turbine fleet; focus on few proven 'workhorse' designs. Once-too-many tower designs over 40+ in 2021, lessened to 9 by 2025. Rotor options cut, from 15 to 4. In hopes profit margins might *possibly,* begin to emerge years ahead. 2024 first saw glimmer of hope maybe for infant California offshore wind. Some optimism end of decade one may finally start to see idea of wind profits ahead. But then a US president hostile to wind re-elected to 2nd term put paid to that. Antagonistic to wind, a New Jersey offshore wind permit revoked 2025, all clouded things enormously for US wind and for the next 4 years, maybe beyond.

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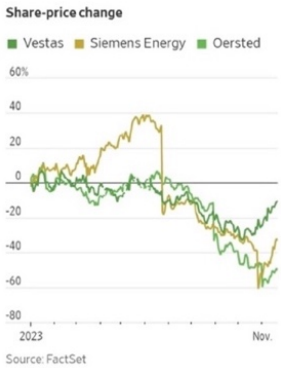
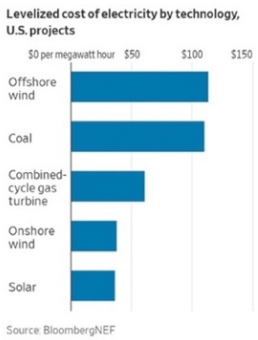
Green energy theme-baskets like ours, have seen an elongated 4+ years of declines into 2025. Partly due to wind: an American firm in 2024 had to drop 2 offshore wind contracts in Maryland US on low offtake offers. Or look at Great Britain/UK, a past leader at times in wind. For all 2024, for its 1st time, wind was #1 in energy mix, @30%. More than natural gas @26.3%. Zero carbon nuclear was 14%. But UK was also badly, sadly, de-industrializing; while electricity imports were much too big @ 14%. Biomass 6.8%; solar 5%; hydro 2%; storage just 1.2%. A last coal-plant in Ratcliff closed 2024 so coal's fading from 0.6%, to nil. Yet on too-high electricity rates, UK is importing far too much costly electricity -- and natural gas (like from Norway)! At issue too, its 'Contracts for Difference' (CfD) at low £44 per MWh offered for offshore wind in 2023 got No takers, that auction flopped. Post 2024 elections, the CfD budget was raised >50% to £1.5 Billion, offshore wind offer £73/GWh. So offshore wind bids returned, 3,367 MW, 9.6 GW total CfDs awarded latter 2024. But far more is needed, if UK is to up its wind capacity by 4-fold, to go from 13 GW in early 2020s -- to a 50 GW targeted capacity by 2030.

UK has suffered from stop/start wind support, falling energy production overall; poor grid; onerous permitting; little energy storage. For instance on 10 Dec. 2024 forecasts were for 2 windless days: output could then plummet from >7 GW, to 2.2 GW. Prices rose to £175 MWh, steepest in 2 years. Meant more costly gas to be burned. Thus needed, is far greater energy production overall in UK, plus storage capacity, plus stronger UK grid. And an end to sending overseas billions of £ pounds for energy imports. That imbalance remains a huge issue.

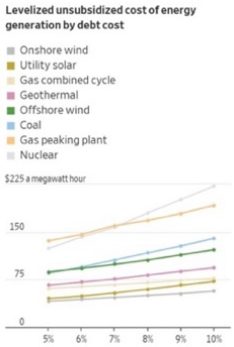
EU too, is far from 2030 targets. A cash-strapped Germany stepped up especially in 2025. Yet China led wind by far, and growing -- unlike a declining west. By 2024, the 3 biggest global wind makers by market share were all Chinese: Goldwind (installed 20 GW), Envision (13 GW), Mingyang (12 GW). Wind power grew 12% year/year on China's domestic demand; fell 9% in west; a story as seen eg in solar, EVs, batteries etc. In solar, German PV support saw 124 solar projects, 1,600 GW new capacity: solar prices 2024 fell to USD $0.056 (EUR 0.051) per kWh, better/lower than prior USD 7 cents. In the US, offshore wind supply chains immature, things were sanguine on the president aiming to shutter wind permits in federal areas 2025-2028. Still extant onshore wind & PV were 2 cheapest-US options, considering energy costs vs. debt. Clearly far better vs. 2 most-costly options: nuclear & gas peaker plants. As coal/ offshore wind sat in middle on costs. Hence 3 relative US winners then were *Utility-scale solar; *Onshore wind; and *Baseload if via just-cheapish natural gas combined cycle:




Source: FactSet, Wall Street J.




Source: Wall Street J./ Bloomberg NEF




Source: Lazard, Roland Berger, WSJ.

Hence for green energy stocks, China overcapacity was an issue. Shorn of market guardrails, of profit/loss signals of the west, profit margins were decimated worldwide. As a west in 2025 resisted buying/ soaking up China's overcapacity & began applying tariffs, results ahead could go a variety of ways, many impactful. And the degree to which China has been / & is still now outspending the whole rest of the world on clean energy, is gob-smacking.

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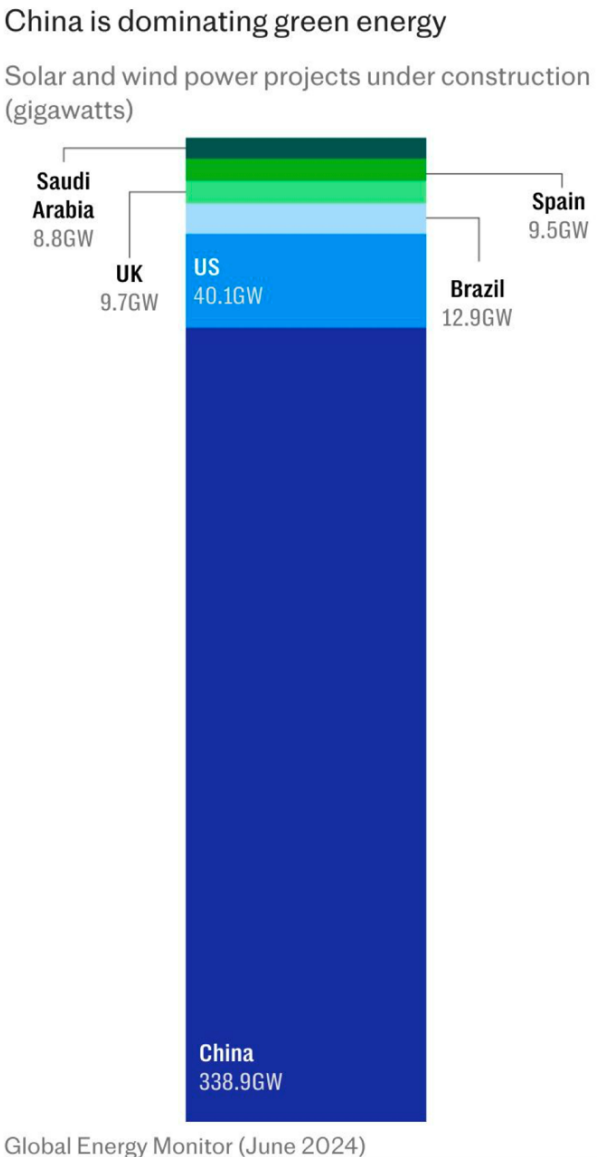
Here's global construction in June 2024, for renewables solar & wind: it's obvious how much China leads the world. Had this chart included somehow efforts worldwide too for electric vehicles, batteries, storage, grid etc -- well this lead by China, would be more jaw-dropping. Folks in west may talk about 'massive efforts' that are going into renewables in 2024 in US -- or in Europe -- but this **2024 lead by China, deep blue below,** puts all into perspective!

Take US record growth 2024 under an IRA and an encouraging white house. New US solar grew then by upper 30 GW in 2024, beat prior record 2023, with big gains in Texas. (Battery storage roughly doubled too although not in chart). Yet, America's 'big' ~**40 GW total construction, mainly in solar / (and some in slower) wind below** was 'near-nothing' vs. China:




Seen at left, wealthy Saudi Arabia in 2024 poured efforts into building immense solar, given ever-unending sunshine, 'limitless' deserts, need to prepare for when oil & gas are no longer in demand. It aimed to get 50% of its electricity from renewables in just a few years (2030?). But its bar for 9 GW left at top, **in deep green,** is here thin.

Spain is much-acknowledged in Europe for growing its solar 'fast', already is leading in utility-scale solar capacity (30 GW); though wind growth there is slowing. Yet their ~9.5 GW total construction, left in green, is just visible as a thin here too.

UK has left centuries of coal; great! But so sadly de-industrialized, less-demand, its oft-imported, priciest gas is ill-suited for baseload. Nuclear sees immense cost over-runs, delays. And its grid charges nationally very high rates set by a priciest (often imported) LNG. De facto wind bans, with support for it in fits & starts. Much better is now needed: in its grid, to streamline permitting, more renewables, and a low-carbon baseload; this 9.7 GW is a start.

Brazil was adding a record of 13 GW new renewables capacity in 2024, almost all solar & wind. And yet, this 'huge' amount at left, light blue, seems like a rounding-error -- versus growth in China.

When one considers 338 GW going into China above 2024, their seriousness is undeniable.

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As poly prices 2023 fell hard in China -50%, panels by -40%, it was tough for anyone in Europe, or America, trying to compete. China's glut was thorny even to its own solar-makers. A state-guided economy sought full employment, ever-lower prices, more market share. In 2022, as China was 90% of world spending on clean energy, a bewildering array of its firms sought to make PV, so extant China firms halted expansion plans. 70 listed firms there moved into PV -- from dairy farming, fish feeds, jewelry, real estate, chemicals etc... (Bit of a story seen before; Toyota of Japan started in weaving looms). A Chinese poly leader defied oversupply; it aimed to *add* 575,000 tons capacity, beyond 200,000 tons needed on market growth. After a China oversupply shakeout in 2010-13, and 2018-20, fears were of a 3rd wave; of China prices falling to maybe record lows well under <USD $6/kg. China global poly share rising to 90%. Yes, non-China poly may command *somewhat* higher prices on aims for a domestic product. But at such very big and widening gap, the cost difference was getting 'ridiculous'...

As PV profits collapsed, margins contracted, solar was challenged. Finished China PV was *sold* in Europe, at near ½ cost of *producing* panels in Europe. Winners few. China 2024 looked to lift a 5% cap on curtailments -- for more green energy. In a side-point, solar *may, or should in theory* be huge: a square 100 miles x 100 miles solar in southwestern US deserts, in theory, *could* make all America's electricity. 0.06% of US continental land make 4 million GWH. Of course it's intermittent, as solar, so add 1x1 mile batteries. Add another 1x1 square mile of storage via green hydrogen, or ammonia, e-methanol. Powerlines to move power, IX/TX so more space. But it's viable, goes past thermals coal, gas, nuclear. China can do it + on PV/wind many-fold over. Nothing technically prohibitive. China sop up its own excess capacity on PV made + used in vast interiors, Gobi, western deserts. Consider in 2024, electric power made there equaled ½ of all US generating capacity. 500 GW in northwest China, five inland provinces and Xinjiang plus 100 GW more in Gobi = 600 GW growing fast. Most new energy in northwest China is now solar/wind + high voltage DC transmission lines. Over 500 GW new solar/wind was planned in China, perhaps hundreds of renewables mega-bases. Kubuqi desert energy base may be 16 GW when done. As India now builds too. All dwarfing anything in a US! There's immense renewables mega-base potential ahead in China deserts. As well ahead in India too. A Kardashev Scale for civilization's progress, underscores the potential.

Ironic, economically, as solar stocks fell 2021-2024 in part on overcapacity. China production targeted ~750 GW, yet demand was ~550 GW. US faced 100+ bankruptcies in a downturn. An analyst felt it may get worse: 500 US residential PV installation firms in trouble; an estimate in 2024 was that of 5,000 US solar installers, some 10%-15% may disappear. And California by its own hand had scenario NEM 3.0; ½ its residential solar installers may not make it. California's NEM 3.0 as noted ahead means a Golden State looked at maybe a huge 50% plummet in its residential PV installations! New rules there had made home roof PV, alone -- without battery storage -- an unattractive economic proposition from 2024. Once a leader, a prognosis there for 2025 was for only maybe a shallow recovery. Maybe a stronger 2026 … Yet a time of rather dismal profits for rooftop solar PV then, in once-proud California.

A longstanding US solar name issued a going concern letter. An abounding uncertainty may shed some light on why solar stocks were down 4 years 2021-24, as PV installations were in a real sense, growing globally. Yet on possibilities of some 'right-sizing', perhaps prospects *may* improve ahead for green energy profits. For instance, late 2022 to mid-'24, pricing for lithium carbonate had collapsed from $84,000/ton - to $10,000/ton; Li is key for EVs, li-ion batteries. Note then, that Fall 2024, as a huge so China-based producer looked to maybe shut-down one of its mines, and a production line too, global lithium stocks then jumped broadly.

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For what Europe's few PV makers faced, some Chinese PV was sold at *below* production costs. Europe doesn't impose Tariffs (unlike the US), so China PV was sold at *half* of US prices. Downstream, European installers opposed Tariffs: they wanted the cheap panels. India added another 20.8 GW PV manufacturing capacity, 65 GW. All the spare capacity dim prospects to grow PV manufacturing in EU, US. PV price wars, like EVs, China eyed making EVs in Mexico -- chilled industry. As China grew capacity & efficiency in search of demand. In 2023, China installed immense 216 GW of solar. *More than a US, which had invented PV, and had installed record for-it 19.6 GW of utility-scale PV in 2023, had ever installed to date!*

For scale & pace of solar pricing declines, consider 2 compelling paragraphs from Raymond James of February 7, 2024, that marked a milestone of ten cents per watt PV modules:

> "Welcome to the world of $0.10/watt solar PV modules... this milestone, reached today in the benchmark price data, has been a long time coming! There is no clearer case study of clean tech commoditization than this. While there is nothing "magic" about $0.10 or any other price point, it is a symbolic milestone and an illustration of just how far the solar value chain has come with regard to cost reduction." ….
>
> "Let's first review some history. In 2008, just before the global financial crisis, crystalline module pricing (we are using PVinsights data as the global benchmark) was $3.00. By 2012, it was $1.00 – a drop of 67% over four years. After another four years, with a more moderate 50% drop, it was $0.50. As shown … declines continued until … $0.16 in 2020, when COVID-era inflation and supply chain complications spurred a two-year period of rising prices that peaked at $0.22 in 2022. This was followed by an extremely steep drop of 45% in 2023, with the year ending at $0.11, en route to $0.10 as of today. Putting everything together, modules are 97% cheaper [in early 2024] compared to 2008. Can you think of any other physical product, energy-related or otherwise, whose price is down 97% over the past 16 years?"

Above excerpt makes clear how relentless, ruthless solar manufacturing in or beyond Asia -- had become! Yes, steeply falling prices were & are conducive to adding solar capacity. Module pricing in mid-2024 was about just ½ that of March 2023. All as wind too, faced its own issues: inflation in materials & labor, warranty claims, inadequate off-take prices -- all hurt. Bit of hope was maybe of some bottoming; perhaps small profits a hoped-for salve for wind.

All amid PV overcapacity mid-2020s; China *could* manufacture twice the number of PV panels being placed worldwide. Yes, near-term to end of decade, US electricity demand may grow to be 10% be from AI, data centers. Solar PV *may* well become planet's single biggest source of electricity mid-2030s. Then 2040s solar may be *the* biggest source of energy -- not only of electricity. And that electricity might cost just ½ the cheapest electric power today. So, the future, just perhaps, may be rather pro-renewables-biased. Still, getting past a tumultuous mid-2020s to reach perhaps profitability later, wring out over-capacity, has been & still is a huge obstacle. Thorny gulf to navigate, if ever! Hence a big question mid-2020s was & still is: how long must loss-making themes endure dismal margins, before unsubsidized renewables, EVs, batteries, grid etc might better become profitable …. Perhaps some insight may be found first by looking back in time, to how we got to this point today.

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To start, how could a US that had invented this practical silicon solar cell, have lost its big poly-making industry-lead to China? Even briefly told, this is illuminating. Bell Labs in 1954 created a modern solar cell; commercial versions soon arose but PV costs meant it was used only for-space @$1,785/watt. Costs began to drop as new ways to make 'poly' more cheaply were found: it's also key in making microcomputer chips. Know-how to melt sand at sufficiently high purities for necessary elemental silicon, polysilicon -- was held by just a few big, staid poly (chip) leaders in a US, Japan, Germany. They mainly made highly-refined poly for chips; by 1976 poly for solar cells globally was a tiny subset, miniscule at <500 kW. Rejected poly just from making chips was enough to satisfy all PV demand. Even years later, in 2010, the world's then-biggest solar poly producer still mainly made computer chips; it was based in Michigan US, and it supplied about 1/4$^{th}$ of the world's solar-grade poly.

15 years later, mid-2020s all had changed. China by then was making >90% of the solar poly -- as US/ Japan/ Europe were all-but-out. Why? While blame is oft put on China's subsidized loans, government incentives stimulating green manufacturing, IP theft, few environmental regulations, super-cheap labor and land -- a case may also be made it was due too to 'normal' aggressive, private investing by its own entrepreneurs convinced of solar's future. Plus importing least-cost practices, & on its super-cheap electricity. That said all would lead soon to it dominating poly/PV worldwide, leaving just husks of collapsed firms outside China.

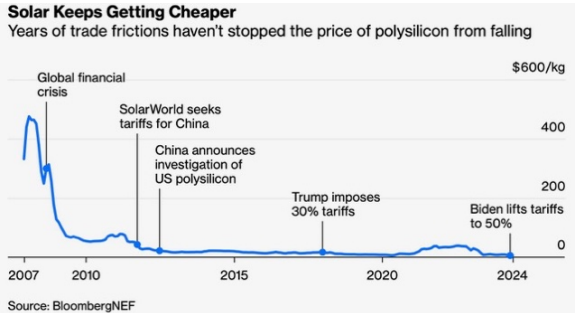
Moore's Law famously shows number of transistors placed on poly chip doubles every 2 years. Such is the room to advance on a silicon base. In China's case, it had faced around year 2000 many vulnerabilities with few oil reserves, and oil price spikes. Its government chose instead to target new poly/solar manufacturing, to maybe begat a new poly & solar PV-boom there. Until then, poly rejected in chip making (needing highest quality, defects <1 part in 10 trillion) was enough to supply PV cells, only needing defects <1 part in 100 million. But early 2000s, seeing opportunity, entrepreneurs in China began focusing on making their own solar poly, & then modules, in fast growing amounts -- hence at ever-cheaper-costs per watt.

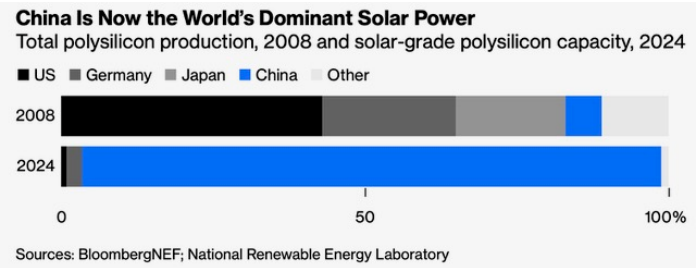
Early 2000s global poly industry grew: that US PV poly producer invested to grow capacity. By 2005 it announced plans to invest $400 million, later, another $1 billion. A lot. But consider too that near 40% of costs in making poly, is the electricity costs. Michigan is industrialized and boasts huge GM & Ford factories, yet electricity consumption by this one poly producer had made it The Biggest Consumer in the State. Cheap hydro power like in Washington State once attracted aluminum producers to it who could then make airplanes. But Michigan, did not have super cheap power. Mid-2000s just 10 sites in US, Japan, Europe made nearly all the poly for computer chips (so for solar panels too). And they all were run by just 7 companies, so obviously the few were not seeking to do it as very-cheaply as possible.

Meanwhile in China mid-2000s, an entrepreneur seeking new business opportunities took note of Yangtze River, world's largest hydroelectric plant Three Gorges Dam, Sichuan's very cheap power-generating capacity exceeding demand. Given 'fat' profits being enjoyed by a few poly producers in the West & Japan, he invested $428 million into a plant dedicated to making cheaper solar poly. Many other investors in China seeing this, soon did likewise believing they too could make poly for PV cheaper than US, Japan, Europe. Noting too China's sparse protections of environment, workers rights, meant 'cheaper' growth. It ignited, swiftly led to overcapacity: by 2008 China's new poly industry had 20,000 tons poly producing capacity, while 80,000 more was in construction -- versus solar poly demand that year just 4,000 tons! Capacity for making the completed PV panels to use that poly, was only beginning.

On a 2009 financial crisis, governments everywhere had reigned in PV subsidies. China's poly, burdened by huge overcapacity and dependent on export-led growth, crashed. Manufacturers began selling poly at any price. Spot PV poly in China in 2009 briefly fell near $15, far cheaper than producing it elsewhere. After rising back up, later again crashed: Aug. to Dec. 2011, China spot poly fell from $50/kg to $25. Again undercutting that biggest US (chips) poly producer. Around then, a German manufacturer with poly plants in Oregon asked the US to impose duties on Chinese poly, arguing it was being dumped at below cost. That was granted, and China responded by imposing its own tariffs in 2013 on US-made poly. Those hit the once-'huge' US poly manufacturer hard. Many of China's paused domestic poly producers could re-open and with new protections, they returned to producing in ever-greater quantities.

In 2020s new Chinese poly producers sprang up especially where electricity was super-cheap. Like near Hydro dams, or by abundant solar & wind power made very very cheaply. In Sichuan, in Yunnan -- and/or Mongolia with so much sun & wind (but also its filthy coal). In 2024 poly prices had fallen further, to just $6; so after brief bump early-2020s, that had resumed falling. One can see in a chart below at left, the huge drop in poly prices since 2009 but for brief rise in early 2020s. At right we see China starting near-zero, came to dominate poly globally: this has been an eye-opening change since 2003 and one that we've witnessed:




2024, one single China-based producer had capacity to make 480,000 tons of poly/per year and it looked to double again. Versus a once-biggest US producer of poly -- that could then make 'just' 30,000 tons/year. To put this in perspective, that 480,000 tons of poly/year was enough to build solar panels that could power UK & Ireland for a year, or Mexico for a year. As sun rises anew each morning, these panels will go on making power, lasting decades. (Our rooftop panels here have powered our building reliably for 2 decades+ now). So compared to oil & gas, a gallon or a BTU of which can be used only once -- over their lifetimes: these solar panels will provide nearly 5 times as much useful energy to our planet, as all oil & gas reserves of an Exxon Mobil. A gasoline gallon is energy dense but combusted, used once in propulsion; that spent energy then becomes useless. A solar panel keeps working, renewably! But perhaps a most helpful fact in Chinese solar startups' growth, was certainty of China's support for green energy & solar. The West by contrast, oft pulls back support (like 2025); so what once was its thriving early solar-lead years ago, later disappeared. A lesson in there somewhere.

We may see it repeated late 2020s in artificial intelligence. AI, invented in the US, is energy-intense: a search on ChatGPT uses 10x that of once-standard google. Data centers were once just 4% of US electricity demand 2024 -- may grow to near 10% demand 2030. For US to keep its leadership, nearly 50 GW of new electricity generating capacity may be needed by 2030; 7 hyperscalers (AI users) each may need 5 GW as soon as 2030. By contrast, China is seeking to become *the leading* AI superpower by 2030, it's building 11 nuclear plants costing $31 billion, has 155 AI-related projects. Huge State Support. So, may happen in AI too: China may swiftly overtake the US, unless action on AI is undertaken fast. But that's another story.

Some tailwinds *may* help clean energy: *Older Utility-power is now getting far costlier; *US electricity Demand 2025 beat records. As *Heating & transport get electrified, *new AI, and re-shoring US chip makers mean GWs of demand: new gas plants to supply juice would be a pricier 7-9 cents per kWh; *nukes trying to match that typically end up as far more time/$$. A US that once spent $400 billion annually on oil imports, was by 2024 the World's Biggest Oil Producer (70% shale) & Gas (80% shale) thanks to shale fracking revolution! And yet, US gas only met a steady 43% of electricity demand in 2024. *Nuclear is costly in a West where nukes met a static 19% of electricity '23, '24, '25. *Costlier coal's share fell from 20% in 2022 to 17% in '23, to 15% in '24, 14% in '25. Coal's role in US electricity 2023 just ½ vs. a decade prior -- mostly replaced by gas. Meanwhile electricity by new wind, hydro, and solar *rose* from 21% in 2023, to 23% in 2024, to 25% in 2025. Growth, yes, but was Not nearly fast enough.

Sec. 45(X, V, Z) tax credits helped build US solar, wind in 2024, but would they survive under a re-elected president hostile to IRA? And for US makers of wind, PV, inverters etc, much is commoditized. Hard to differentiate premium brands. 2024, the biggest PV maker in China so world, asked its own government to bar competitors from selling PV below cost; sub-par failing panels were giving solar a bad name. A US premium solar brand, IP protected, initially guided Up for 2024 with revenues expected up 36%, 2/3$^{rds}$ on new Sec. 45X credits. One analyst felt a leading PV maker of competing commodity panels may trade 8-12x EBITDA -- Earnings Before Interest, Taxes, Depreciation, Amortization. They expected long term revenue growth 8-12%, EBITDA growth 1.5x; that stock then traded at multiples of just 5.5x 2025E EBITDA, so hardly a high or risky estimate. Hence latter-2020s may be an interesting time. One may look around & see if overcapacity, margins are being at last better-addressed. Equities, as ever forward-looking may seek to anticipate profitability -- and *might* move ahead of that.

In other news, $7 billion had been slated ahead in federal funds for 7 US hydrogen hubs, but may be dramatically cut from-2025; just fossils $H_2$ surviving. Like an Appalachia hub's maybe $925 million on natural gas -- for so-called 'blue' $H_2$ that isn't truly clean. Or Gulf Coast $1.2 billion partly natural gas to $H_2$ so not truly clean -- and in a red-states region. A blue state California's $1.2 billion was to be renewable $H_2$. America Heartland $925 million was to decarbonize agriculture fertilizer-use. Atlantic was $750 million for $H_2$ by renewables, but also from nuclear. Midwest was for steel, glass, power production, also sustainable in aviation fuels at $1 billion. Pacific Northwest electrolysis for clean $H_2$ was $1 billion. Of course, green, locally clean-$H_2$ using 'additionality' from new renewables solar/wind -- is always best. Made from additional clean power+$H_2$ -- matching hours the sun shines, or wind blows. But in 2025 more important seemed maybe whether it was in red-states region, and tied to fossils.

Fossil interests are clearly growing. A COP28 Climate Conference late 2023 choreographed a shiny (oily) veneer of success. It highlighted global Agreement for 3x renewables by end of decade: nothing wrong there! The petrostate heading it was smart, put that 3x in front. But what they did Not highlight, was also worth considering. Fossil representatives had dominated COP28 like never before, at ~4 times the number of attendees vs. Egypt a year before. Its 2,400 people was greater than any Country's Delegation, save Brazil. Quietly they'd put the *Petro-states' interests as a main centerpiece -- eg citing 'carbon capture' that can allow oil/gas, and coal to go on decades to come -- while also *Removing teeth from final language. COP Drafts went from "phase out" of fossils -- to softer "transition away from". Some silliness like "responsible yachting". Worse was wording to 'accelerate' [so-called] 'carbon capture and storage'. COP28 end-product was deemed 'devastating', 'dangerous' by many climate scientists, who often used much saltier language. In sum the fossil-focused nations viewed this COPs 'favorable' result as significant success, indeed they Voted for its outcome.

**Other Recent Items of Relevance:**

Looking at recent past. there were especially interesting times, like say, 2019. S&P profits then soon would hit a record. Government stimulus was about to flow; profits jump +25% to records. Still, looking back, operating margins were also about to hit a plateau. By 2021, less room for growth. And soon, pessimism was backed by metrics like a Cyclically-Adjusted Price Earnings (CAPE) rising near 40. A CAPE since 1877, had only hit 40 once-before, in dot.com frenzy and we recall how that ended. When S&P500 fell -40% over 3-years in dot.com declines, it took another 13 years for that S&P500 to once again, to re-reach its prior levels.

From 2021, a new headwind too was higher interest rates hurting equites. Not long-before, investors got near Zero % from bonds. So, demand grew for higher-risk themes, better-returns at times. But, if low-risk bonds & alternatives soon boast respectable rates -- Treasuries etc seeing a capital return can be a smart place to call home. Real rates 2014-2018, had meant inflation-adjusted 10-year Treasury yields expected just +1.0%. On Covid, fell to eyebrow-raising *negative -1%*. As PEs rose from a 'common' 21 - to 27, CAPE went from a normal 20s -- to a yikes! 38 in late 2021. Rate hikes that followed were bearish for stocks. All fundamental points in first ½ of 2020s. For instance, in December 2024, CAPE had again reached near 38 -- 3rd highest point while in a bull market since 1871. Only 6 times before had CAPE gone over 30 in 153 years; and 5 of those times, Dow, S&P500, and/or Nasdaq subsequently had declined between 20% and 89%. So, a high CAPE = was some reason for concern! In 2025 a newer look at CAPE though did reassess in light of just current components. Because deleted components removed from S&P500, can skew CAPE 10 years after removal, by looking instead at only these data for current components, those revised calculations since the spike of 2000 -- saw CAPE in 2025 at a smaller 2nd rise. This a 'current components' CAPE, was bit less alarming.

If the threat was Not of 'Unprecedented' inflation -- like it had been in a much higher 1981 -- maybe it was inflation might take root, grow hard to kill, rates higher for longer. Inflation is partly a state of mind, psychological. If expectations take root, both higher rates + stagnant / sluggish economy can mean stagflation; Fed tools are wickedly un-useful in recession. No central bank aims to hike rates, going into a recession, an economy cooling. Equity-risk premiums for risky stocks (vs. safer bonds) makes equities a decidedly unhappy place to be. CD rates over 5% = a new world vs. 2020. High 1970s rates were something a young generation doesn't viscerally remember. A decade to 2022, no G7 central bank had rates above 2.5%. But in 1990, they'd all been over 5%! High rates 2020s were decidedly not great for volatile, high PE green themes. Made 'entry-point' tough; it's impossible to consistently time markets.

After a US 2024 election & red wave, policies crafted to help fossils -- hit decarbonization. A new US administration looked to maybe erode the legal, scientific, administrative bases for undertaking US climate action. Think of a Paris Climate Treaty; initially the US was in it, which sought pro-renewables policies. A new president in 2016 pulled out, in their 1st term. After US re-entered, in 2025 this president re-elected pulled out of it again. We've written about this in 'Pulling Out of Paris' in the Stanford Law & Policy Review, https://law.stanford.edu/publications/pulling-paris-united-states-withdrawal-will-not-matter-much/ Notably, far stronger domestic US actions after advanced, too. Their first day back in office in 2025, the president issued an executive order to start a process of looking at striking down the EPAs power to regulate $CO_2$, greenhouse gases, via the foundational 2009 'endangerment finding'. This finding was made possible by US Supreme Court ruling in *Mass. v. EPA* (2007). After it the EPA in 2009 found a broad range of gases could be regulated via Clean Air Act. Under a 'major questions' doctrine, significant executive actions require express congressional authority, and it had not been given here. Hence, removal of 'endangerment' would be huge.

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To do so could dramatically curtail ability to regulate 'in-scope pollutants' on Clean Air Act. Administration might then reverse decarbonization, net-zero goals. Yes, they also can intend (more so for oil & gas) to streamline permitting, improve grid. That in theory may enable renewables too, as solar/wind can be the cheapest domestic energy. And if there's a rising tide of energy abundance, that may lift all boats. But with renewables then Under Attack, there was uncertainty, even chaos. These next years should be interesting indeed.

Another big, relevant factor in recent years, was war. Big moves down in equity valuations -- or up, are oft associated with surprise. And so a big 'surprise' in Feb. 2022 was war, energy used as a weapon. Fossil prices spiked as shooting went beyond Crimea & Donbass; all hell broke loose. First weeks of war in 2022, ECO jumped +40% from intraday 101.64 on Feb. 24th at invasion cusp -- to 141.82 on March 30. Maybe on re-assessments round the world 2022 of a fast transition to clean like here. And a need for energy security: 13 European nations had in 2022 relied on Russia for >1/3rd their oil. Yet ECO soon after, fell back to <90 in 2022 -- then into 30s in 2024 & 2025. As US fast grew natural gas LNG exports 3-fold after a start of war, all huge! Still, arguably Russia's invasion shouldn't have been such very big surprise -- if one had been watching closely early-in-2022. There were then small hints.

To global intelligence assets watching a run-up, there'd been warning signs. To wit, months before invasion, Russia had moved 3 LNG ships to its geopolitically-vital, stranded Kaliningrad Oblast on Baltic Sea. Natural gas was piped there from Belarus, via Lithuania to Kaliningrad; this had kept Russia from potentially shutting gas to Lithuania. Re-positioning ships unusually to Kaliningrad, gave Russia an option to *possibly* sever gas. Gave Kaliningrad 4-5 weeks' gas. Vital Kaliningrad Oblast may let Russia try to alter NATO power in its own backyard, as may Suwalki Gap link to Belarus. So was notable Gazprom sent its ships Energy Integrity, Velikiy Novgorod & Marshal Vasilevskiy regasser in Jan 2022. Before, that first ship had carried its LNG from Russia's Far North to Asia. To re-position Integrity, it weirdly went long distance, Cameroon to Kaliningrad. It carried gas before, to China, only 2 of 58 shipments to Europe -- so all unusual. Having moved LNG ships meant if a conflict began, and went past Ukraine -- Russia with gas as weapon may keep strategic Kaliningrad outpost, 4x size of Manhattan and militarily significant, energized for weeks. Perhaps Russia at first envisioned a possibly quick run into Ukraine, then Kyiv falls … maybe afterwards, try for a bigger claim to Baltic Sea off Kaliningrad. After invading, June of 2022, Russia's leader mused about how Peter the Great had once 'taken back' … 'Russian land' from Sweden; he gave in the speech a 'shout out' to Narva now in Estonia. Notable too is that what's today Estonia, much of Latvia, once had been captured by Russia's Peter the Great back in a Northern War from 1700 to 1721.

It seemed invasion *might* happen -- though some experts felt it was 'impossible'; Russia denied any plans to invade Ukraine. Germany's Navy Chief took Russia at its word, felt Crimea was forever lost, 'Russia wanted respect', nothing more. When invasion did begin 2022 it was clear from a start Ukraine was in precarious spot. Concerns worsened, extended even to Narva in Estonia, Gotland Island in Baltic. Yet narrative of maybe fast gains by Russia got flipped on its head post-invasion, as tanks heading towards Kyiv were stymied. Lithuania, Europe etc, found leverage as they stopped buying Russia gas. Vilnius etc fast went to floating regasser vessels to import LNG via Qatar, Norway, US. Germany needed 90 billion cubic meters/year -- it aimed for over >90% storage 2022, a mission swiftly done. Floating re-gassers became all the rage. War was 3D chess game and via LNG, Russia no longer had so much gas power. Still, Kosmos 2553 rocket launch (anti-sat warfare test?) was a bit worrying for the integrity of the West's satellites. Plus, on fears that key undersea cables could be / will be cut.

Russia moved 3 MiG-31 warplanes & Kinzhal Dagger hypersonic missiles, bit like China's DF-17 hypersonic 4,000 mph carrier killers, to Kaliningrad for defense (or offense?). Susceptible to Patriot missiles, smack in NATO 'twixt Lithuania & Poland -- yet Kinzhals had obliterated Ivano-Frankivsk depot. In a far more pathbreaking change, Germany at last, swiftly ended its long overreliance on Russian gas. Russia/Germany once promised Nord I & II commercial only -- not political. But war & gas cuts put paid to that! Germany moved plans forward 15 years aiming for 100% renewables maybe by 2035. It started planning 20+ GW/year solar for latter decade. Onshore wind, 10 GW/year. Offshore wind capacity to hit 30 GW by 2030; 70 GW by 2045. Germany's Greens 2022 swallowed new LNG terminals -- to reach 100% renewables sooner. Hopes were in some places to shut its nuclear, zero-out coal; but if no Russian gas, something fast was needed to fill gaps as renewables got built. Faster-storage; more new LNG terminals that could be used after maybe for $H_2$ 'til renewables take over. Still, gas storage may get past normal winters/summers… but what if, few-reserves left, high demand returns!? In 2022-24 Europe had moved fast to non-Russian gas. More alternate LNG routes than anyone (Russia included) had expected. But, would that be enough latter 2020s in cold/heat??!

Clean energy so ECO did rise briefly mid-2022. In Real-Life 'IRL', oil & gas jumped like little in recent memory. My, what reversal from what we'd seen in fossil fuels last decade! With a new 2022 US IRA law, clean energy so ECO had briefly jumped. Jan 2023, late-2024, then fell! One item that had set a stage for volatility was a long-ailing, then failing $4 billion+ BBB bill: on a repeated staccato NO -- then a Yes from 1 US Senator to pass the IRA. After that, inflation and lack of profits arguably helped push down clean energy equities hard 2021 to 2024.

How is it solar/wind did so poorly after 2020 (if up briefly, a bit) -- as fossil prices at times, spiked??! As noted, overall, energy prices tend to reflect the 1 fuel that is the most crucial -- the 1 that is key to grid stability. Rather like how income tax rates reflect last marginal rate on highest/ last dollar earned. As natural gas is key in power generation, it prices electricity. When natural gas prices did spike hard -- electricity costs did too. US electricity by coal rose +22% in sympathy (with gas) in 2021. Natural gas spikes shall recur, like seen early 2025. Falls too, like 2023/24 -- though oil may jump. Given that renewables do Not determine electricity rates. Meanwhile, natural gas prices that eg *rose* in 2021, can/will fall back at times, spike again unsurprisingly like early 2025 -- on the longstanding fossil boom/bust cycles there.

What's Past is Prologue. In 2021 an oil price spike had come only *after* fossils plunged 2020. Only *after* US coal production hit 50-year lows, after 151 mines were closed/idled. Only *after* oil hit historic lows 2020 on Demand Collapse, fears of 'tank tops' so little storage. Meanwhile, much oil industry early 2020s sought oil >$60; so oil down at 'just' $50 in 2020, punished shale producers. $40 oil was misery to them. Equities are forward-looking; oil in 2020 hadn't been very attractive for investment. Only with supply cuts, some output shut+renewed demand post-Covid discussed ahead -- did oil roar back $60s-$90s/barrel on supply curtailments 2023, 2024. From 2025 new US production including Alaska and mainland may bring prices back down, if a bit painful for Russia, Saudis. At any rate, if there's again high/ dear oil & gas prices, that too may(?) yet again make renewables more attractive in years ahead.

A key point to be repeated, is, *Costs for wind & solar electricity by contrast, can/do go very low and stay there at times, naturally.* It's a characteristic, indeed trait of renewables. Oil, by contrast, faces make or break price floors, beneath which industry suffers. Oil busts mean lost jobs, lost-capacity, non-producing wells shut-in eg in 2020 as oil hit a floor. What changed dramatically 2021 after a demand destruction -- was renewed demand. It's aptly said that 'the *cure for cheap oil, is cheap oil'* -- and lo & behold, fossils had jumped in 2021.

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Said another way, were prior 100m+ barrels/day of oil drilled in 2020, it could have prolonged collapse. In coal, *Global* demand after rose, prices jumped +25% in 2021; gas too up on war. In the US, coal's economics are dismal; miners look more to where it's burned, Asia, Europe. Today, the fact America's own domestic coal supplies had once been last century's cheapest, dirtiest, most stable source of US electricity, suddenly is no longer much in its favor.

Discussed ahead too so just touched on here, is greenwashing by fossil interests. Like hyped 'blue hydrogen' -- though methane leaks can make $H_2$ (hydrogen) made from fossil gas, nearly as bad, as burning gas directly. Future bodes ill for blue H2. Yet scarily, electricity made from gas will still be big in US, and & China in 2030. On climate crisis it's a huge worry, as is burning coal. Rich Europe *may* in 2030 have reduced gas-use sizably -- coal more so, but big stumbles like acute gas shortages discussed ahead. Like 2021 on China's coal-use records; 385 million tons of coal mined walloped prior levels. A new global record, its coal grew +9%. More coal used 2022, as gas costs rocketed on war. Even in rich EU coal made more electricity in 2022 -- than in year before. Europe/Germany *may* go over 50% of its electricity from renewables, by 2030. But, scarily, the fact 1 or even 2 of the world's 3 big blocs may still rely much on non-renewable gas (burning coal too!) at end of this decade, looms large. As does sneakily, inevitable hydrogen leaks: a 10% leak rate by this GHG may obviate advantages.

A horrid issue discussed ahead, was possibility of forced labor in China. Awful to contemplate, it had led in 2021 to a Withhold Release Order (WRO) by US Customs. Anything from forced-labor obviously would be wholly wrong. Thus, makers of PV etc must carefully vet, address all supply chains. Tracing complex supply-chains takes time & effort. By 2022, Gigawatts of solar PV from China passed -- yet some was withheld from entering US due to this WRO issue. It has begun to be addressed such as by WROs, and we are watching carefully.

Broadly, change is afoot. Maybe spiff electric aircraft helping electrify all, challenging a past fossils hegemony in short-range air transport; even EVTOLs that make use of FAA Part 103. Cleaner power too for ships. Batteries made of lower-carbon lithium, or graphite. 'Greening' rare Earths in wind, EVs -- or avoiding rare Earths -- instead, ferrite, strontium increasingly substitutes 2025 onwards, even if less magnetic potential. Likely recycling batteries, new circular economies. In 2023 a Model S from America's leading EV maker had cost $4.33 on average to charge at home; that saved $10.87 over a 'gasser' car's then-fuel costs. Such a delta will favor EVs, especially when gasoline prices spike, as they will do at times!

On $CO_2$ levels over 425+ ppm & rising fast, there's no true possibility of holding global heating to under 2.0 C. Let alone <1.5 degrees C -- a threshold already breached at times mid-2020s. Thus climate-induced weather whiplash forbiddingly may loom just ahead. Agricultural crises too, shortages of food, and of water/ on drought -- as well as ironically flooding given hotter air holds more moisture. Action necessary -- yet what's contemplated is nowhere fast enough. Other ironies too: Russia's war in Ukraine stoked new European energy fears, yes, pushed rich Europe to move faster, beyond Russian gas -- yet world is burning *more* coal. Talk of a new 'Marshall Plan' for green, yet still it's just dreams. Shorter term, LNG is a compromise that's embraced; one Germany's Greens grimly accepted, with reason: before war in 2022, fully 40% of Europe's piped natural gas came from Russia; after was just 8%. Yet 3 landlocked countries in that bloc still had to rely mid-2020s on piped gas sent from Russia to West. Unable to import LNG like by sea from US; rich Austria 2024 still relied on Russian gas for 97% of its piped gas imports. Likewise, Slovakia was at a high 89%. Hungary was at 47%. But, let's return now to US listed equities, and any interesting moves/coincidences in ECO first part of 2020s.

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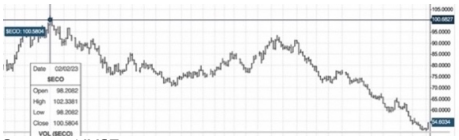
Next for data-lovers, are math parlor-tricks, a few coincidences discoverable in clean energy's story given so much data. Of mild interest only, thanks to ECO calculating live 20+ years. Take a volatile 3 down-years: 2021, 2022, 2023. Clean energy's story, tracked by passive ECO saw very 'steady' declines. So steady 1) Each year's high had come early on in 2021, 2022, 2023 -- AND 2) Followed by nadir Low, very late in each calendar year; AND 3) coincidentally too steadiness of falls took each year's nadir low down -½. For ALL Three Factors. Thus was 2021 286.89 intraday high on Feb. 10, 2021 -- AND fell to nadir intraday low very late in that year on December 29, 2021, AND that 142.39 low had dropped by a near 'neat' -½ (-49.6%).

Then, in 2022, green energy's story fell a 2nd time again from the high early on in that year -- AND to low very late in year, AND by near -½ at nadir. From a 1st day 2022 high at 152.87 -- AND nadir low that year on last day of 2022 -- AND a bit interestingly near -50% (-49.7%) to 76.02. Such a 2nd, -50% fall in this passive story again by chance only, seen looking *backwards* on rich data. Still 2 non-imprecise consecutive steady drops -50%. Looking for coincidences say Q1 2022, it also fell near, say, 100-resistance level 4 times. Or, early 2023 it initially fell repeatedly to a 70; of course, later that year it obliterated that fully-random, 70 value.

A few falls by near -50% in clean energy, so ECO, were mere coincidences in a data-rich past. Meaningless looking forward. Sometimes, was infra-year only; other times only start of year -- sometimes intraday, other times, at closing values. Can't be used to predict future, but do show *how volatile this theme is,* falling -50% early, even in a 2020 big up year! Or take a non-calendar 12 months say, end Q1 2021 -- to end Q1 2022. Meaningless as non-calendar period, yet went roughly 200-100, from April 2021 at 205.65 close -- to 2 lows Jan. 27th & Feb 23rd. Just noting again not far off -50% from round 205 -- to 102. War sparked a brief +40% rally in better solutions here, then fell back. But, to so cherry-pick from data, especially infra-year or day, is NOT predictive. Only bit of fun given so many data points. As Mark Twain humorously put it, "Lies, Damn Lies, and Statistics". Just playing with ample data, thousands of data points here. More importantly, this brief bit of fun is of no real help when looking forward.

Thus, one mustn't read too much into it, other than to confirm great volatility, often down! Like Jan. 2022 this passive theme fell by near neat -30% in blow-out. Or down -20% Jan. 2024. Never predictive, it's ephemeral. Maybe points a bit to 'enter on dips, sell on rips'! One thing noticeable here was a sheer steadiness as clean energy fell these years -- so 2022's high point/ and a start of year -- were nearly the same; 2022's low point/and end of year also near same. Just for giggles, conjecture, we'd seen 2022's high close was 152.87 Jan. 3rd (154.41 intraday Jan 4th), so hypothetical calendar year's low, if another 'exact' -½ down, just playing might be near a 76.43 nadir close very late 2022. Nadir low any day of year, is possible of course -- yet all the maths were it's very unlikely to be at very end of year! So was interesting to see when/where 2022's nadir did fall. Not surprisingly, *not* exactly 76.43! Interestingly, though, on Dec. 28, 2022 this theme did hit a 2022 nadir low of 76.02. As noted not so far off a 'neat' -50% nadir of 76.43. Just for fun, in rounding to whole numbers, both were near to 76.

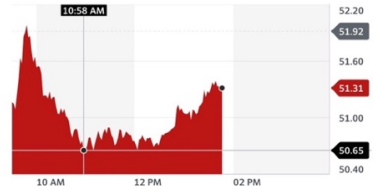
Hence for fun we'd looked 3rd year at What would be a 2023 High in clean energy's story. It did come on high of 102.33 (intraday) but just early-ish that year: Feb. 2, 2023. Of mild (but bit more) interest: might it be rather symmetrical fall in clean energy's story, -50% in theme; maybe hit next nadir -½ low, late in 2023 near rounded figure of 51 (or intraday low 51.16). A head-scratcher was how close to it, was born-out. Next page left is theme's high Feb. 2nd -- as ECO hit a rounded 102(.33) high intraday. AND far right, bottom, one sees a rounded 51 then-low was 1st touched on later'ish'-on Nov. 1st -- so near a roughly -50% conjecture:



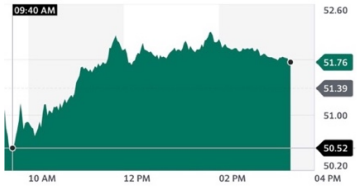
*Source: NYSE.com*

Oct. 2023 this theme was falling fast towards (past??) a 'conjectured' 51 low: it hit 53 on Oct 23rd; again 25th/26th. Then hit 51(.62) hard on 27th. Plummeting, felt like a rounded 51 (as floor) might be about to be decidedly breached -- so proven quite-wrong in that 3rd year! And yet. End of October clean energy's theme fast bottomed, nearby a conjectured 51 (-50%) -- touched again Oct. 30th. On November 1st it touched (only) tad lower, 3rd time low so far: still rounded 51. If this low were to hold as nadir all 2023 -- then near -50% conjecture might be born out, though Not Coming very End of Year. ECO is just a passive theme, yet curious coincidences may be discerned in a sea of data. Next, this theme did hit a low on Nov. 1st for a 3rd time in 2023, and that was barely still at an intraday low of rounded off 51 (50.61).

On Nov. 2nd this theme rose somewhat, laying-in 51 as something of resistance-level. A modest chance this low could possibly stand as nadir for year… rounded 51 (50.61) nearly 'as surmised/ conjectured'. But on other hand, shorts were then attacking solar, wind, EVs, fuel cells, hydrogen hard; one could guess a 51 might be re-tested, or soon fall into 40s. Indeed 10 days later, it touched rounded 51 a 4th time. A fuel cell name raised doubts as going concern, solar trackers were crashing, EVs hammered. In this environment was no surprise to see this theme again touch that round 51 low (50.65 intraday) on Friday, Nov. 10th at left. It touched it a 5th time at about 51 (just barely so, at 50.52) at right Nov. 13th:




*Source: YahooFinance.com*




*Source: YahooFinance.com*

And then, it held. So, 2023 did Not fall to 40s, nor bust 'just-for-fun' conjecture of story -½. A lane opened for maybe Rate *Cut hopes, which* reduced concerns. Theme leapt into 60s, a big jump, yet arguably premature. Hopes in 2024 went from 4 cuts -- to maybe 3, to 2, or less. Looking back, 2023 saw just 1 of the 3 'AND' factors: low near -50% clearly fulfilled. A high at near year's start, and low at end of year, or 2 of the 3 factors Not so fully-fulfilled.

Then 2024's high literally came on 1st day of year, at 62.38 (intraday); so was a bit interesting to see if a nadir ALSO might be late in year -- AND down – 50% (to 31.19). Such did Not happen: low would be Sept. 10th, well before end of year -- @ 36.49 so not conjectured -50% (to near just 31). Notable too, late 2024 changes like electing a new president/congress; story having fallen so much into the 30s too, seemed to break an earlier steadiness. To again look for an early-year high/ AND a late-year low/ AND a -50% conjecture seemed to no longer apply.

That said, a Q1 2025 high so far this year did come early-ish YTD at 49.04 (intraday, or 47.29 close) on January 7th. And Q1's low YTD came very late that Quarter at 32.18 (Intraday, 33.10 close) on very last day, March 31st; what will yet be as 2025 unfolds shall be interesting. (A small side-question: might sheer coincidences of pretty steady fall fulfilling all 3 'AND' factors as in 2021-2023, resume ahead(?). It's highly unlikely! Just parenthetically for fun tiny conjecture, and *highly-unlikely*, might the year's nadir Also fall near very end of 2025; And be down near ½ so bit near to just 24.52 (49.04 year's high x 0.50)). For ample past data for ECO see, https://www.nyse.com/quote/index/ECO

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For 20 years we've looked at new energy innovations that *may* be superior vis-à-vis old energy. At ways disruptive new solar, wind, EVs, storage, hydrogen ($H_2$) *may* potentially make sense in their own right. We've emphasized too, clean energy stocks shall be *volatile; they can & will 'drop like a rock'*. We're proud as originals through our Benchmark ECO live since 2004 -- and Global NEX since 2006, to pioneer zero-carbon themes to help avoid climate risks. As solutions that may appeal regardless of climate. And yet, climate concerns unsurprisingly are rising to the fore of late. Our heating planet seems to be shouting along with undeniable scientific consensus, that tipping points may scarily loom, or already be now at hand.

It's so significant, we'll take some precious pages here for this science. Consider: carbon dioxide ($CO_2$) levels over 425 ppm & rising fast haven't been this high, since a Pliocene 2.6 million to 5.3 million years ago -- when Earth looked very different. July 2023, like that year, set planetary records, blew away a prior 16.63 degrees C (Celsius). Much more than cranking up AC may be needed in response. 18,000 to 6,000 years ago, Earth warmed very rapidly on natural causes, discussed ahead. At times sea levels jumped dramatically. Astoundingly by 10 ft or more per century; let's ponder that huge 'delta'/ or *change,* for a moment.

Sea levels in 'recent' human history were weirdly stable in geological-terms -- rising by only 2 millimeters (mm)/year. As there's 25 mm to an inch, it meant a near-nothing under <1 inch per decade. But, rises are now quickening. Lately US Gulf of Mexico rose 10 mm+/per year(!), near ½ inch/year -- or 5 inches/decade. Local soil compaction, subsidence, gravity, are at play here too. Yet seas are rising non-linear ways. And it implies 10 ft per century -- *could* be seen again. Especially as we push $CO_2$ up at rates 100-times that which once-unfolded over many thousands of years. Leaving a last Ice age, it took 'only' 6,000 years for $CO_2$ to rise swiftly by 80 ppm. Now, in one human's lifespan, $CO_2$ is shoved up in just decades -- by more ppm! Sea levels later in this century and the next, may soon be a top-level concern.

As late-night ads shout, 'but wait, there's more!'. Melting ice in Greenland & Arctic may spill freshwater lens atop North Atlantic, lowering salinity. Pausing key thermohaline circulation -- the deep ocean currents like blood coursing in our bodies. If 'AMOC' slows, it could end the Gulf Stream; 2023 models raised concerns it potentially may happen in this century, or next. Such would be catastrophic; temperatures might immediately swing some 18 to 30 degrees F or more. Given the data indicate that: a) It's already slowing; b) Slowing and shut-downs of Gulf Stream have happened in past; and c) Greenland & much of Arctic are projected to become 'ice-free' in this millennium -- severe impacts seem far more than just-plausible.

Just following the science: nothing political. Pleasant European climes we've long known, warmed by a Gulf Stream at high latitudes -- otherwise frozen -- may end. Perhaps loss of not only Europe's benign temps, but habitability. Rises on US Eastern seaboard. But there's more. A 'river' high in atmosphere too, the Jet Stream is driven by sharp contrasts (a delta) between equatorial/ vs. polar temps. Lately it's faltering -- may weaken, change. It has long kept arctic air far up north; instability in it too, may mean extreme weather. Climate whiplash. The blazing hot summer -- and freezing winter seen in 2021 -- may soon seem like a year of nicely mild temperatures. A past we can only hope for again. Hence, concerns this is *Not* a 'new normal' -- but maybe, just a beginning. Start of long, drastic changes. Extremes that can't be unwound. Putting massive greenhouse gases in air -- *may* mean no happy ending. However, there's cheaper, sensible, saner pathways -- and decarbonization is indeed one emphasis throughout our Indexes. Let's briefly look then at some ways that clean energy innovations in say, Summer of 2023 recently aided a great, Lone Star State of Texas.

A bitter freeze had hit Texas in Feb. of 2021, and that famously took down its grid for days. Misery, deaths resulted. We'll examine that in detail ahead (including a false claim it was due to frozen wind power -- when in fact natural gas freezing off was lion's share of fault). But let's turn first, to more recent baking Summer of 2023 as Texas saw record High temps. Here clearly, zero-carbon renewables solar & wind were heroes -- plus nuclear; the 3 kept on electricity in June and July 2023 -- power flowing, firm, and without huge prices spikes.

Fortunately for it, Texas had already begun better positioning itself a few years prior. So it then had a 16 GW (gigawatts) of solar power deployable by June 2023 -- it was a bit like 16 nuclear plants, although not-as-firm. This 16 GW was 8x vs. puny 2 GW solar it'd had in 2019. As baking heat arrived June 2023, temps soared: what helped its grid? Operate no anomaly, prices fairly-low, instead of spiking as thermal plants went offline, unable to handle heat/less maintenance? Notably in intense heat June 28th & 29th, renewable solar/wind, plus nuclear -- met 55% of power demand. At peak demand so early evenings, renewables -- plus nukes, met near 50% of electricity demand. Solar worked well as intended daylight. Wind performed well, oft best nighttime. But, needed now, is far more energy *Storage*. It has only begun to grow to help further smooth out intermittency. Of 700 MW of new energy storage that went in across all the US in a 1st Quarter of 2023, 70% of that went into just Texas.

Despite love for oil/gas felt by some of its leaders, Texas blew away all other US states in recent gains in solar & wind. It's needed: Texas is now seeing hot & cold extremes its old energy systems Were Not Built For. Indeed, 2023 it installed *another* 7 GW utility-scale PV; no other US state was close. Aimed for 25 GW utility-scale solar capacity in 2026: enough to energize 10 million Texas homes. For comparison as peak demand had hit in July 2022, a then 59% of demand was met by gas; next coal was 15%; just 10% was solar, 9% wind. Yet a next year, July 2023 on a record 83,414 MW demand, 57% was met by natural gas; while solar was a better 2nd at 14%; edging out coal 14%; wind 9% (a calm day, would be more if windy), 6% nukes. So on 25+ GW new solar + much more wind, far more storage can't come soon enough! Despite certainty some leaders felt that its grid was firm 2024 -- that is sure to be challenged by hurricanes, weather extremes ahead. Even in Texas' 'normal' Summer 2023, all its thermal plants had suffered from intense heat. Its fossil fuels & nukes were forced down in planned -- and for unplanned maintenance. All power is impacted by this sort of intermittency. Not what fossils/nukes want to pin on solar (that it 'won't work if cloudy or night') or pin on wind ('only works if breezy') -- *thermal plants instead can't handle new weather 'normal' extremes*. Thermals are at whims too of fuel costs. Contrasts with solar, wind that work more stable ways -- and enjoy 'free fuel' to boot. It's estimated Texas' renewables had saved its consumers over a billion $ dollars during that 2023 heatwave. Money its citizens didn't need to send senselessly (as they had done in 2021) towards spiking energy costs.

In Summer 2023, extreme heat became too much. Aug. 6th power prices skyrocketed 800% from $275, to $2,500/MWh. Just 1.6 GW spare capacity left 6 pm sunset, as demand peaked at 84.4 GW -- new State record. Emergency cooling centers were set up. Renewables propped up its fossils-grid, kept prices lower thanks to sun/wind -- but could only do so much. Sept. emergency saw just 500 MW left! Or, Derecho winds in a Spring may bring 100+ MPH winds. So, a need for far more PV/wind + storage is crystal clear. 150 years ago, it was humorously said 'everyone talks about the weather, but nobody does anything about it.' Well, in a cruel irony we all may be doing something about it now, unalterably. Normally, a rise of ocean temps of a 10th of a degree is notable: seas require far more heat to rise than air. Yet in North Atlantic off Newfoundland, Summer 2023, sea surface temps reached 9-18 degrees Fahrenheit (5–10 degrees C) above normal: beyond even many of the most extreme climate models.

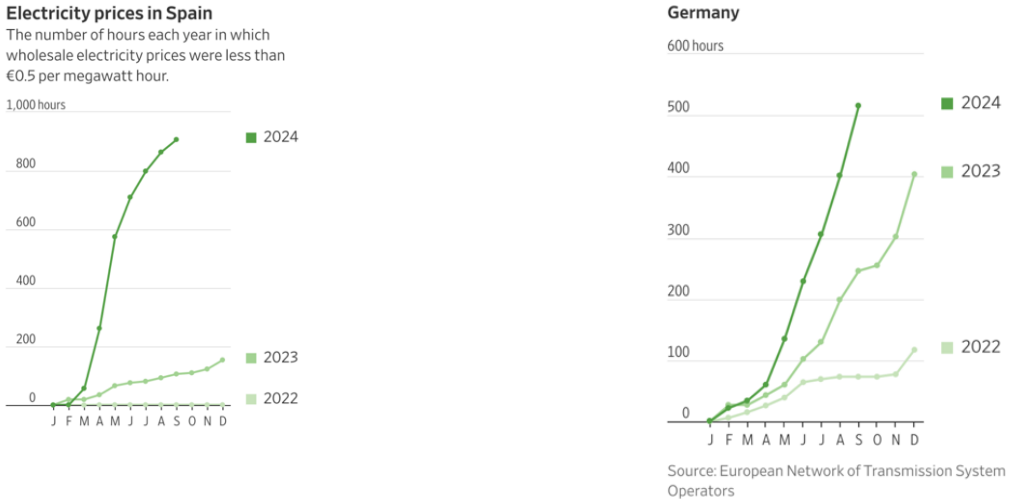
Or in Florida Keys, sea temps in 2023 went >100 degrees Fahrenheit, hot tub temps. Yes, was in shallow waters, less open ocean flushing, seagrass dark bottom absorbing heat … but still. Antarctic sea ice lately is not rebuilding like normal in winters -- worrying scientists who fear maybe collapse in sea ice extent. Fears too of a slowing Antarctic overturning current, which keeps stable and 'normal' the very basic planetary systems upon which we all depend.

Bloomberg New Energy Finance (and NEF partnered with us early on in creating the NEX) has noted that end of 2020s so in just few years, the US may build 600 gigawatts (GW) new *solar, *wind, *energy storage capacity. BNEF points as new impetus to Inflation Reduction Act (IRA) discussed ahead: may go over $1 trillion plus other support. Yet there's big hurdles to 600 GW: *costs of capital, *inflation, *supply chains, *slow permitting, *antiquated grid: all impediments to growth this decade. Still leaps compared to past. It had forecast 358 GW of US solar capacity 2023-30, near 3-fold total US solar capacity seen 2022. They foresaw 137 GW new wind capacity to 2030, near 2x total wind capacity of 2022. 111 GW battery storage capacity to 2030 -- 9x gains over 2022; starting from low base yes, but growth. Fact is, US in 2020s badly lacked grid capacity for growth. So perhaps too $83 billion in grid investments; yet even that would be $172 billion short of spending needed if US is to reach 50% emission cuts by 2030. The IRA is mostly a package of tax breaks, incentives; it's NOT a strategy to decarbonize; mainly carrots, no sticks. So some green growth; but 600 GW still falls well short of achieving US targets of 50% cuts in $CO_2$ emissions by end of this decade.

Looked at another way, on 3 big Federal laws since 2022, US may double its recent pace of decarbonizing – to hit 4%/per year *fewer* emissions by 2030. That 4%/year of cuts, brings down emissions by 40% to 2030 -- but that rate still falls short of 50% emission cut then called for by White House. A 50% cut is what's needed to stay <2 degrees C heating, and 50% by 2030 may tee up US for net-zero 2050. But a 50% by 2030 means doubling, or 2x our fastest rates of new solar/wind to 2030. Then, growing pace more, 3.5x in 2030-2035. To achieve that pace, we'd have to act *now*, cut $CO_2$ not 4%/year -- but 6%/year to 2030. Then, speed up cuts even more. While not now in cards, especially after 2025 cuts to IRA, it's technically do-able. Thus, no surprise clean energy spilled into American politics 2020s. Criticisms rife. Some critiques, accurate. Such as far *more* US minerals are needed to decarbonize US & electrify -- vs. a fossil-economy; that few minerals are domestic-sourced. True too: electrifying heat will be costly, heat pumps vs. furnaces: but then, costs equalize too on efficiency. And yet many other harsh criticisms, aimed at clean energy in 2020s, were far less accurate.

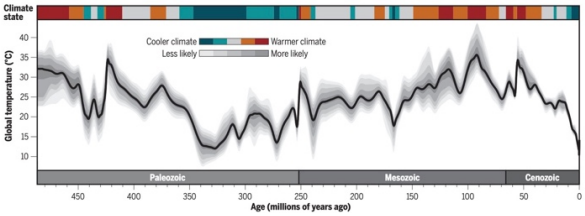
For example contrary to politically-driven claims, clean energy *help to reduce* energy costs -- *renewables can be Deflationary*. An Australia that had clung to coal, resisted new energy -- is seeing change as renewables surge. PV output up year/year. With less need for costlier gas, its wholesale power prices did go to zero or negative, 12% of time; 9 am-5 pm in populous Victoria & in S. Australia, negative 55% of time. Yet, negative prices disrupt all; old-energy incentives in coal too. Power prices are set in day ahead markets next 24 hours, so if there's excess ahead, they'll bid 'negative' prices, harming themselves (harder still on nukes & coal plants that can't easily shut down). By 2025 over >40% of freestanding Australian homes had PV, >18% of electricity & it began to make sense to heat water in days on excess PV. Just as wrong too, have been critics who've claimed that EVs must-forever-be-too-costly: China has <$10k EVs with 200+ mile range. Other criticisms perplex, like skeptics who claim since climate has always changed over Earth's history, it will go on, and pro-renewables tax policies are bad: perhaps that's on mis-understanding the science. Such skeptics' arguments may in future retreat just a small bit -- but for certain not yet! Skeptics and climate deniers remain vocal in so many ways. The 2024 election results in US and red wave reflect that.

3 Charts below on newer data, are a bit startling for what they imply, what one may infer. A 1st two show how some consumers in Europe mid-2020s, lately can take advantage of (at times) negative electricity dynamic pricing. In most US (unlike EU) consumers can't access dynamic pricing. (Some US states may rethink & might allow some retail access too). In Europe in 2022, prices went below zero only a tiny 0.3% of time. That rose to 2.2% in 2023. In 2024 to a bigger 6%. Places with lots of renewables, can get higher/ 'better' (for consumers): was 8% in Netherlands, 11% in Finland, 12% in Spain. Also shows what may come to US if rules are relaxed. In US 2023, just 21% of electricity generation was made by renewables -- EU was clearly ahead then: 44% in 2023 -- yet some US regions may see changes, if negative dynamic pricing is allowed. Southern California wholesale prices went <zero only 5% of time 2023; but a boom utility-scale solar meant went negative ~20% in 2024. (A downside was 3 million megawatt hours curtailed 2024, could have powered half a million homes -- but that was on lack of energy storage). Windy Iowa US, may see wind power going 'too cheap' at times as a boon for its consumers on windy days & nights. The 2 Charts for Spain left, about to go over 1,000 hours -- and for a Germany right, to go over 600 hours -- show remarkable growth in their negative pricing that came about in just a three years to late 2024:




*Source for both: Wall Street Journal*

Lastly, step way, way(!) back for 3rd Chart: remarkable reconstruction, newer data of Earth's surface temperatures past 485 million years linking $CO_2$ - to temps. Reflects too troubling sensitivity to any doubling of $CO_2$; at 8 degrees C avg. hotter, average tropical temperatures were higher than previously assumed at a horrid 42 degrees C (107 F): life endured extremes. Refutes a natural ceiling on how hot it may get. Had it looked farther back, would have captured too a snowball Earth of the Cryogenian: happened twice 710 million to 640 million years ago, lasted 10 million years each maybe due to Earth's rings, or on less volcanic $CO_2$, or absorption by rocks -- so $CO_2$ can also go 'too low', extinction events. Over a past half-billion years, Earth's temperatures were thus often far hotter, than a presently 'cool' 59 F:




*Source: Judd et al, A 485-Million Year History of Earth's Surface temperature. Science 385 (2024).*

In Europe science is more of a given; it has ambitious climate action aims. In 2023 Europe had installed 2x as much new renewables capacity as a US: 56 GW of solar, 17 GW wind. Bloomberg NEF notes Europe may invest $32 *Trillion* -- to hit net zero 2050. *More than 3-fold higher pace rest of 2020s*, then *4-fold 2030s* vs 2022. More €€ invested in renewables, EVs, heat pumps etc. Like nothing before in old-Europe. Heat pumps (costly!) replacing furnaces may get $1.4 Trillion. EVs a massive $21 Trillion 2023-2050. Generating side, $3.8+ Trillion in wind & solar by 2050. Onshore & offshore wind may jump from 234 GW in 2022 -- to 675 GW wind by 2030. Europe's solar in 2023 out-generated its coal, in 1st-time ever. Yet on lack of grid capacity, pushed prices at times to below <zero (bad for suppliers including renewables)! If Europe's grid is to accept huge renewables generation, grid spending may need to hit $3.8 Trillion. Solar to rise from 226 GW 2022 -- to 774 GW by 2030. If solar is to be #1 electricity source 2030, tripling. If solar & wind by 2050 are to meet >80% of Europe electricity demand, means big changes in manufacturing too. Germany in 2012 (we recall) was a player in PV-making. But by 2022, China was instead making 97% of all silicon wafers in panels, made 2/3rds+ of world's PV modules. So, for Germany to again be big in PV is *very* ambitious. Like everywhere, there's strong opposition. And all this must also work 'against' a tide of negative pricing, when renewables 'overproduce': first 6 months 2024, the UK jumped 3.5x in # of times its prices went negative (due to its wind!) vs. all of 2023.

Thanks to better efficiencies, cleaning by electrifying heat, transport etc = *could* also cut energy-use by 30% to 2050 -- vs had heat, transport, still been done by fossil fuels. By 2050, electricity *may* be Single-Biggest component in new energy-applications. Going from 20% in 2023 -- to 46%. COP27 Conference had highlighted a $4 Trillion figure for renewables investing by 2030. With hopes of helping achieve net zero by 2050. All huge numbers!

We are not on track for any of it. Figures imply shifts have begun: global investments in solar in 2023 were greater than for oil, 1st time ever. $1.7 Trillion went to renewables, storage, non-fossil energies, low-carbon nuclear -- 'only' $1 Trillion went to old coal, oil & gas. Perhaps start of a shift. Separately, spectre of possible US Debt Default casts a shadow. Some in Congress bitter over slim passage of IRA in 2022 -- saw 1st US Debt Default threat as opportune 2nd bite at apple, an unprecedented 2nd chance to hobble US renewables. But, a liberal party president had made clear in 2023 undoing a recent IRA was a red line not to be crossed. So IRA survived intact, then. Still a 'final Debt Deal' is done. Meanwhile the IRA that had passed just narrowly by reconciliation in 2022, could easily be cut too by reconciliation in 2025. Unlike bipartisan-passed legislation, not easily unwound, taking the reconciliation path in the 1st place meant being possibly hoist by one's own petard. Recognizing this, interestingly, the $$ dollars that did start rolling out on IRA 2023/2024 -- went at first heavily to key red political swing states. But that was not enough, post-2024 elections, to keep the IRA from being cut many places 2025. Expect recurring fights too over 11 annual spending Bills (and energy).

Utterly different, was shifts in 2022/2023 from La Nina that held global temperatures down -- to instead its twin, El Nino, for hotter oceans many places. Or further out, hotter seas likely that also directly impacts us humans. While we simply don't see stunning ocean heat now happening being as consequential, as foreboding as it deeply is, a hotter oceans & Mediterranean Sea may have great impacts for even we air-breathing, finless bipedal, land-based humans. More than just turning up air conditioning a bit would be needed. Potentially new ocean regimes may be existential threats we can't yet conceive of. Like slowing of key Antarctic overturning current that drives much. All that, right now is right in front of us. May be big near-term risks, yet that we humans seem unable to fathom.

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There's been stop & start progress. Texas' wind & solar is ruffling some politicians' feathers, but has saved that grid. Texas is conservative, yet its private sector is growing some new energy at near-Europe-pace, a bit akin to Portugal. Portugal's solar in 2023 met 7% of demand (like Texas) -- with wind power 25% of electricity demand -- like-Texas levels. Yet, different, is Portugal's far greater hydropower also met 23% of demand 2023. So, Portugal & Texas were 2023 near 7% solar/25% wind & growing. Other ways, they differ. Europe natural gas is pricey, not-secure, nor-domestic, so far less used than Texas. In 2023 renewables had met 61% of Portugal's demand -- up from 50% in 2022. Portugal benefits by hydro -- unlike flat arid Texas. In sunny/windy Aug. 2024, wind in Portugal had met 29% of monthly demand; solar 21%; hydro 17%; biomass 9%; for 77% in total. Its natural gas needs were just 8.8%, closing in on zero. On biomass too, its renewables may hit 85% by 2030 (then 100% ahead). So Portugal is growing its clean faster, yet Texas 'wins' within a US, moving at a far-slower pace than Europe.

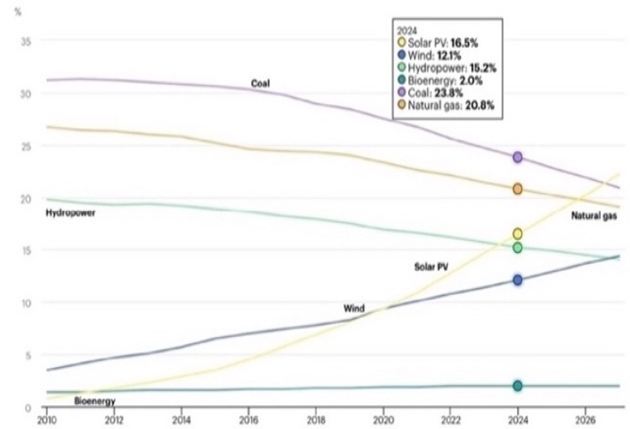
Still, via climate lens it's scary: nowhere, is clean energy going fast enough! Everywhere, sees decarbonizing setbacks. On unending human $CO_2$ it won't be 'just' 1.5 C hotter ahead; not-realistic. In 2023, China & Saudis refused to raise 2025 targets at a G-20 ministers meeting. China was 196% of increased emissions 2019-2022; 1/3$^{rd}$ of all emissions. Even per-capita, China was 3/4$^{ths}$ of increased emissions, it ok'd 50 GW of coal: 41 GW announced, 8 GW of 'shelved' coal revived. On that coal alone, any optimism for our Earth is unfounded.

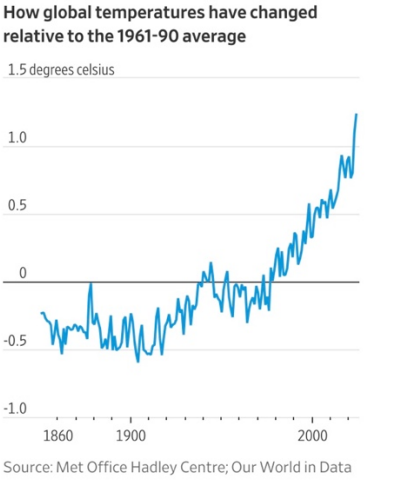
Take UK that once had led on wind, but in 2023 chose oil & gas. It sought then even if at 'net-zero' in 2050, to get 25% from oil & gas. Hopeful UK offshore wind deals were cancelled 2023 as a Party then in power, felt wind won't pencil on capital costs. Underlying was a belief that putting off climate action, was 'pragmatic'. But, *that was wrong;* renewables *are tangibly cheaper*. Spain's new solar in July 2023 met 24% of demand -- up from 16% in 2022. In Sicily, ½ excess demand on hot summer days was met by new solar. 2024 a new UK Party took power; a 1$^{st}$ move was to end de facto ban on new onshore wind since 2015. It faces though de-industrializing threat. A German/Spanish wind giant had giant losses, announced a €2.2 billion charge on wind turbine troubles, a net fiscal year Loss 3x that expected. Markets had valued its wind unit at €5.5 billion; after, near-zero valuation. Wind was pared back worldwide early-2020s; fell 20% 2022 from prior year; saw 32% less growth than a record 2020. Oil & gas though, were different. In 2023, 20% of oil & gas projects slated to start in 2023-28 were at Final Investment Decision stage (FID). Far better than 8% seen in offshore wind; meagre for $H_2$. Things after improved: a record 12.3 GW offshore wind reached FID in 2023; vs. just 0.8 GW 2022; later 8 Euro wind projects for 9.3 GW hit FID 2023. Clean $H_2$ saw just $10 Billion at FID stage 2020, 102 projects worldwide -- after, projects at FID rose 7-fold in value to $75 Billion, 434 projects latter 2024; 90% greater FID numbers that October 2023. For sure clean $H_2$ costs are still much, much too costly in 2020s, but optimists at least are hopeful for 2030s.

Again, big Texas in a US is a case in point. Its gas plants *will* struggle in cold/heat extremes -- fuel costs *will* soar at times. Its Grid is far more prone to breaking down, than leaders knew early 2020s. One issue is 'firm' fossils & nuke plants will Fail: like in Texas when gas froze off 2021 and some tried to blame renewables: PR efforts scrambled to call only fossils reliable -- despite facts. Again and again will show gas straining, hot/cold beyond that expected when thermal plants were built. *It shall happen again!* As weather extremes grow in frequency, they'll challenge thermals struggling in new-typical temps. Greatly adding PV, wind, storage, better grid, will help lift teetering lines from failure; keep prices from skyrocketing. Still on climate, without more tremendous growth in solar/wind, storage, transmission, robust grid, a resiliency to help keep renewables firm & dispatchable, *that will not be near enough*.

There's bits of good news. Global solar capacity has been growing 2x every 3 years; works to 10x/per decade! 10 years ago, mid 2010s, solar was 1/10th that of mid-2020s. On 10 years of growth later was up 10-fold. Was like growing planet's nuclear plants 8-fold -- faster than building one nuclear plant in a west! Globally, nuclear divides by geography; 2024-2030 may see 55 new nuke reactors: 61 GW or ½ in China (26) -- rest in Asia & Middle East; 0 in US, 4 in Europe. Newer, safer, smaller modular nuclear reactors -- beyond 2nd gen light water reactors that typified America's nukes built to 1990s, may suddenly grow in US given needs of AI from latter 2020s. However, via lens of what's needed to hold heating to 1.5 degrees C, this decade ends scarily Bust. New temperature records, eg, Sept. 2023 was hottest Sept. then on record, not by a usual 1/10th of a degree -- but by 0.83 F! 2024 was after hottest year on record -- yet it may turn out to be one of the coolest-ever years that a young person now will know in their lifetime. Still, in latter 2020s natural gas is slated to be making huge gobs of power -- despite that $CO_2$. Global coal to be still abundant 2027. Some green growth but spending projected Nowhere near $4.5 Trillion in 2030. Instead, all overshadowed by inertia of big dirty energy, that made huge 45% of electricity in 2024; coal was 23%, natural gas 22%. Fossils will be still core 2027. On climate science, on $CO_2$ /greenhouse gases, the 2020s will end a Bust for all -- with world temps going well over 1.5 C degrees heating:

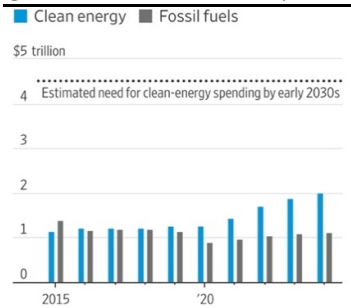
**Left: Share of Cumulative Power Capacity By Tech, 2010 – 2027; Right: Global Temps.**




Source, left: IEA, *Share of cumulative power capacity by technology, 2010-2027.* Right, Wall Street Journal; Met Office; OWID.

**Global Investments Must Grow Significantly -- To Keep Heating Under 1.5 Degrees C:**




Source, chart at left: IEA, Wall Street Journal; 2024 figures estimates.

(Side note: it's hard to capture natural gas, although an important commodity, in an Index -- that are normally are made up of equities. Gas futures too are more local than oil, location is key. And contract roll over may be a drag on Index/ETF, drift if renewed in contango. Still, for comparative purposes, we (must) use a major natural gas tracker ETF to portray it.)

Green shoots in windy North Sea, 2020s may hint at what's ahead. Perhaps bit like how newly-cheap 19th century hydropower led to 2,500 mills: for ½ the world cotton in Lancashire UK in 1860s. Or how cheap hydropower led to aluminum smelters, airplanes in Seattle last century. After all industry follows cheap energy. Ruhr Valley's dirty coal once led to steel-industries. But this time, better *clean* economies *possibly may* grow ahead. For say, a zero $CO_2$ steel. Or cheap green hydrogen ($H_2$), ammonia ($NH_3$), e-methane, low-$CO_2$ derivatives -- possibly made from clean (& prerequisite cheap) renewables. But Green $H_2$ now is S*till Much Too Costly,* and so renewables *will also have to get far* cheaper. Dec. 2024, a first Iberian Index for emerging new $H_2$ made on renewables, priced it at €5.85.kg so much too costly, vs. grey $H_2$, yet well below a nosebleed high €11 being asked in Germany. True, Europe's offshore wind *might* be able to scale fast. Turbines at sea can work at greater 60% capacity -- vs 30%-40% for wind on land. 9 North Sea countries lately aim to install 260 gigawatts offshore wind in <30 years to 2050, 5x world's wind capacity of 2022. Bit like 24,000 biggish turbines. Enough to make electricity for say, 200 million European households. Some firms that kit out for oil & gas may shift to offshore wind, like say Esbjerg Denmark. This town of just 72,000 souls could boast in 2023 of having helped on 2/3 of region's offshore turbines, enough to run 40 million homes. It aims to grow its capacity ahead, maybe as 3x to 2026.

Like Northern Europe with big winds, Spain is blessed with bounteous solar. It's PV had met only <8% of demand 2021. Or, North Africa's sun may 'be moved' via undersea power cable -- or by green $H_2$ in ships and/or pipelines to voracious Europe. War ended a past affinity for cheap Russian gas, to new aims on security+climate. Fossil fuels got us to today. But in future, bold new opportunities just might belong instead to sustainable energy. A key concern now, *is that it's* ***far*** *from cheap enough!* So great strides must yet be made. In US, an Inflation Reduction Act (IRA) of 2022 led to some new investing. For eg fresh US battery manufacturing, minerals mining, refining. Car builders try to onshore battery-making, take advantage of Tax Credits. No surprise, many seek to build US supplies from scratch. The US Treasury arguably too slowly, drafted rules in 2023/2024 for what will count as US battery minerals, domestic EV content -- allowing a 'commercial use' loophole if say, EVs are leased. Meanwhile all want to get minerals in greener ways. A big US-based solar maker enjoyed near 4 cents/watt premium on tellurium, cadmium; it bought a European pervovskite specialist in 2023. There'd been brief optimism, equities up at times -- on hopes 2024 inflation peaks and Fed pivots to lower rates, as costs too come down. So when Lower Rates didn't happen 2023 & early 2024, was hard for risky equities to compete with 5% returns in safe bonds, Treasuries. Stocks fell on inflation, on scares about a debt bomb, recession. Moves widely towards risk-off, some collapse globally in riskier-assets appetite and in confidence across 2021-2024.

Not to ignore good news. In 2023, first time-ever, it was cheaper to *build a* new US solar/ wind farm from scratch -- than was to get electricity from an *existing US* coal plant -- at all but 1 US coal plant! On IRA + new Rules, coal was costlier at 99% of US power plants. Of 210 US coal plants, just Dry Fork Plant in Wyoming was cost-competitive. Marginal costs at many US coal plants were near $36 per megawatt-hour -- vs. $24 per megawatt-hour for well-sited solar. US coal, US nukes, grew only pricier for servicing, plus big labor costs. Take say in Texas' big Samson Solar Energy Center, a new 1.3 GW solar farm: it needs just 12 full-time staff + some goats to keep the grass down. By contrast a South Texas Nuclear Project also 1.3 GW in size, needed 1,300 expensive, trained full-time staff! Solar's/wind fuel is free + no pollutants. Meanwhile fuel for coal, gas is costly. Coal's pollutants costly too beyond the climate risks, besides carbon dioxide. Coal's own mercury causes brain damage. Its sulphur dioxide makes acid rain, its NOx vexes air quality, has huge wastes. And of course, nuke's extremely toxic wastes must be safeguarded for centuries to come, and even longer!

Wow, green energy has grown. 3 decades ago, 11 now-tiny turbines made up a world's 1st offshore wind farm: 5 MW total in Vindeby, Denmark. Now just 1 offshore turbine can be 18+ MW -- *per turbine!* Bigger MW models unveiled. Just imagine 100 say, of the 15 MW offshore behemoths -- or why not say, 1,000, or even more(!?). Wind ahead can make TWs. Indeed China has huge ambitions for its own wind/solar/storage ahead, plus nuclear. That nation has sheer ability to make thousands of GWs happen, along with less coal. A US president did in 2025 suspend all wind federal leasing, but that's just one country. And of course a filthy coal, once very big in US; still is Huge in China. Now, as a Harvard economist has said of US coal, "We can't shutter all these plants tomorrow; we need to do it in an orderly fashion to support grid reliability but we should be able to do it in fairly fast order. Coal has been natural decline due to economics: those economics are going to continue, this is a transition that's just going to happen. We built a lot of coal plants in US around 50 years ago because we were worried about energy security in the world. That made sense at the time and made an important contribution. But we know a lot more now about climate change, so now we need to make different decisions." Coal's US future is inauspicious. Interestingly though, some conservatives who normally venerate free markets -- look to *Require* coal be kept going(!) -- even if a coal plant owner wants to shut it down! In West Virginia, Kentucky, Montana, Utah, Wyoming, they've lately claimed that it is now a fight about 'culture'.

In 2022 the world had invested $1.1 Trillion into low-carbon technologies, a 31% gain over 2021. 1st time over $1 Trillion; fossil fuel levels. What saw its biggest % gains -- vs. not-as-big % gains in 2022? A big gain was in electrifying transport: it jumped 54% year over year, to $466 billion. Near totals in solar & wind, at $495 billion; latter only up 17% vs 2021. Other than a nuclear then flatlining -- investments rose for storage, heat, electrifying transport. Even very speculative hydrogen ($H_2$) drew interest, although 'only' $1 billion 2022, still 3x of 2021.

So much is driving demand. The International Energy Agency (IEA) opined in 2023 that even with war, efforts to rein in demand, demand still *grew* 2% in 2022. IEA forecasted in 3 years to 2025, demand could grow 3%/year. Maybe all that new demand, met by renewables + nuclear. Renewables might rise from meeting 29% of power needs 2022 -- to 35% by 2025. A US (pre-IRA data) might lag on only 6% of renewables' growth; the EU may be better at 15%. Meanwhile China could make up an incredible 45% of renewables' growth. Or not. Collapse of China Evergrande Group in 2021; then of its Country Garden in 2023 was scary -- in real estate. Yet China dominates in green energy. At equivalent USD $546 billion worth of investments, it was #1 -- far ahead of US at $141 billion; or EU led by Germany, France. For Chinese factories making clean tech investing rose from $52.6 billion in 2021 -- to $78.7 billion in 2022. Unsurprisingly, China then received 91% of investments, and China was moving too farthest & the fastest, along with having the most supply chain diversification.

Green hydrogen is new, very uncertain, yet China is targeting it for massive investments. Its national government aims for 50,000 hydrogen FC powered vehicles on roads -- running on 100,000-200,000 tons annually of green $H_2$ by electrolysis on renewable power. Getting sufficient demand will be key; so note local/municipal entities may aim high. Inner Mongolia, Qinghai, Gansu together seek 740,000 tons annual green $H_2$ production. 13 cities/ provinces aim for 110,000 fuel cells vehicles 2025. One might think this means sure green $H_2$ *over*-production -- too many electrolyzers chasing little demand: its green $H_2$ needs maybe only 10 GW in 2025, as >70 GW electrolyzer capacity comes online. But, **China is the biggest** producer of grey $H_2$, made from dirty fuels -- and $H_2$ used in industry in steel, cement *could* switch *if less costly to do so*. Huge If! But could go from bad, grey -- to renewable green. Whether green $H_2$ can make economic sense is a Huge Hurdle! Doubtful, yet remains to be seen

As we stress, to hit net zero, current spending figures are Nowhere near enough. Bloomberg New Energy Finance (and NEF was an early partner on NEX) estimated the world must invest on average, *USD $4.55 Trillion/year -- each year for rest of decade(!) for a Net Zero Scenario*. IEA says *$35 Trillion more* must still be invested, just to 2030. Global deployment must go from 3,000 GW -- to an enormous 10,000 GW -- if we're to stay below <1.5 degrees C.

China's an 800-pound gorilla making renewables cheaper. We may think of Oil now, as being too-dominated by OPEC -- but China's control in green manufacturing is *far greater*. So many ways, its control is already much too much! Take cobalt used in batteries, 95% of world's cobalt is refined in China. Future battery designs may no longer need cobalt so, 1 stranglehold can be broken. But what of nickel, or graphite?! Or key areas of solar cell manufacturing, PV modules, global capacity for battery production, as China leads near 70%-75%. In a comparison with oil, just 14 OPEC nations now control fully 40% of global oil supply. Or as OPEC+ with Russia, it jumps to 60%. Compare that 60% seen in oil 2020s -- with just one China, whose hold on green tech is far greater than is OPEC's over oil. This conundrum got entrenched in a last decade. China intentionally then became THE global leader in wind, solar etc as it took near ~70% market share. It aims similarly high/for new leadership in EVs soon, too.

Only is 'ok' in a sense very cheap PV helps in climate crisis; 2010 to 2021, solar costs fell 90%. Building a Chinese PV factory is 1/5$^{th}$ the cost of in US, Europe. Conversely, electrolyzers cost 5x+ more in US, Europe 2023 -- than in China -- so catching up isn't easy! But there's issues aplenty with China. Some PV from there is intercepted at US border on big forced-labor concerns discussed ahead. In 2023, US Customs released meaningful numbers of panels, for a brief bounce in China solar. Yet there's dark clouds on accounting (non)transparency & so maybe delisting off US exchanges. Tensions, issues do keep appearing. On energy security, decarbonizing, onshoring green jobs, Taiwan: argues for more, diverse overseas production -- outside China. Even if is costlier short-term. Studies show even fossils-heavy China, may hit its own domestic zero-carbon power aims in under <40 years by 2060 @ costs of just <1% of GDP. So, some cause for optimism. And looking at clean energy stocks, their P/Es fell so much 2021-2024, made some equities perhaps more akin to value, than high P/E growth. *If* inflation is tamed, rates fall, capital gets cheaper, *if* supply chains loosen, profits come back with risk appetite, perhaps animal spirits *may* return. But other side are concerns over say, tensions with China, recession, debt, all are dire shadows too. As are supply chains in vital minerals, a 'nickel pickle' etc, and issues for domestic green refining going forward.

All as China's EVs are about to challenge the world's best. Its firms work hard, smart, with policy support. And China is determined not to miss its EV chance. For level of EV scaling -- like seen in renewables, batteries -- consider 650,000 EV chargers were put in China in 2022, 10x the US. 4 million EVs were sold in China 2022 -- 4x the US. Hundreds of thousands of chargers installed each year in China, 1.8 million to 2023; low-utilization rates yet dwarfs its 30,000 of a decade prior. In 2022, 380,000 chargers went in Guangdong Province -- 2x all US. Doesn't count 2.6 million private chargers in China 2022. Their 1 standard plug -- contrasts a lingering US CCS or a sad J1772 -- themselves bad vs. far-better 250 kW v3 NACS plug by America's leading EV maker. In 2023 that US EV leader opened its NACS to all: to Ford, GM etc which all trailed badly. Better than a walled garden for 1 EV leader; all using NACS can mean a better US EV experience overall. On newer 3$^{rd}$ party 350+ kW chargers, and NACS v4, that soon may pass 500 kW+. Still the US lags in EV sales, and to keep up with faster-China has meant US EV charger installs had to grow 4-fold 2023 to 2025 (they did not). EU is growing its EV sales much faster than in America, yet it must raise its rate of EU charging points from 2,000/week seen in 2023 -- to near new 14,000/ week by 2030. Huge challenges!

Other side of coin, juxtaposed, are many reasons for bearishness in clean energy. True, $1.2 Trillion+ total might have gone into US solar/wind/EVs on an ***uncapped*** 2022 IRA. But that was an original version of IRA, later hit very hard 2025, dollars reduced. Many renewable projects were recently slowed or even killed. As supply chains in solar, wind, EVs, still full of pitfalls. For instance in a US, approval to connect to grid takes far too many years, sometimes a decade+! Local regulations & protests vex. US big wind farm starts fell by a dramatic 77.5% in Q3 of 2022 -- vs in a 3rd Quarter of 2021. New utility-scale solar projects fell 40% in 2022 -- vs in 2021 -- despite big ongoing demand for green electrons and so green projects.

Investors early 2020s, *wanted* to pour $ billions into renewable energy. But PV panels mainly come from China -- many of whose panels were held back by tariff battles. A US President paused tariffs on 4 Asian nations' finished China-panels, but that pause ends. As some Chinese PV was withheld, it needed proof of course No forced labor was used in manufacture. Plus, further troubles remain on non-transparency of China accounting firms. Perhaps some China solar/wind stocks might be delisted from US exchanges, depriving them of capital; that was maybe avoided briefly, but threat lingers. Yes Q1 2023 saw record 6 GW US solar, installed -- thanks in part to Chinese PV being so bloody cheap. But there's myriad costs to that.

And troubling self-goals. California once led in solar; it cut back home solar value in 2023. Three public Utilities seriously pushed to end incentives for home solar -- to instead charge based on users' income, rather than electricity use. In Q1 2023, Florida installed 70% more new solar capacity than California. In other matters wind turbines have grown fast in size, but unreliability has made some wind maker's warranty costs double. That industry needs to improve reliability of huge turbines -- before turbines grow further. The US Treasury was slow to proffer details implementing tax credits. A US Senator key in IRA was surprised by criticisms at Davos 2023 on incentives to build in US. Europe more accustomed to sticks, than carrots -- (rightly) feared it was driving Euro-firms to US. They called for a European Green Deal Industrial Plan, mimicking America's IRA, for carrots to draw firms to old-world in a race to top. Largely due to IRA of 2022 -- US in just Q4 of 2022 saw $40 billion in new US solar, wind, storage; as much as in all 2021. Private companies & public entities contracted for a record 36 GW clean power in 2022, up 18% over 2021. Many firms clamored to invest. Whether wanting to decarbonize -- or merely virtue signaling. Either way, the demand to contract for clean electrons (if affordable) in late 2022 on hopes, was enormous. Cut hard in 2025!

As demand has contended with long leads in high voltage equipment -- gone from 30 weeks -- to 70 weeks. Proposed standalone-batteries suffocated by wait times for grid connections stretched places to 2030s. Far more interconnection requests made, & for fossil plants, too -- than built. Recently, only 23% of requests were built; 19 GW of wind proposed, later withdrawn, only 20% completed. 60 GW solar requested -- just 16% completed. 2020, there was 5,600 connection requests. 2021 saw a grand 8,100 requests: grid operators not well staffed, were overwhelmed. Back in 1st decade of 2000s, wait times had averaged 2.1 years/ per project. By 2011-2021 it rose to 3.7 years, near 5 years. Things improved some 2024 on US FERC rules to speed approvals, yet 2,000 GW proposed *new* clean energy awaited approval -- near as extant generating capacity -- so change was most sorely needed!

Local opposition to some new wind, solar, grid etc grew in Europe & US. In 2021, 'only' 19 big solar proposals were vetoed, which after jumped to 75 vetoed 2022. In England/ Wales/Scotland, only 4 proposals were rejected from 2017 to 2020. That jumped to 23 proposals rejected in 2021 to July 2022. Other side of coin, France looked for example 2023 to maybe require all new parking lots over 80 spaces in size, be covered with solar panels.

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A recent past shows how fast things *can* change -- if political will is there. In Europe back in early-2020s, wind & solar had met a record 24% of EU electricity demand in a 1st six months of that awful war, March-Sept. In doing so a 27-nation EU avoided spending €99 billion for natural gas. (Late 2022, €1 Euro had near-equaled $1 Dollar, so USD $99 billion). EU then generated €11 billion more clean new energy that period, than all 2021, thanks to green growth/ demands of war. As imported / piped Russia gas started dropping fast on war, from meeting 40% of demand in 2021, to 7% early 2023, solar output nearly doubled. In 2022, the % of electricity demand being met by wind/solar -- exceeded that from gas -- first-time ever. Might have been even better were not large hydroelectric dams output then down by -21% on drought & heat. Let's look just a bit closer, at who led and who were relative laggards.

19 EU nations made then-record amounts wind & solar. Poland's lingering coal, had meant it had most scope to improve as percentage. So, was small surprise its renewables jumped by 48.5% year over year, 2022. Sunnier Spain boasted best absolute increase: it grew its green energy by 7.4 terawatts hours (TWh) -- avoided €1.7 billion natural gas cost. Was summed up in 2022 as "More Renewables = Less Inflation". Poignant for a Europe hammered by (energy) Inflation; its fossil fuels costs then rose by a gob-smacked 40.8% over prior year. In all, EU spending on its energy accounted for a big 30.6% of its very large 10%(!) inflation in 2022.

Yet rarely is news 100% good; no exception here. In 2010s, wind & solar got ever-cheaper nearly-every year -- vs. a year before. But it paused, when instead, 2022 saw *rising* costs in green energy. Wind power prices in 3rd Quarter 2022 were *Up* 37% year over year; solar was *Up* 30%. A lot! To be sure, everything else was up too; higher prices for fossil gas, oil/ diesel, coal, nuclear. Still, no looking away from higher-prices in renewables too. Higher wind/solar costs in 2022 didn't kill green demand. Rather on chaos, demand, tight supply chains, coal demand rose 1.2% in 2022. It set a sad new world record of 8 Billion metric tons.

Inflation had meant higher costs for everything. Solar panels start of 2022 cost 35 cents/watt. But by mid 2022, was 45 cents, then 50+ cents. European power purchase agreements (PPAs) for blended wind & solar generation 3rd Quarter 2022, jumped 11.3% to €73.54 per megawatt-hour (MWh), 51% higher than Q3 2021. A Europe beleaguered by over-relying on (Russian) gas, saw fossil-electricity prices some cases @ €500 per MWh(!). Among renewables, prices rose 2x faster in solar -- than wind in Q3 2022; solar rose 15% to €68 MWh. Wind rose 8% to €78 MWh. Still, the prices were better than for gas in 2022; despite more coal use, clean energy bottlenecks, rampant permit delays, long waits to connect to grid. Windfall profit taxes were proposed then, and some energy auctions failed. Highly volatile gas prices – much up -- would soon fall hard globally in 2023. Even more in a domestically gas-abundant US, than Europe.

An energy-pricing system based around Price of Natural Gas -- birthed 1990s was and still is, a bit absurd today. Means (volatile, at times costly) natural gas is The Key Fuel in determining what all power plants are paid, per megawatt made. For nuclear & renewables (latter on free fuel) – that do Not need gas -- it had meant that in 2022 they got relative financial 'windfalls' by making power more cheaply. So these 2 zero-$CO_2$ sources benefitted in 'unforeseen' ways as gas spiked in 2022. As for Spain & Portugal, they'd cleverly asked EU earlier that year to allow different pricing mechanism. They had much solar/wind, less nexus to pan-European grid, used relatively less (piped) Russian gas; they were thus granted unusual Exceptions. Spain already imported much of its needed gas via LNG vessels, not pipelines. And that gas came more conveniently from Algeria, US, and elsewhere (non-Russian).

It insulated Iberia some from €s being paid for gas by others, in 2021, €50, €100, even €200+ per megawatt -- vs. €40 'fixed cost' for zero-carbon hydro, wind, solar, and nuclear. Yet kept the deflationary zero-carbon generators from enjoying huge profits, even as gas-costs soared. Some natural gas still was used -- but less, which proved relatively less-inflationary in the 2 Iberian sisters Spain & Portugal. There were other interesting consequences.

Spain, first 4 months 2022 did nicely reduce consumer bills a big €3 billion. Spanish electricity bills were then 35% lower vs. in Germany, 70% lower vs. Italy. Portugal's consumers saved 18% vs had it not changed. But, problems arose too; Portugal imported *more* Spanish power due to drought at its dams. France bought *more* cheap Spanish power, so Spain then had to buy & to burn more gas. Spain found itself burning 2x the gas ironically, as 2022, a year before. Electricity prices in 2 Iberian nations were lower, yes, than rest of EU -- but higher than in past. Gas in EU was costly, renewables/storage not yet big enough, and troubles in fossils prevented truer solutions. Then, EU in 2022 proposed a twist: an unhelpful windfall profits tax on inframarginal generators: renewables/nukes may see revenues capped @€180 per MWh -- on grounds they'd seen more profits than expected. Revenues "never dreamt of". But then a windfall profit tax also *Discourages* investments -- opposite of what was wanted! Spain 2022 capped renewable energy bids in Auction at <€45 MWh -- yet most project costs were then nearer to €60+ MWh, given inflation. That fast led to failed auction results (like in UK).

Gas prices had spiked everywhere 2021 -- before falling 2024 -- hitting nations in diverse ways. China pulled back off promises to move off coal soonish. Yet some locales planned enormous renewables. Chaozhou, Guangdong in China began to plan for 43 GW offshore wind from 2025. 50 to 115 miles off China in windy seas, could run 43% to 49% of the time, 4,000 hours/year. Notably China in 2021 had added more new offshore wind capacity, 17 GW or 80% of world's new 21 GW -- than rest of world past 5 years together! Of globally 54 GW offshore wind in 2021, China was half. 43 GW wind to make more electricity than all Norway's power plants in 2021! Thanks to China's subsidy of 850 yuan (USD $134)/MWh (then ending). It also put to shame America's puny plans for just 6 GW worth of new offshore wind by 2029.

After decades of warning us clean energy is too costly, is too intermittent -- that only fossils gas, oil & coal can save us, that they alone be economic -- it turns out we needed to think in new ways! And what of energy demand-side & efficiency: can't much be done too in 2020s? Absolutely! Take Helsinki Finland. It's long burned coal, gas to make low-grade heat in winters for people. But mid-2020s it was constructing a new heating system using nearly-unlimited cold water piped from offshore – via heat pumps -- to warm homes, offices etc. The trick is, water at just 2 degrees C sure sounds cold, yet there's enough embedded heat even in low temps, to provide needed (clean) warmth. Enough to get far more heat too, than by combustion! Heat pump 'efficiencies' in heat-transfer sense can be like hundreds of percent! Very unlike old furnaces, or boilers. And electricity used to run the heat pumps in Helsinki, can be from sustainable, zero-carbon, clean renewable sources (plus nuclear).

War, and the initial fears about insufficient gas helped trigger "unprecedented momentum"; IEA made its "largest ever upwards revision", of a renewables surge by 2,400 GW in 5 years. Renewables to overtake coal as world's biggest electricity source by 2026. Elsewhere, we may be nearing end of a 'Great Moderation': a long-term decline in inflation + yet with growth that had lasted 40 years … now left in shambles. Renewables not yet big enough to fill that hole. Far more impactful though maybe we all near end of 'Great Moderation', 7 millennia -- in Climate. That once let civilizations, flourish. If lost, in a hotter-house Earth, that may existentially challenge an ability of cultures, even our human species, to flourish.

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A bit of geology helps if looking far longer back to Past -- than in Financial Reports! $CO_2$ had dropped hard in past Ice Age to 160 ppm (parts per million). Naturally had been cold at times, very hot at other times -- long before we humans. Explained by a fact Earth moves in predictable ways around the sun, in non-round, not-perfectly elliptical orbits. Over tens of thousands of years, our Planet moves via 'precession', and 'axial tilt' like a top spinning on a table. 3 predictable moves explained by Milankovitch cycles, variable/cyclic cold or warming. Meanwhile continents drift changing Earth's surface, impacting big ocean currents. How much land is in Northern vs. Southern hemispheres affects how much heat is absorbed -- or reflects sun's heat. Ice sheets near poles reflect sun (cooler) -- dark oceans at poles facing sun, absorb heat. Net result of variable 26,000 years precession, of 41,000 year cycles in axial-tilt, plus continents drifting is a cooling, warming. It can & does change climate by a few degrees C at poles (that's a Lot!). Over time, naturally. Once renewed heating re-starts via many factors, like a $CO_2$ released naturally by volcanism, or $CO_2$ from decomposing vegetation, or methane under permafrost etc, they can 'kick-start' more rapid heating via water vapor naturally in air. Water vapor is a very potent greenhouse gas in just thousands of years.

It's significant then that Earth's $CO_2$ levels varied so very little in a past 1 million years. From 160 ppm in Ice Ages -- to just 2x that, or 280 ppm at start of Industrial Revolution. To find higher ppm -- one must go back 3-4 million years to a hot Earth if >420 ppm $CO_2$ like today. $CO_2$ rising hard took thousands of years. Instead, vast $CO_2$ spewing now in 3 centuries means huge heating is already baked in. Much, much more heat & so lonnggg sea rises unfolding over tens of millennia+ ahead. On inertia. May grow 'normal' to see lethal 50+ degrees C (122+ F) or normalized Arctic Circle temps 30+ C (86+ F). At first, brief hellish hothouse *conditions* (masked at times by La Nina) -- then after, a long-hothouse *state*. We don't see how oceans already, terrifyingly, are absorbing heat. 2023 data showed 396 zeta joules of heat was absorbed from 1971 to 2018, in just 1 lifetime. That's equivalent to 25 *Billion* Hiroshima atom bombs and growing. In 2022 the oceans added 10 ZJ more heat than 2021, enough to boil 700 million kettles -- every second! The data indicate that much $CO_2$ was last seen, not 1 million years ago -- but instead 14 million years ago; we may see 600, even 800 ppm by year 2100.

Hence our problem: by so massively burning fossil fuels, we've put into air 'old' carbon once safely locked away for millions of years. Natural gas is 4 parts Hydrogen -- each part C carbon, thus = $CH_4$. Most hydrogen-rich/ least carbon-laden fossil fuel at 4:1. Industry calls it 'clean' (it is Not!). Burning each molecule only bit less-horrid than burning oil or worst, coal. Take black coal, anthracite (please!): it's near all carbon, very dense. Burning 1 ton of that poison for power puts out 4 tons $CO_2$ -- worse than gas(!). So coal spews 67% more $CO_2$ plus mercury, particulates, sulphur dioxide, awful ways to make power! Young wet brown coal with impurities is incredibly worse. Could lead to future wet-bulb global temps that may kill.

Hence, was remarkable that as war spiked gas prices, more coal was used. In 2020 US natural gas had cost $1.48/million BTUs; in 2022 was briefly $8.00+ or up +400%+! Then fell back hard to near $2.00 in 2024. A Europe that in 2020 was near off coal, returned to it. Short-term, coal = warmth & power. But there's a price burning carbon gathered over millions of years, and releasing it all at once. Renewables may help keep $CO_2$ emissions steadier (despite coal), even drop a bit latter-decade. *But, big reductions in $CO_2$*/GHG concentrations are needed. Necessary, with electricity made saner ways than by fossils -- or in a Zaporizhzhia nuclear plant in Ukraine near-shelling of war, with explosives stored, safety threatened(!). Tsk tsk, silly ways to boil water. Ukraine's Kakhovka dam also under threat. So too cables on sea floors carrying information globally, a backbone of internet or power that could be severed.

It's not been a straight line. Nor the same, all places. Europe, for instance in 2022 enjoyed relatively better/lower costs installing solar vs. a US. Why? For starters, Europeans didn't pay solar tariffs like US buyers had to for energy kit from China. Didn't have America's state by state added net metering (NEM) costs. Nor same restrictions on China. Plus, natural gas is a core competing fuel in Europe -- and natural gas there has been very expensive. Mid-2022 was $40+ per Mcf. So, a gas option there was often 3x more than in US -- that helped make any pro-clean energy decisions far easier in Europe. In short it was far easier & cheaper there to install new wind energy & solar in Europe -- than it was in the US in say, early 2020s.

Per IRENA data of 2021, Europe had cut its average all-in installed utility-scale solar costs, by a lot. Germany had pushed solar install costs down to $0.69/watt. Italy to $0.79, UK $0.85. Meanwhile, US was more costly 2021: $1.09/watt. Europe shaved $0.10/watt off install PV costs relative to US. Surely in a world facing unending climate crises, one may think decarbonizing fast is a priority. But No. US champions less regulatory burdens, but it lately has had higher soft costs for solar -- for design, permitting, installation -- vs. Europe's lesser burdens. If comparing like, for like, say 2 systems of similar sizes even putting aside the costs of PV hardware (lower as well in Europe), America in 2023 was much less efficient.

Step back, cost *trends* to install renewables 2020 to 2021 worldwide had as one hopes to see, Declined. More recent inflation, 2022 & 2023 hadn't shown up in those data yet. We'll see that inflation later. Yet looking 2020 to 2021 here, levelized costs of energy (LCOE) for new utility-scale solar, show electricity cost *fell* 13% in 2020/2021 to $0.048/kWh. Onshore wind, fell 15% y/over/y to $0.033 per kWh. Offshore wind, fell 13% year over year to $0.075/kWh. This is significant. Take say, Germany. It has a *potential* to raise offshore wind generating capacity to 81 GW. For rather like ~81 mid-sized current-gen nuclear reactors. Sure, wind is intermittent. Yet to a Germany facing electricity fears, that much new power can be stupendous. 10x more energy, than the 7.8 GW its operating offshore wind had then made in 1H 2022. Put in perspective 139 billion KWhs of clean energy was made by all of Germany's renewables 1H 2022, and met near 49% its total electricity demand! Its onshore wind energy, had made 59 billion (Bn) KWhs; its solar plants made 33 Bn KWhs; its biomass 24 Bn KWhs; its hydro 9 Bn KWhs, and its offshore wind energy had made then 12 Bn KWhs.

In 2022/2023 renewables costs briefly rose in solar/wind. Still, fossil prices rose inordinately, so renewables' changes were moderated. And clean, can beat fossils in unprecedented ways. Look at average fuel-only costs in gas-fired electricity (no $CO_2$ Fees) mid-2022: these rose to $0.23/kWh: so 23 cents per kilowatt hour wholesale cost ***for just fuel alone***. Extant, built gas plants in Europe were pricier to run -- than to build new onshore wind or solar on free fuel. When gas fuel costs in 2022 jumped briefly 540% vs. 2020, was no contest. Add carbon Fees in Europe, and 'once-cheap' (not-clean) gas-fired power went >27 cents/ kilowatt hour, 4 to 6-fold more than solar & onshore wind in 2022. No wonder renewables if competing on even-playing field, were obvious choice. Thermals coal, gas, nukes struggled to work in Summers. That said, big hydropower struggled too, given droughts at dams worldwide 2022. Big hydro may have already peaked at ~15%, it will never again be a global growth driver.

In a dozen years, 2010 to 2022, LCOE figure pretty much had said it all. For electricity made from natural gas, costs had briefly hit 23 cents/kWh for fuel-alone, 27 cents with carbon Fees like Europe. By comparison, best-case onshore wind was down near just 3 cents(!) thanks to free fuel -- a 68% cost drop since 2010! Solar PV's best cost was then near 5 cents on declines of 88%! Offshore wind, best case was just 7 cents on falls of 60%. Renewables enjoy free fuel, plus can much get cheaper over time to boot. Was becoming No Contest.

As for a piped Russian gas, once EU's chosen path, suddenly it was a red letter of shame. Went from cheap/plentiful -- to unavailable/unwanted. A security risk. Russian gas suddenly a liability, weakness. Energy Security hawks wanted all non-Russian gas they could get, even if LNG vessels meant more fossil infrastructure. On other hand, the Climate hawks wanted immediately to get off all that. To go directly to zero-carbon infrastructure exclusively, now. So, to keep with mainly LNG or natural gas, was seen by latter as a mutual suicide pact.

Still, both sides concurred: Germany & Europe could Not use Russian gas. Emphasizes need, agreed by all, for vastly more electricity Storage. (Electric storage can be measured as Power, so in watts -- or as Energy, so in watts over time -- megawatt/hours. And 95% of electricity once was stored as pumped hydro: moving water between 2 elevations. As power by turbine size & elevation difference, globally 165 GW could be stored. Or as energy, how much water in reservoirs; in 2021 that was 9,000 GW/hrs or 9 TW/hrs. Anyways pumped hydro storage capacity was capped: dams can't much grow, best sites are taken. Electricity storage capacity if once was mainly pumped hydro – is not now nearly enough given intermittency & diversity of renewables. Electricity must be used at once when made -- or be stored. So intermittent sun & wind always will demand much storage. Maybe green hydrogen, one day storage too. More storage & a better grid are keys to unlocking magnitudes of clean energy growth.

Batteries give just a short-term storage to say 4 hours. Longer-term storage options can hold electricity for days, weeks, months. Yet achieving huge-enough zero-emissions global Storage by 2040, meant new capacity of some 2.5 terawatts (TW) power, 150 TW/hrs of energy. Thus, Herculean efforts are needed, fast. But outside of pumped hydro, little capacity existed. Consider: if all non-pumped-hydro base storage then extant in 2020 were grown 20-fold, from 2020 to 2030, then that would only come to 1 TW/hr. Just 150$^{th}$ the projected energy storage capacity *need* of 150 TW/hrs. No doubt, new non-hydro technology will appear, and can advance\e the curve in unexpected ways. But, this new 2.5 TW sought is quite an ask!

Some rely on hope. Hope say, energy crises in late 2020s/and 30s aren't as bad as in 1970s. Yet may be worse ahead. Two 1970s crises were both on oil. Now, 2020s/30s, they're partly about oil -- and vital natural gas too -- even nuclear-fuel-cycle. And demand pushing up prices is for ugly coal too, as $CO_2$ grows worse. Yes EVs / renewables may soon help keep year over year rises to $CO_2$ to 'smallish', then nearer nil gains. But fossils need to Drop, Hard, fast.

Others deny the science of $CO_2$. Yet given big consequences if they're wrong -- and science shouts that Wrong they are -- that's a slender reed on which to hang all one's hopes. In 2022, a major world leader had maybe intended perhaps to stoke conflicts among Europe's elites. To start an invasion to re-claim past territories, re-open old energy rivalries. Divide EU/ West. Tear down NATO, EU elites, promote global populism. As a key gas supplier to Europe, had wherewithal to withhold that gas, and daily we were reminded of horrors of war. Yet Europe moved surprisingly fast off their gas -- as other things were going on early/mid-2020s too.

They included 'bad' surprises not-covered in media. Like methane concentrations in air that 2022 inexplicably went far higher than expected/projected. If on anthropogenic causes, say leaky gas pipes, sabotage, it's one thing. Or agricultural practices too may be addressed. Yet methane's a very-potent greenhouse gas. More short-term than discussed $CO_2$, 80x potency. Capping well leaks everywhere, Turkmenistan to Texas should be an obvious fix, immediately. But should a then-record 17 ppb methane increase, since grown to 1,900+ ppb levels in air be on 'natural, positive feedbacks', a global heating factor we *can't* mitigate -- then surprises may be frightening. That methane's still overlooked, in the 2020s, is of little comfort.

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All as ideas battled over what's best. For those mostly climate-concerned, 2020 had been 1st about a huge omnibus Build Back Better (BBB) draft bill with both carrots -- and sticks too to limit fossil fuels. After that narrowly failed, 2021/2022 it was then about a narrower path. After that failed, hopes were for big Executive Action. In words of a US Senator, Executive 'beast mode', A cost of Carbon Rule; Require Capture at All Major Emitters; Stricter Limits on co-Pollutants of Coal & Gas; Emission Controls for Vehicles; Emissions Front & Center in Procurement (like USPS); Locate Methane Leaks; use DOJ in Climate Litigation and more. Yet any suggestions above, were far easier said than done. Each certain to be killed IRL/'in real life' then early 2020s. Opponents sure to call all Inflationary (though renewables can *reduce* energy costs, be deflationary). Plus, Europe badly wanted American LNG from 2022, and many in America called for a big ramp in exporting fossils. As US Supreme Court tamped down on EPA's abilities on carbon. Plus, any sticks in an IRA would be bogged down in Courts, and no doubt could be reversed in just a day by a new President with mere stroke of a pen.

That 1 Senator's change in 2022 was 'big', to let Reconciliation Bill IRA pass into law on just 50 votes, well short of a filibuster-proof 60 votes. It let IRA happen. Not all could be done via reconciliation: some actions Parliamentarian ruled non-revenue, for bipartisan 60 votes. Like streamlining permitting for oil, gas, grid. Here, a conservative party angry at that 1 Senator -- balked at giving another 'win'. Even if streamlined permits was in normal times desired by that Party. It eyed majority/POTUS ahead. Still IRA was a brief up to green stocks, July gains. Then all soon drifted back, H2X & WNX as well showing broad selloff latter 2022 to -2024.

Even with an IRA, issues abounded that vex clean energy going forward. So much yet to be done, to ramp renewables & storage, to streamline permits, more. For example, new offshore wind turbines are eye-openingly huge. Since as wind power output doesn't just double if rotor diameter doubles -- it can go up 4x by doubling wind speeds offshore, huge gives turbines 8x+ more power. All maths pointed to more enormous scaled-up offshore turbines. Yet US ships extant say in 2023 that once could install a not-long-ago 'big' 1.5 MW turbine at sea -- couldn't cope at all with skyscraper-tall blades of gigantic turbines putting out 10, or 12 MW+. Soon to be 18 MW in size each, and so 10+ times bigger in output than earlier sized blades.

Thus nowadays ships are purpose-built, wind turbine-installation vessels (WTIVs). In US it gets 'interesting' due to a longstanding Jones Act that stops foreign-owned, built, crewed vessels from operating in between 2 US ports. So the European WTIVs can't be simply brought over. IRA calls for rapid increases (huzzah!) in offshore wind capacity at US, looks to 30 new GW by 2030. Yet the costs are eye-wateringly-high to build WTIVs; Jones-Act ready vessels not online until 2024 at soonest. A new 'Edison' vessel could have its housing & warehouse built in, as oil rig platforms have crew quarters. Hoped-for ships, Southfork, Revolution, Sunrise, to install 1.7 GW. Meanwhile early Jones Act-qualified wind installation vessel, Charybdis built in Texas was chartered, yet in 2023 offshore wind projects were being cancelled -- so work-arounds needed. Like maybe basing WTIVs offshore Canada at first, to help on huge turbines to go off New England; use US flagged barges to transport turbines to these waiting WTIVs from Europe, Asia, etc. Or in 2023, two mid-sized wind vessel firms for purpose-made offshore installation ships merged, for a larger single-firm; a step in accessing the kind of capital and scale needed to build offshore wind swiftly including in the US. Yet big picture, by tough 2025 and a new president so hostile to offshore wind, large wind names were shelving US offshore projects. 2025 to - 2028 did not look especially auspicious, at least for offshore wind in a US. Needed ahead very late 2020s, if a new administration, could be capital for huge investments in capacity, loosening supply chains -- a start to building US renewables offshore.

May be best to think of scales needed to 2050, in rough back-of-napkin figures. To focus not on what 1 Senator was prepared to give in IRA -- but rather $CO_2$ cuts needed on global carbon budget according to the best available science. These figures are enormous -- yet that's a true scale of this problem that's hard to deny. *Roughly it's estimated $100 Trillion+ total needs to be invested worldwide to decarbonize all activity in 3 decades to 2050*. Tremendous sums. But they can also create immense new gains/jobs -- unlike *costs* due to Hothouse Earth, sea levels rising to destroy say, State of Florida, New York City, many mega-cities and sooner than is yet realized. According to International Energy Agency (IEA), to get to net-zero (not even true zero) emissions, humanity must invest over $4,000 billion/ per year. That works out as $4 Trillion/year averaged worldwide. Annually over next three decades to 2050.

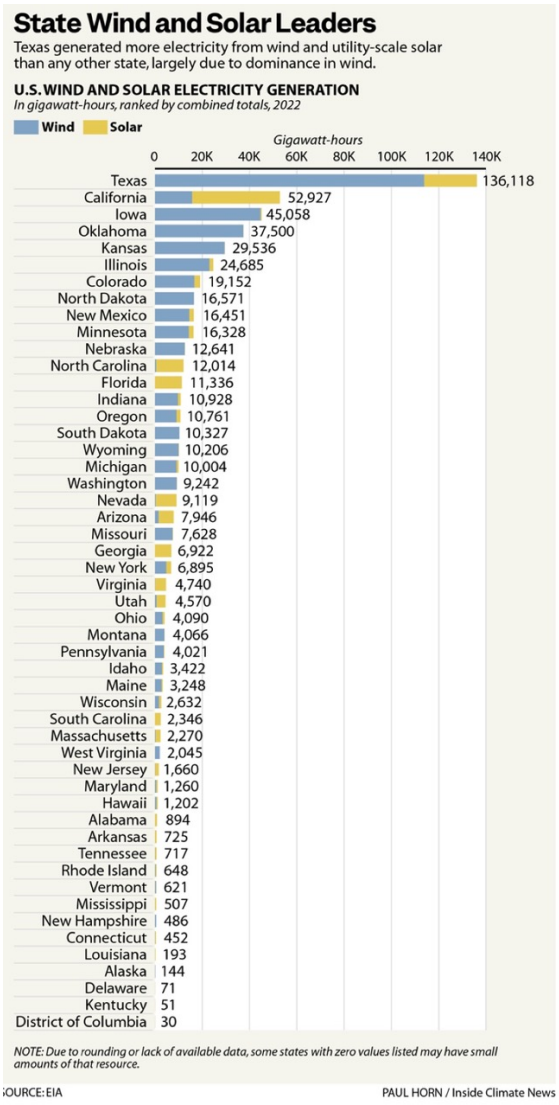
First good news: global investments had hit $1,000 Bn ($1 Trillion) 2022, a then-record. A breakdown from 2021 showed renewables wind/solar investments had grown just modestly 5 years before to $361 billion. What really took off, was electrifying transport: it leapt to $273 billion in 2021, up +77% from year before as EVs & charging infrastructure overtook renewable inflows. Yet to meet 2050 $CO_2$ goals, spending 2022 to 2025 must hit $2.1 Trillion/year, twice that of 2021. 3x a $595 billion figure that was seen 2020. Renewables growth in wind/solar was too small @ 'only' 6%/year; only green transport was of late fast-enough.

In 2026 to 2030, total new spending/investments needs double yet again -- to $4,200 billion (or $4.2 Trillion) per year. Thus 4-fold greater than seen in 2022! Yes, there's $369 billion a least (uncapped – so can be several times that) public spending in IRA for $$ *All decade*; say $50-$100 billion/ year. And of $4,000 billion/year (or $4 Trillion/year) *needed,* obviously most is private sector investments, rightly so. Back-of-napkin, say US spend is 25%, $1,000 billion/yr = $1 Trillion/yr. China similarly 25% but nuclear-heavy path, much wind/PV manufacturing, strategic minerals, big electric vehicle growth. Europe is say, 20%, $800 billion/yr over 3 decades, also with renewables, transport, green hydrogen for power, heat pumps etc.

On these metrics, US $369 Billion 2022 IRA goes >$1 Trillion, with PTC/ITC lasting decades as discussed ahead as a start. Think of IRA as public sector catalyst for private sector spending on far bigger scales. For example, another place where investing needs are great, is building more robust smarter, modern grid. Interestingly antiquated US grid was so full-of-bottlenecks in 2021, it forced wholesale electricity prices to go negative not a little … but 200 million times. That was 2x a figure of five years prior, measured in 5-minute intervals over 7 US grids, 41,000 nodes. Not enough to crash regional wholesale prices. But, meant so much wind, solar was held up, it did push prices below zero. Wind/solar was curtailed (shut), and offtakers *paid* to take electricity. Plus waits too long to connect too though addressed some in US in mid-2020s. Grids have prevented rapid-build of new wind -- also solar -- around the globe.

Insufficient transmission had kept green electrons from reaching far-off demand, for example in America's SouthWest Power Pool (SWP). A vast & windy area from New Mexico to Montana -- only 19 million people serviced. Unsurprisingly wind oft is a main electricity generator here. And January-July 2022, wholesale prices there had gone negative big 17% of time. Versus 7% for grids in heavily-populated California, or Texas. In Q2 2022 nearly 25% of all SWP real-time wholesale prices had gone negative! Thus wind + solar faced increasing bottlenecks stifling potential for growth. A Princeton University study estimated $2.5 Trillion in investments by private sector are needed to 2050, to meet US grid transmission needs. Yes, much $$! But the US grid is nearing end-of-expected life in many places; it was built in a different era as 1-way power transmission from big thermal plants. Demand, and costs of blackouts are now far-higher too, so $ Trillions to invest in grid improvements may seem even appropriate(!).

Folks are excused if they'd assumed California is America's #1 State for renewables; in fact, it's Texas. Many Texas business & local leaders embrace renewables. Yet some Texas political leaders curiously make much of their allegiance to fossils, antipathy to renewables. Maybe as cheaper renewables became a threat to gas, oil, coal, nukes; in 2022 wind & solar made 25%+ of that State's power -- at times it had passed 50% of electric power in 2023 -- vs. what was just a measly 0.7% in 2002. Indeed, a slew of anti-renewables Bills curiously were introduced in 2023/'24/'25 -- trying to reverse clean energy growth. Here one sees America's highest vs. lowest states ranked for renewables wind/solar in 2022, many Red states at top:



Source: Energy Information Agency (EIA), Inside Climate News

136,118 gigawatt-hours of green power was made in Texas 2022 from wind, utility-scale solar (above). Yet its electric power needs were so huge, renewables still had only met 34% of the Texas total electricity demand. Adding nuclear, & hydropower, Texas led nation by making a big 180,000 gigawatt-hours of zero-carbon electricity. That's all nice, but its coal & natural gas still are very big there -- yet feeling threatened. In 2023 a raft of Bills were introduced in Texas' Legislature to stop/slow renewables. Nationally for how big renewables & nuclear had gotten in all US, of total demand in 2022, ~40% of US electricity was met by zero-carbon sources. That was some ~22% met by renewables, and ~18% met by nuclear power.

What can grow wind & solar generation faster? Modern grid infrastructure using & sharing power with better resilience. This means big changes akin to building Interstate Highways in 1950s. So far, instead, it's been just patchy repairs, few big upgrades, catch as catch can. Grid bottlenecks led to wholesale electricity prices going negative 2022 (to Aug. 15th) at 6.8% of time -- vs. 4.6% all 2021. Wind/solar had to be curtailed (shut) at times, or it might have been worse. Fossil & nuclear interests often criticize renewables as intermittent, a 'defect' in no wind or sun -- yet they prefer Not to discuss when sun/wind flip-side are abundant. Then, firm coal/nukes -- not nimble, unable to start/stop, must stay on as prices drop near zero -- even negative! On May 7, 2022, a Texas coal plant saw prices briefly fall to -$8,977, negative per megawatt/hr; *paying* users to take power! 'Firm' can be a liability, if renewables can & do make power at times very, very cheaply/or free. Yes, some $2.5 Trillion in spending by private sector for stronger grid might indeed happen, and for many reasons.

By an end of 2022, 31 huge grid outages had impacted 1+ million persons globally past 4 years. Christmas 2022 a freeze hit much of US. Ukraine was hit by Russian drones. Florida hit by Hurricane – something that has lately become an expectation. 10 other outages affected over 10 million! If uninterruptable power is mission-critical, outages >8 hours more than li-ion batteries bridge. So instead of just storage, think too of fuel cells; they run unlimited long as fuel is supplied. Days, weeks, months. In 2020s, fuel likely natural gas, $CH_4$. But ahead it may be (green) $H_2$. Even natural gas may be less costly, less-dirty, than a diesel genset. Diesel spews 161 lbs $CO_2$ per MMBtu, a gas turbine is bad too @117 lbs; a fuel cell works by electrochemical reaction -- not combusting, so is more efficient, less polluting. A fuel cell is pollutant-free if using green hydrogen $H_2$ -- no SOx, nor NOx from burning. In such a future, green $H_2$ fuel may be made from wind or sun plus water, so simple using electrolyzers!

Consider more severe power outages: 3 days impacted 100 million in India on a coal shortage. 7 days out for 1 million people in Canada due to Derecho. 10 days in UK from lightning strike. On 1 day, 120 million out in Indonesia on power line disruptions. Clearly, more & bigger power grid failures lay at our collective doorsteps ahead. Attacks on grids, or on nukes. Scary, is blackouts lasting weeks, months; that may mean tens or hundreds of thousands of deaths. Longer could mean millions dead. Attempts at risky black starts, bootstrap large grids back to operation. Doesn't take much to knock out a grid: few bullets, bit of explosives, a DNS-cyberattack, even just rusty bolt cutters. First 8 months 2022, 107 physical attacks on US grid were the most seen in a decade. It's been an open secret that big, custom & critical transformers for the US grid are generally Not made in the USA; they come from China, India -- and there's insufficient backups if they're fast 'taken out'. Destroy just 9 key grid electrical substations + a few key transformer manufacturers -- and that can decimate a US power grid largely made up of 3 parts; in areas for for up to a year. Given such sleeping vulnerabilities -- and a potential for widespread deaths in the USA -- more needs to be considered.

Blackouts may lead to some conservatives to want a stronger grid '*now*'! Some may embrace green energy. Conservative-Iowa in 2022 got 60% of its power by wind; Kansas got near 50%; Oklahoma close. Yet their Senators opposed renewables stimulus in 2022 IRA, though they increasingly benefit from wind. Later, in 2024, IRA funds rolling out 1st went largely to few key red Swing States in '24 elections. Despite that, a hatchet was taken to the IRA in 2025. Conceivably, after 2028, a GOP Senator, House Members, may tear away from past partisan opposition to green energy. Maybe on new weather extremes, or unpalatable Russian fossils. Catalysts, or sticks that can nudge $CO_2$ heavy plants to retire. Once-heretical ideas like a carbon-tax, might be re-considered. Or $ Trillions spent on fossil troubles, climate disasters, or war/s fought again and again over oil & gas, may be rethought -- to reframe thinking.

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As a consequential 2022 ended much had changed. An option some had hoped to see, shine -- older, traditional 2nd generation nuclear typified in an aging US nuclear power fleet built to 1990s (nuclear is Not in our Indexes) was instead hard hit by problems. One may have hoped France's shiny, 2nd-generation nuclear tech could 'ride to a rescue' 2022 on war. That the French nuclear fleet's know-how could grow output full tilt. Send more electrons to Europe, sit back pretty, be unvexed by slowing or near-cessation of Russian piped natural gas.

Instead, France 2022 was badly handicapped too, ½ its modern nuclear plants stuck offline. Not long ago they'd been *the* poster child for top-shelf Western nuclear. Proud of sovereign nuclear abilities, highest-percent nuclear in world, without mega-disasters of Chernobyl or Fukishima. But instead, France in 2022 was hit by massive-forced power cuts. 12 of her 56 reactors were stuck offline, 27% year over year output drop, to power levels ~30 years ago. Taxpayer subsidized, yet high electricity costs seemed to vex in perpetuity. Power cuts 2022 had taken La Belle France to under <300 terawatt/hours. All with consequences for Europe, which struggled at first then to find enough fossil fuels-fired electric power.

Not yet well-known, then, was France's nuclear plants had been acutely hit by unexpectedly bad corrosion issues, maintenance needing time to sort. Only could hope 30 GW is back online fast. And that focus on nuclear unhelpfully also held back renewables; in 2022 they'd only met 9% of demand (vs. 25% in UK). France looked to nationalize her debt-laden private nuke champion -- then did so. Plus, problems rife too at big Hinkley Point C nuke plant going up in Britain. Predictably far behind-schedule, far over-budget -- yet a biggest modern nuclear plant going up then in the West. In the words of The Economist (June 25, 2022):

> "Over the 4 years that Hinkley Point C (HPC) has been under construction on the edge of Bristol Channel in the west of England, it has consistently been held up as an example of the industry's current problems. Nuclear energy's long-standing cost and schedule issues used to mean it was hard to compete with natural gas and coal. Now they make it hard for nuclear to compete with ever-cheapening renewable energy.
>
> When the British Government and EDF Energy, the plant's owner, signed the relevant contracts in 2013, HPC was expected to produce a megawatt-hour for GBP £92 (then USD $145). The same amount of energy from a new offshore wind farm was at the time expected to cost GBP £125. Nine years on, HPC is two years behind schedule and GBP £10 Billion over budget; so its power will cost more. Offshore-wind producers, for their part, are offering energy at less than GBP £50 (now USD $60) per megawatt-hour. The cost of electricity from solar panels has fallen yet further." ….

What of spiffy nukes built speedily elsewhere? Don't those going up fast, on budget, mean lessons were learned in colossal mistakes like Hinkley? After all, nuclear-proponents talk of lessons learned. Yes, but not in a West. Take America's attempts to do new nuclear cheaply, in Vogtle Units 3 & 4 in Georgia -- 1st US fission nuke in 3 decades. Begun 2009 on understood Westinghouse designs, costs were to be $14 Billion & done by 2017. But, instead, it drove Westinghouse bankrupt. By 2018 costs were re-estimated $25 Billion. Then 2021 costs re, re-estimated $28 Billion; operation only began 2024 @$35 billion -- crazy *$17 billion over-budget!* France's 'new' Flamanville from 2007 was a decade+ behind schedule, hundreds of re-welds in 2022 cost € billions. Germany might close nukes. And the Olkiluoto nuke in Finland set to open in 2009, had only begun its regular output 'just' 18 years late, in 2023.

*Built* nukes to be retired, saw closings put on hold given 2022 war crisis. True, China & Russia have shown an ability to build big nuclear plants on schedule, on budget. Of 31 reactors begun in 2017 to 2022, 27 were being built using standard Chinese or Russian plans. But, to contract with Russia for a new nuclear plant, now, was 'impossible'. Left China, but future contracts with it too, question marks for the West. Maybe, say S. Korea, or??? Point was & is: there's No Easy Simple Energy Answers! Plus, much had changed dramatically on war.

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In Europe weaning off Russian fossil gas wasn't easy -- but then came fast. Still take Germany's car making so core to its economy. Germany exiting diesel -- moving fast to EVs that may be renewably-powered. But, what of its auto factories? Can they too go past natural gas/heat in vehicle *manufacturing?!* For the required heat, needed just say, in its paint shops?

Shell-games like 'carbon offsets', or 'renewable energy certificates' had let firms pretend to use little natural gas. Claim say trees left on slopes so steep they can't be cut, 'reduced' fossil-use via carbon credits. Surplus, non-transparent, European hydro certificates somehow incentivized renewables. But that was oft virtue signaling. Once Russian gas supply tapered -- then was mainly shut, fast exposed how reliant on non-renewable fossil gas & coal for its high heat -- and for electricity too -- Germany's automobile industry actually was.

It was by a lot. In 2021, >½ of German auto factory power had come from non-renewables. Put another way only 13% of heating needs at her 3 big carmakers, was met by renewables. At Volkswagen, 80% of heat was from non-renewables. It did aim for cogeneration, combined heat & power at Wolfsburg 6.5 million square meters plant. Go from coal -- to gas. But war in 2022 meant it would stay longer on awful abundant coal. At BMW, 60% of energy was from fossils; gas so typical of industry. One Potemkin-Village façade crowd-pleasing response was to site big renewables near a factory. But those only supplied overall some 1% of electric energy, eg 2021 at Volkswagen, less at Mercedes, BMW. An exception was a BMW I3 plant in Leipzig: it got 20% of *electricity* (but not heat) from 4 nearby big-wind turbines. Meanwhile the cheapest-hydroelectric power was hit by drought 2022, perhaps with irony if due to fossils and climates changing. Droughts stifled other industries too like Sichuan China -- where 30% of China's hydro was sited. That hit manufacturers there, its aluminum smelters etc.

Again, exceptions. Like efficient Mercedes Sindelfingen plant 56 that got 30% of *electricity* from solar. Still, those were one-offs, nice for marketing – but not such a norm. Plus, drought was killing hydropower. And what of dearly-needed, high-grade heat? Major parts supplier Bosch got only 1% of its *energy* worldwide from on-site renewables. It aimed for 5% by 2030 – but that's a few years away & a low bar obviously. Sustainably-made *electricity* is fast getting cheaper thanks to wind & solar. Green *electricity* ever easier to obtain. But to get soon a green *energy*, which noticeably means a high-grade *heat* of many hundreds of degrees Celsius like for making steel, cement, glass, aluminum, etc etc – that is much tougher.

For how easier green *electricity* from renewables was, big auto parts maker ZF in 2022 signed power purchase agreements to get 210 GWh of wind power for manufacturing in Germany. Statkraft Norway supplied ZF with 100 GWh from wind farms in Spain 2022. Then, 150 GWh more 2023. In 2024 & 2025 Enovos Energie Deutschland provided ZF with green electricity from its wind farms in Scandinavia. ZF got enough green electricity to power 72,000 German households. Was a modest start at least on the *green electricity power* supply front.

Hard fact remains: *electricity* (green or otherwise) is a poor way to make *heat*. Homes can get low-grade warmth by heat-pumps. But for high industrial heat -- to decarbonize via green hydrogen, or derivatives ammonia, or e-methane from green $H_2$+$CO_2$ -- takes in light of climate crisis, too much time. Time-scale decades, may mean a hothouse world different from our habitable one. In short, green electricity & green *energy heat* are needed ***Now***. On climate -- plus on war, seemingly-always-energy security crises. In the 2020s, 'solutions' were Not yet happening swiftly enough. Not one bit. Meanwhile that much needed high-grade industrial heat cannot *directly* come from sustainable wind, hydro, or solar electricity.

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Curiously, a well-known active fund manager criticized passive Indexes/ETFs in Spring 2022, in claiming 1) passive indexes underperform active-managed funds, & 2) Indexing prevents having growth stories like a notable Tesla early. Yet both claims were demonstrably wrong. First point is shown repeatedly false for years: in fact, passive Indexes oft *Outperform active-managed Funds some 80% of the time!* No wonder passive indexes are 'eating active Funds lunch', growing at latter's expense. We saw ECO had beat an active-Fund here, many periods. 2nd, ECO had added a Tesla, notable to this theme, at start/IPO. Indeed, a Tesla cited by that fund manager was in fact added here/put into ECO Index in the about first Quarter that was possible after its own IPO, which had been way back around the start Q3 in 2010, https://wildershares.com/pdf/2010%20Q3%20ECO%20Quarterly%20Report.pdf Prior to that, we'd written a good deal about this rather important EV company too -- they'd kindly noted us as well.

Let's take a brief look specifically at ARKK. It's a well-known, big-performing, active managed fund that rose hugely in 2020. Indeed, if one sought a bit similar performance to that ARKK -- then ECO & NEX Indexes 5 years to late 2023 presented then rather comparable finish. That ARKK, which is younger, is also innovation heavy; it had begun 1 decade *after* our own ECO -- yet also in disruptive (but different) themes. ARKK started much later; as it began in 2014 -- vs ECO in 2004/ tracker 2005. And our 1st Global clean energy NEX was born 2006/tracker 2007. All 3 themes center on innovation; in say a 5 years since Sept. 2018, ECO, NEX, and ARKK all jumped fast about same time, March 2020 – then all three afterwards fell hard. ECO at first jumped higher, went farther up, than NEX, or ARKK: all 3 co-peaked, Feb. 8, 2021. Then all 3 painfully plummeted. To end of 2023 or about 5+ years from say, Sept. 2018 -- to end of 2023, ECO was nil -- NEX was +15%; vs. ARKK which at the end of 2023, was down about -8% so a bit underwater. For all our warnings about ECO/NEX re: their acute risk, those 2 here were up a bit more, down a bit less than ARKK Yes, we see periods too where ECO/NEX drop more than ARKK; no doubt but all 3 are very volatile! As always too, innovation/tech are hugely risky areas. Clean energy never a haven of calm. Full too, of 'on the other hands.'

Take renewables in applied ways. A good milestone in 2022, was when California on a windy day, for 1st time briefly got 100% of its power from renewables. A sample, less-windy day, on May 5, 2022, saw 23,000 MW of demand – met by 17,000 MW or 70% PV, wind, geothermal. All may ramp ahead, displacing more natural gas. Sunny days, much demand is met by solar, maybe wind. But these figures are behind where they must get -- given $CO_2$ levels & climate emergency. Small wonder its 1 nuclear plant though costly, firm, meeting 6% of State demand, saw its life extended by 5 years in 2022, to go from 2025 -- to now a later 2030 Retirement. Shortages threaten, not just in this rich US state, but all of Europe, China, and globally.

Consider declines at one of world's biggest western (non-Chinese) wind turbine makers, 2021. (In China too a big wind maker saw profits fall 5.3% in 2021; revenues were up just 3.3% on material costs rising, supply chains chaos). This Spanish/German firm's stock fell -45% to end 2021, market cap down by near 1/2. October-Dec. 2021 saw revenues fall to €1.83 billion; year on year -20%. Expected revenues to fall more. It blamed stretched supply chains, cost inflation. Pointed to volatility that "impacted some customers investment decisions", project delays. Dire straits, yet it was not alone: a competing European name also noted "supply chains instability caused by pandemic", "cost inflation in raw materials, turbine components, energy costs." All doubtless at issue in wind energy. Indeed 2022 it posted Q3 loss of €147m -- vs €116m profit in Q3 a year before; quarterly revenue down 29% over 2022 year to €3.91 billion, EBIT margin minus 3.2%. By latter 2023 prior plans to add capacity were paused and there was a €2.2 billion charge due to quality issues, €4.5 billion net loss.

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Once, huge hydropower dams was The Renewable, in 1970s, 1980s. Some places, dams made 10%+ of energy mix -- near 100%/all renewables. But that potential mostly is capped, as few new places for big dams to go. So it's with no regrets scalable solar & wind instead grow fast. Big oil may explore geothermal, drilling holes, which they're good at. Early 2020s, geothermal was costly, yet conjoined say with lithium co-production, beginning to show promise. 'Big Oil' may give way to 'Big Shovel', as minerals become more vital with clean energy's rise. There's far more copper in wind turbines -- than copper in a similarly-sized gas fired plant.

Net result is wind & solar were 2 biggest renewables start of decade, and rich Europe led. Europe gross electricity demand met in 2020 by renewables was near 1/4$^{th}$, close to 25%. The 2020 figures showed its 2 leaders were Norway & Iceland, at 77% and 84% respectively. Among the 27 EU states, Nordics again led: Sweden was at 60%, Finland 44%. But of course, laggards too. Belgium then got only 13% from renewables; The Netherlands then 14%. Both only barely reached then targets (better since!), so were unusual vs. rest of a more ambitious Europe. Hence near all EU 27 was *beating* targets. That bloc set goals in 2009 and while that included as 'renewable' - dubious municipal waste burning (Not classed as clean here at ECO) - their main focus rightly was/and remains, wind & solar. Most exceeding goals. 2 lovelies Sweden & Croatia, did so by 11 percentage points. Poorer Bulgaria, by 7 percentage points. Poland (16%) had lagged in renewables but altered definition let (dubious) biomass burning meet EU targets. A 'less green' lane of biomass burning was an exception; most goals were truer clean energy – primarily wind & solar. Russia's invasion & war in 2022 would give a horrible fillip, yes, to dirty coal, oil, diesel - but here's how EU had looked at start of decade 2020:

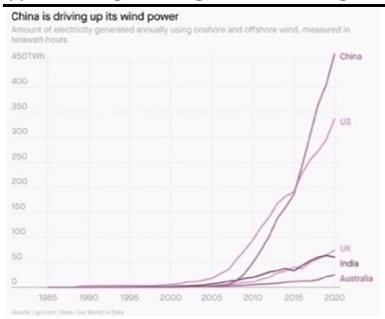
UK famously had left 27 member European Union in 2020, so isn't seen above. But, the UK did in 2020 source 42% of its energy needs from renewables, thanks to a big wind push. Expect offshore wind to fast rise in UK & Europe. Yet curiously if renewable costs in UK, like elsewhere fell -- why did UK average home energy bills in 2021 *jump* to GBP £1,200/or USD $1,630? And go *higher* 2022 as UK wind power was made @ just 5p per kilowatt hour (kWh) -- under ¼ what a homeowner pays?! That, was due to the 4x jumps in natural gas prices 2021 -- for energy markets were set by a *costliest,* yet most needed (still fossil!) fuel. In an energy transition, it made no intuitive sense to see energy bills spike -- as renewables got cheaper! Yet, Ireland showed what can be; in Feb. 2022 its wind supplied 53% of needed electricity. Less windy hours there, its wholesale electricity had cost EUR €229/MWh; in windier hours it dropped to €134/MWh. And even in bit less-windy Nov. 2022, wind made up 48% of its power generated. Average wholesale electricity then had cost €143.12 MWh -- windier days it cost just €106.99 per MWh, Even counting non-windy days, weeks, that wind power had met 1/3$^{rd}$ of Ireland's electricity demand whole year, 2022. Still, skyrocketing natural gas was a big part in Ireland's electricity – so power costs there jumped by 3x year over year.

Meanwhile a US that got only 19.8% of its energy by renewables 2020, lagged Europe's 22.1%. Then on war 2022, Europe faster-upped its renewables commitments, far ahead of US. Of roughly 20% US renewables in 2020, 13% or 2/3rds was solar/wind; 7% or 1/3 big hydro. $105 billion got invested 2021 in renewables, EVs, batteries, etc -- 37 GW solar & wind. Yet natural gas was generating twice that, 20%, or a key 2x or 40% of power. As Europe pulled ahead big picture was neither Europe, nor US made near enough clean power (India too was just 22%). Each must grow 2x or 3x faster, given decarbonization's goals. War did change much early 2020s; Europe grew its renewables, EVs faster. European light duty EV sales were 19% of vehicles 2021, double 8% world average. Then, 1 of 6 cars sold in Europe (more China) were soon EVs -- growing faster. Vastly beat US at just 1 EV out of every 20 cars.

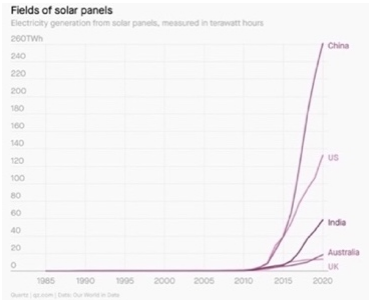
What of China? As arguably THE most important bloc, for renewables? China in 2020 was world leader in its absolute energy generating capacity. Yet its 342 gigawatts (GW) green capacity still meant (only) 14% of power was from renewables. 14% not far off figures for the US. Still, figures can deceive. China's energy demand is so enormous, ramping renewables just some is a damp squib. Yes, relative to Europe or to US, its GW growth far outstripped all, everywhere. In 2021 it aimed to install 1,200 GW new wind & solar by 2030. Unlike at times hollow promises of the West, China tends to meet the goals laid out for itself. So 1,200+ GW can be envisioned. Yet a burning [no pun intended] issue was that China still is utterly reliant on burning record amounts of polluting coal. And then in 2022 and 2023, it was burning even more.

In a run up to 2022's Beijing Olympics, China put renewables into overdrive. It had added 134 new offshore wind turbines able to power ~900,000 homes. 17 GW of new offshore wind was built 2021, taking its total to 26 GW: more than new rest of world past 5 years combined. 21 GW of onshore wind. And it added in 2021, 55 GW solar capacity. That took its total for solar installed capacity to 305 GW – for 1/3rd of the entire world. A startling pace of change in 2022 -- as China, to put it simply, had far outpaced the world in new green GW:

**Wind & Solar Growth in China surpassing all:**

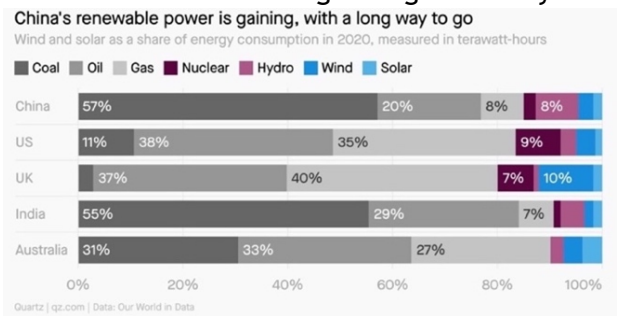



Source: Quartz / Our World in Data.




Source: Quartz / Our World in Data.

Yet China's voracious demand puts it into perspective. In 2020 China had needed 40,170 TWh of energy - only 15% was met by 'renewables' (which in China includes current-gen nuclear). In US, 23,927 TWh was needed, a similar 17%-20% was met by renewables. Europe's green % figure was only a bit ahead of both in 2020, so is much room for improvement at all 3 major blocs. Especially for coal -- where China is undisputedly the pejorative 'king of coal'. But before a rich US, or Germany etc can climb up to crow on their 'uses-less-coal' grandstand -- note they are all burning immense amounts of coal too. Plus, oil in transport. Natural gas for power. With war 2022, coal-use jumped globally on spiking natural gas costs. Thus, fossils oil/diesel, gas and still far-too-often coal -- go on overshadowing our world energy mix.
How 5 big countries had fared in 2020 is seen here as fossils in charcoals, browns & grays dominate, left. At right, blues & pinks, solar, wind, hydro + nuclear have mild penetration, near 20% in 2020 -- and growing. Left way too much room to improve, while Rome burns:




Source: Quartz / Our World in Data

A then-coal-loving-Australia was at bottom, its coal 60% of electric generation back in 2021. Though renewables' are a better bet; a Badgingarra Western Australia wind farm capacity rate (time operating) was 64% in 2022: competitive vs. coal that must shut for maintenance, must buy fuel. Even old/current Gen II nukes touted by proponents as firm, saw dire straits 2022. France had to nationalize its nuke leader on a huge €350 Billion in liabilities & with €19 Bn pre-tax losses 2022. Unforeseen corrosion, poor welds at Flamanville reactor and capped power prices. Of 6 latest-designs reactors built since 1999, 1 in France, 5 abroad -- only 2 in China are working. All as Summer heat & drought threatened cooling, vex-nukes. Small modular reactors, 'SMRs' hope to be cheaper, better ahead; but whether they'll deliver is very questionable: one test in America shut down late 2023. Much preferable would be distributed 'SMR's but of another kind, clean & greener too, 'Small Modular Renewables'.

World fossil linchpin China, seen at top, burns so much coal absolute & relatively, it ensured we humans release unprecedented $CO_2$. In 2021 China's coal production leapt to 4.07 billion tons/year for climate crisis, +4.7% over prior year. Rising electricity demand there 2021 was met by a +9% *increase* in its coal use. 2022, then 2023 were worse: more coal. Meanwhile we release potent greenhouse gases like methane to air freely, like to a sewer, treat it as meaningless. Despite flowery words by rich nations to contrary. It all *makes* our climate emergency a foreseeable, and maybe existential threat, right under our noses.

Even supposed climate leaders flailed in 2022, '23, '24. In California, a Commission overseeing power favored centralized utilities, over small rooftop solar. To the consternation of many -- in 2022 it *reversed* incentives for home rooftop PV so only solar+storage could make sense. A draft 'NEM 3.0' even had $8/kW solar tax that could push payback from reasonable 6-9 years for solar -- to 20+ years: No economic sense. That was changed after uproar; but brought a 75% drop in value of solar-alone. Eliminated retail rates, went to 'avoided cost' -- thus compensation plunged from 30 cents /kWh, to just 7 cents. It made solar-only (no battery) unaffordable, purely non-sensical to most people. Only PV with battery for backup etc -- made sense -- but was unaffordable to great many Californians. In verdant green California! San Diego's local Utility was charging on average, a retail rate of 47 cents/kWh ($470 a megawatt hour) -- yet Utilities were still able to hobble, or to nearly-sink home solar.

An expert in Net Energy Metering (NEM) called 2022's draft NEM 3.0 decision, 'dystopian'. Without roof PV, few will install batteries in first place. Noted payback was not a short 3-4 years (as PD claimed) -- but ~7 years [born out by our own experience]. Installed PV doesn't cost a low $2.38/watt as proffered in PD, but nearer $4/watt. To put huge costs on PV -- *retroactively* -- can kill distributed home solar. And, adding storage -- costs much $$$.
Early outcry over the draft solar tax seemed to kill a $10-$20/month, 'grid participation' fee. Discriminatory anti-solar charges might have been paid only by homes with PV, yet are rare: seen at just 2 of 172 investor-owned utilities nationwide, <3%. Yes, 27 times in past, various utilities *proposed to* add charges for solar homes, only. But nearly all 27 were withdrawn or rejected outright. And none were imposed retroactively, like was proposed here!

Still, Utilities saw by being 'holier than thou', they could show concerns for home PV 'cost shifting' to non-solar customers. And yet. Providing electricity is long "riven by cost shifts". Cost shifts occur as between lower users, vs heavier users, between rural vs urban users, apartments vs single family homes etc. Those investing in efficiency vs those who don't. Cost shifts have gone on for decades, are well-accepted. Utilities may give 'No cost shifts' as main anti-home roof PV rationale, but it's a bit dubious as real cause. Especially given their concerns have been over growth of decentralized, home-owned, solar rooftop PV.

Utilities are accustomed to big centralized thermal-plants -- that they alone own/control. They may support big solar farms which they own -- but those haven't much lowered retail power costs yet at some 25+ cents per kilowatt hour (kWh). By contrast decentralized rooftop home solar like in California could fast cut retail costs by ½ to two-thirds. In 2022 a (rich) customer say of one of California's 3 big investor-owned utilities could save ~50% by upgrading -- go from buying utility-supplied electricity & driving a gasser car -- to instead have solar roof & EV. The 1st PD would quash this, even in progressive California, even in 2022. Pushback was swift & vocal. Notably when California pushed that off to after the 2022 Elections -- it piled on more uncertainty. Pushed down a solar sector already hit by anti-circumvention, further. Only the very costliest solar + storage might then make sense. Not just in California either: sunny Florida had its factions trying to halt rise of roof solar in 2022. A bill introduced in Florida's State legislature, backed by its huge electric utility, could decimate home rooftop solar. Well, the legislation wasn't just 'backed' by that utility. It was later uncovered that the Florida legislator who'd introduced the bill to slash home solar, had this draft bill delivered to them by State's largest public utility. While they may simply hold similar views of 'what's good for the State', that close nexus was notable.

A bit like California, it was centered on net metering, how much $ a solar customer gets back, usually reimbursed retail rate. Florida had come late to home solar PV party but was rising fast. By 2022 it had 90,000 solar roofs (1%) -- vs 1.3 million in California. Florida's utilities could see writing on the wall, but Florida's Governor in 2022 wisely Vetoed that bill. Another state, Nevada, had before made such big change years ago and its nascent solar industry then plummeted. It was later repealed, but those impacts lingered. In sum, utilities may accept big centralized PV -- if they alone own and sell power from their own solar farms -- but as for individually-owned rooftops, making decentralized home PV power, not so much. That said, there's a regressive aspect to net metering -- as it favors wealthier populations. Thus, to more directly assist and help or subsidize lower-income applicants to also go solar too -- and doing so very transparently through the State's budget, would make good sense.

Or, optimistically, note a draft Plan by California Operator (CAISO) in charge of 80% of State grid. Drafted 2022 it laid out State power supply ideas for 2040. It looked to add a new, clean, 120 GW (120,000 megawatts/MW) to meet California's fast-rising demand. Largest source could be utility-scale solar at 53 GW; battery storage 37 GW; wind power from out of state 12 GW; offshore wind 10 GW. With greater-than 4 hours energy storage, another 4 GW.

As vital as what California may *add* next 20 years -- is what it may *take away* under this Plan. 2 big targets in crosshairs were to *slash Natural Gas due to greenhouse gases -- and *end current-gen II Nuclear as exceptionally risky, costly. Cutting much natural gas near-term, is a huge ask. Gas has long been at heart of California's power -- in-State, and in imported electrons. In 2021 natural gas was a key 48.35% of in-State power generation; and still made up 37.06% of State's total electricity mix when one includes typical imported power.

So, to target turning away from natural gas in power generation, is no small thing. May be a gaping firm-power hole. Hence, this plan sought for utility-scale solar, to triple. Energy storage short-term (<4 hours via batteries) to jump 15x, from 2.6 GW in 2021. Longer-duration >4 hours energy storage like pumped water, to rise 4 GW. Of course, was just theory in 2022. How then, near-term, to actually replace those GWs of firm natural gas -- plus big last nuclear plant soon, with anything nearly as energy-rich? Mid-2020s the answer wasn't 100% certain, and threats of rolling blackouts, ahem, real. In an energy transition that's highlighting demand for yet *more* natural gas, and keeping nukes -- not one seeking less of either.

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That 2022 Plan saw 12 GW of renewables brought in from out of state. 3 GW wind/sun on a SunZia line from New Mexico/AZ, which got $11 billion in funds and after 17 years of Permits, began construction 2024 as one of biggest clean energy projects in US history. Plus 4.7 GW transmission of Wyoming's wind on TransWest line. The GWs can't happen soon enough. CAISO's draft Plan projected going from 7.8 GW of wind power, to 24 GW Western wind 2040. In past, a too long ~10 years was needed for permits; yet green electrons are needed faster. So helpfully, regulatory bureaucracy is being cut of late. $30 Billion for transmission upgrades do-able. Like $11 Billion to improve substations & powerlines; $8 Billion for local off-takers to use offshore wind, $11 Billion to bring wind power from out of state. Maybe $2.5 Trillion in spending over a decade, Huge sums! (As Sen. Dirksen joked, 'A billion here and a billion there, pretty soon you're talking real money'). But in context of vaster oil & gas sums, the $$ for renewables are relatable. Particularly for resilience in California's $3 Trillion economy. Were that state, a nation, it'd be the 4$^{th}$ or 5$^{th}$ largest in the world. Ahead of India, the UK. As blackouts there -- or anywhere, due to heat/freezes/attacks etc must be avoided.

A biting issue 2020s was poor US grid resilience -- power was being lost too frequently. 2021 saw 180 big power disruptions; 20 years earlier, was under 2 dozen. Not just unprecedented weather extremes at fault, the US grid is aging badly. 70% of transmission & distribution was far into 2$^{nd}$ half of 50-year lifespans, 600,000 miles of key transmission lines, 5.5 million miles of local distribution. Back in 2010, big thermal coal, gas & nukes had made most US power; later, natural gas was king as shale fracking made it cheap. Since then, renewables began competing and at times beat all on price. But given intermittency of renewables & a need for bidirectionality, storage -- with problems rife in all fossils, nukes, razor-thin power reserves -- plus old grid non-resiliency, it all will stay problematic 'til vast new storage comes online. There's no easy answer/s. But for certain, the abundant, cheap, and clean renewables, new storage & better modern grid -- all simply have got to be grown swiftly too.

Storage & grid will take time to be built. So, what of big parts to this puzzle: natural gas & current gen II nuclear near-term? Early 2020s California needed all its 25 GW of renewables -- and soon 50+ GW more green power. 17 GW utility solar should have been added 'yesterday' -- even utilities support it. More offshore wind. Were gen IV/V nukes safe, affordable now, no wastes, it would be wonderful! The State has one gen II nuke, its life extended from 2025 -- to 2030 closure, but it was none of that -- yet is needed. California's grid in 2032 *might* be 70% renewables, & 85% greenhouse-gases free. But the latter 2020s is scary.
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It's easy, thinking of politics, to forget that $CO_2$/ climate actually have THE final say. Politics ignores that, though science indicates this error may revisit us many-fold. Work's happening in future-gazing science, getting ever-more right models that help better see what may be ahead. For instance, how the clouds, water vapor may contribute to heating -- or not -- like other greenhouse gases (GHGs) is vital. Potentially, clouds *may* mean Earth gets much hotter still. Or, reflective clouds might instead mean we're in less blazing cauldron than predicted. A newer National Center for Atmospheric Research (NCAR) Community Earth System Model 2 (CESM2) has implied more impactful heating *may* come, sooner than was forecast by 20 prior models. So, scientists re-looked at that CESM2. More granular, sophisticated than in prior models, this bigger amplification seen as *possible* from clouds, should be worrying. Clouds may reduce heating (yay) -- or may instead supercharge it -- so getting clouds' complicated impacts right, is of the essence. Like impacts of short-lived methane, or GHGs besides carbon dioxide ($CO_2$) -- consequences can be planetary-scale. Clearly, water vapor is crucial.

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Past brute models were somewhat right -- even if at times they *understated* heating since. A look at 17 basic models 1970 to 2007 showed pretty good overlap with what later was seen. Still clouds' complexity vexes. Older models expected if $CO_2$ levels doubled from a start of industrial era -- from earlier 270 ppm to 550 ppm where we're fast headed on $CO_2$ already over 425 ppm, we all may be baking early next century between 2.7 degrees F -- 8 degrees F (1.5 C - 4.5 degrees C). CESM2 implies an unbearable 9.5 degrees F (5.3 degrees C) baking may be possible! Result of doubling+ $CO_2$ partly due to water vapor/clouds. Nearly 1/3$^{rd}$ higher temperatures, than prior models implied, so getting accurate modeling was no small interest. 9 degrees F would feel places like a furnace. On accuracy of climate models then, much depends. It's an entirely different way to forecast what may be, than look back in geologic time to when $CO_2$ levels were roughly similar, estimate what temperatures may be like ahead. (Maybe it's back to Pliocene, then Miocene for us)! Either way a 'merely' **transitory** extreme heating we may feel in a 1$^{st}$ century or two @550 ppm, can pale to far hotter **equilibria** temps later unfolding over many millennia. Far Hotter. With long rising seas, discussed ahead.

That's why, when review of 39 climate models found that 13 showed higher heat ahead, partly on water vapor/clouds, it was potentially very troubling. A 'wolf pack' of outlier results didn't match actual temperatures -- so models were reworked. UN climate assessments stayed away from such high heat predictions, given uncertainty. But what if models are partly right? To say nothing of unstoppable permafrost melt, undersea methane, clathrates or hydrates like 125,000 years ago in an Eemian interglacial 'hot' era, as global seas were 20+ ft higher.

Let's shift gears back from climate -- to finance & equities, for a bit of helpful news here. There's now much more breadth among potential candidate clean energy stocks. Far more companies in clean energy, climate/tech solutions. Markets better advancing global energy innovation. Firms by market capitalization 2020s, now are far larger than turn of millennium ~25 ago, even 10 years ago. In an applied side-note related to Indexing here, markets 2022-2024 resulted in a few changes to Guidelines. NEX Index average daily traded value (ADTV) floor became USD $1 million/day past 90 days for adds, and USD $750k for the extant components. Screens for NEX/H2X/WNX using Global Standards Screening (GSS), Controversy Scoring, 'ESG'/Risk Ratings (ESG RR), & various Product Involvement (PI) fields; so companies that miss GSS, Controversy, ESG/RR or all PI fields, are removed from the eligible universe. In a Consultation of October 2024 for NEX/H2X/WNX, it was determined to align with EU Paris-aligned benchmarks, changes were added to align the Article 12 Exclusions with Commission Delegated Regulation (EU) 2020/1818. More is on those Indexes' websites.

Staying with reasons perhaps 2021 to 2024 were so rough for green – besides inflation -- and for wider equities too one was that investment banks already in 2021 were predicting sparse profits for 2022 and after. Earnings targets at S&P500 firms were 'lower-highs & lower-lows'. Take S&P 500's add, Tesla: it had carried already-huge huge market cap, among the S&P's biggest when it entered the 500 (funny enough, late on hesitancy over reputational risk). It set a tone too when its head aptly expressed concerns for supply chains risks in coming 2022. A high-end estimate for all S&P 2022 saw only gain of +9.1%. Other forecasts were flat, or negative like S&P ends 2022 down -7.7%. An average at 9 institutions saw a puny +2.8% return for 2022. Causes for pessimism were not transitory; headwinds were sticky. As valuations began 2022 at a high from late 2021, S&P500 price/earnings (PE) 27, maybe meant falls likely. A high 27 PE then not seen since the tech bubble -- and we recall how that had ended. To expect earnings to soon justify so rich a PE as 27, was maybe a fool's errand.

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Not-long-ago 2021 had been wracked by record heat, drought, storms, flooding. Yet in just a few decades, maybe sooner, people may look back at 2021 with its miserable heat, floods, cold, hurricanes, rapidly disappearing sea ice, and rising seas -- as having been part of a far cooler, a more stable, and much more desirable past. One that can't ever be recovered.

Data have since made clear too, there never was any hoped-for, post-Covid, Green recovery. Clearly no post-pandemic green moves *away* from fossil fuels; $CO_2$ emissions first fell, then *exceeded* pre-pandemic by >5%. Got worse 2021, worse still mid-2020s. On climate, we're losing badly. Facts so far no cause for optimism. Not in this decade, nor this century.

2021 + 2022 did flesh out debate on a proposed big US climate spending plan. Outlines of that Gordian knot well known: 2 legislative bills were in play. One was a 'smaller' Infrastructure Bill supported by some conservatives, so Bipartisan yet did near *nothing* on climate -- so was not too-relevant. Less-costly of the 2, yet still $1.2 Trillion(!), it had clear 'pay-fors', revenue sources relative to the past big deficit spending/or tax cuts used by both parties.

Most of the time in politics, debate is on human-scale timeframes. There's a moderate place or stance to stake out -- a middle ground twixt 2 fiercely opposing sides. Common sense, a compromise between sharply opposing views. Singularly, for climate, the middle ground we may so instinctively seek isn't there. Punting for carrots-only, preserving fossils/no sticks, may mean Loser is our common future. A planet that centuries ahead may start to look alien. Perhaps not hyperbole to fear what's lost, was just maybe, could be more habitable future.

In politics, biggest greenhouse emitter China said it wouldn't be at COP26 in Scotland. After a prior outcry China's 5-year Plan wouldn't reduce coal sizably, they'd upped ambitious aims to peak coal sooner. But after steps away from coal -- China was hit 2021 by a severe energy crunch. It grew less certain they could keep peak pre-2030 aims. Seems on coal, little chance -- but for their huge growth of renewables. Plus, rich nations failed in their own $100 billion commitments to transfer funds & know-how to a developing world to reduce carbon emissions, so little reason developing China, India, Indonesia etc felt to offer more. Besides Russia, Brazil, Mexico didn't show at COP 2021: they likewise hardly enthused about rich-world calls there for more 'cuts' soon in carbon. Especially post-2025 as a US pulled out.

Anyway most all nations were, & are carbon-addicted, despite flowery words to contrary. Not just a usual China, India, Russia, Saudi Arabia, Qatar -- but rich G-20 polluters too who self-proclaim virtue: US, Japan, Germany, UK, others. Whose addictions were at odds with prettier promises at G-20 events, Climate Conferences. Private industry, gave more of same. State-owned fossil firms offered vague promises, glossy blue hydrogen ads, talk of distant 'carbon neutrality' in say distant 2050. All conflict with pressing $CO_2$ reality. On 3 reasons, that 2021's COP goals were small beer. 1) Rich nations big 'commitments' of $100 Billion/year for developing nations were easier to mouth in a Paris Agreement -- than actually to mobilize at COP; 2) Global carbon rules as mere talk, was seen in a flailing US Congress and a disintegrating BBB; and 3) Most blatant, cuts big enough to keep to 2 degrees C heating -- let alone 1.5 C -- were obviously far deeper than what nations were prepared to offer. Commitments on offer were far short of a 2 degrees C ceiling; to say nothing of 1.5 C via 45% *fewer* emissions, a bridge too far. Simply adding up all 2021 commitments, meant emissions if followed, would drop by oh … umm, ahem, *Nothing!* Instead, they'd go Up +14% *higher* on best commitments of 2021. Canada increased ambitions at COP26, yet its new 'tougher' goals were so lax, that they'd still be in line with 4 degrees C of further heating.

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Physics & chemistry can give us total carbon budget: how much emissions with 50% chance to not go past 1.5 degrees C. That's 2,890 Bn tons of $CO_2$ -- but we'd emitted 2,390 Bn tons by 2019. Left 400 Bn tons by 2022, and since we spew 40 Bn tons/year, to stay under 1.5 C is Not possible; we're toast. On current trends we'll pass that 'ceiling' soon. It's laughable to think we'd go for years -- then, switch off say 2030 all $CO_2$ emissions 100% at once. In 1824, Frenchman Joseph Fourier showed how Earth is warmer, than a planet without atmosphere. In 1856 a brilliant US scientist Eunice Foote noted how $CO_2$ warms the inside of a jar; she predicted $CO_2$ can cause climate change -- century & half ago. John Tyndall in 1860s correctly showed how $CO_2$, water vapor, methane will heat the planet's climate. Over a century ago, Svante Arrhenius & Arvid Hogbom of Sweden determined Why a then-forecasted 3 degrees+ C rise in global warming will result from each 3/2 rise of $CO_2$. That ratio has since been refined, but principle roughly same, with still more heating at poles than at equator. A linear increase first, of $CO_2$ -- means by power law for second, temperatures will rise as a logarithm of $CO_2$. In 2024, Fermi Resonance had helped explain Quantum aspects of this heating; here $CO_2$ is exciting a broader spectrum at either side of 15 microns wavelengths.

As for what's possible, think of a carbon linchpin, China. So wedded to coal it hadn't talked at COP26 of a coal 'phase-out' -- but of 'phase-down.' Yet its possibilities for solar power are immense. China, more than any can make vast solar growth happen. Reminiscent of US mobilizing 1941 for war. By 2021 China already had 250 GW of solar power capacity, nicely 2x what was called-for in its earlier Plans. It could boast 1/3$^{rd}$ global solar capacity, due to its domestic China demand with reverberating benefits planet-wide. And yet.

Consider what's possible at high end. In theory if all China's areas that could easily go solar, had it. In a sparse-populated northwest (most folks are in southeast), a 'technical potential' of all solar in 2020 was 100 petawatt-hours. That was 13x all China's then total 7.5 PW/hrs of Electricity Demand (or 2x then-Total demand all energy with heat). By 2060 as solar efficiencies improve, its solar potential might rise +50% more to 150 PW/hr, when China plans for net-zero emissions. ½ its potential solar-areas already capable of PV as cheaper there in 2020, than coal. 80% of its solar areas could be cheaper than coal in 2022. As solar improves more, 2030, solar can be cheaper than coal -- across all China! It's solar costs had averaged 4.93 cents/kWh back in 2020. Costs were projected then to drop to 1.3 cents/kWh by 2030. Then solar could get cheaper still, down to 0.3 cents/kWh by 2060! If a price is put on coal pollution, say carbon tax, cost difference gets immense. And so, coal cannot compete ahead; all sides know that. But coal means jobs; it is firm, dispatchable, uninterruptible -- a vast domestic power source if needed. Solar, hobbled by intermittency, dearly needs energy storage to be firm. Put together storage + solar can be 100% dispatchable then; by 2030 a projected 5.2 petawatt-hours of solar+storage might be available in China. All that could be cheaper than dirty coal, too -- and be near its 7.5 PW total demand.

By 2060 solar+storage could make 7.2 petawatt-hours, so meet 1/2 of China's electricity demand. Compliment it with huge wind, geothermal to meet all needs -- alongside maybe nuclear (fusion? -- better than fission)! Yet put aside unknown fusion -- think of the challenges in ramping proven renewables. Battery designs if needing say cobalt, may hoover 36% of world known cobalt reserves -- on past battery designs. But, on better, batteries not needing cobalt, discussed ahead, all gets easier. Even lithium needs may be 'only' 8% of global reserves. Hence green, alternative technologies are crucial -- myriad ideas may blossom. Materials domestic availability is important; so too cost, efficiency that may also impact choices.
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Looking back a few years: it may have been lucrative to have 'gone into **Photons**' then, so into solar, one 'P' (as China did). Look ahead, another P, **Protons** are riskier; energy storage & energy conversion that use electrons in $H_2$, fuel cells etc; it *may be* propitious ahead. But was unknowable 2020s, with huge volatility. What is certain, is this 'protons' theme in 2020s *is still hugely risky*. Much more so than surer-solar. Solar is steeply cutting costs, and on modern manufacturing gets ever cheaper, like semi chips. Energy conversion/via Protons, is different. Vexed by uncertainties, many breakthroughs still needed to harness protons (eg by fuel cells) -- unlike photons/solar where PV costs fell. Unlike battery-making too, where persistent cost reductions of roughly 6-8%/year have been helpful. Instead, Protons in 2020s as via fuel cells, green $H_2$, ammonia, methanol, far more a wild card. Thus, key renewables like solar/wind, with storage pervade ECO. Other areas may resist easy decarbonizing.

A wilder hair late 2020s was *potential, for* nuclear fusion. Put aside attention to $H_2$, fuel cells, PV, batteries a moment. Instead, focus here on neutrons: to fuse 2 isotopes of hydrogen, deuterium ($^2$H as in seawater at 2 Neutrons) -- with tritium ($^3$H on 3 neutrons bred by lithium) -- and it creates a 2 neutrons helium ($^4$HE). Critically a 3$^{rd}$ neutron is then 'gone'; on Mr. Einstein's $E=MC^2$ this mass imbalance is immense kinetic energy: 17.59 MeV mass disappears! Immense energy, no waste! But, practical issues like overcoming a Coulomb barrier in positive ways, inertial confinement at temps/pressures mimicking sun's core, mean latter half century at soonest before significant applied fusion is on grid. It's been lately said, energy-positive -- but in fact, 100x that ignition power was used by lasers -- so is yet far from it!! Next century, it *may be* a new addition. But on climate risk + energy security today, much faster growth is needed in renewables; in solar/wind, storage, geothermal too, 2030s, '40s, 50s, etc.

All as input costs to grow clean energy soared. Supply chains stretched. Inflation was much more than a 'transitory' as was at first (long) curiously said by Fed. Steeply rising input costs, were/ and are thorny for clean energy. Went from a 'just in time delivery', to 'what if' worries. Take solar. If US, Europe, & Japan are to wrest back manufacturing leadership that had shifted to China in 2010s (we recall 20 years ago Japan, US, Europe dominated PV making; China was near zero) -- then Big changes are needed fast. Confinement needed too. Not just physical like $^2$H/$^3$H DT fusion ignition -- but of price rises like 2021 as Europe's wholesale PV prices that inflated +19%. Panel prices in 2021 were up 50% euro cents/kW vs. 2020, poly prices spiked 4x from 2020 to 2021. If the US is to grow its own solar from meeting a meager 3% of its demand in 2021 -- to meeting 50%+ by 2050, then hurdles loom large. Poly is discussed ahead. But there's other key input materials in the manufacturing of solar PV.

To fast ramp solar PV, start with costlier, thorniest inputs. Take pricey silver in making PV panels, ripe for change as conductor in PV. How better to reduce, or better yet to replace dear silver with plentiful copper. Panels in 2021 had devoured 20% of global industrial, silver supply. In inflationary times, silver can be 15% total costs of a solar cell. *May* be worse on 'slugflation' (sluggish growth + inflation), or stagflation! So, to grow solar even more swiftly, think then of displacing that silver, since it's such vexing $$ constraint.

For comparisons sake, back in 2021 silver had cost $750,000/ton -- vs. copper @$9,000/ton -- even after copper's price increases. But obstacles to switching include copper oxidizing; it's not easily used in PV cells. So, an advance could be to make copper better than silver. Testing new solar cell with copper did find efficiencies, 25.5%. Whether large-scale PV manufacturing can use copper ahead in place of silver, is to be seen. But it's clear that many other, diverse sorts of greener changes lay ahead, like say, use of perovskites for better/cheap PV.

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For now, natural gas storage & LNG have big roles. Like if cold European Winters. An issue began mid-2021 as Russia suddenly exported less gas into Europe, than prior typical 80 million cubic meters (mcm)/day. Russia lowered its gas exports to Europe in July '21. Lowered again in Aug '21. Gas levels were already low in UK & globally too. Why? Covid supply cuts + weather volatility had cut supplies worldwide. US hurricanes compounded that. Net/net on sharp losses of supply, & less storage -- natural gas prices jumped. Europe doesn't frack, has few domestic gas suppliers, so long (over)relied on cheap Russian piped gas. As natural gas costs spiked, so too did electricity prices skyrocket 2021. Asia is hungry for that gas as well, so eye-watering-high electricity costs in 2021 and 2022 had at first hit a then-prostate Europe.

It was suggested tight gas exports 2021 from Russia, was maybe to help win OK for a Nord Stream 2 pipeline to Germany. Or, to prepare to stifle Europe's gas 2022. Europeans for their part wanted uncontracted, cheap spot gas. Alternatives were few; get more Norwegian gas -- and/or import lots of liquid LNG by ship -- though latter means competing with a voracious Asia so high prices. And Germany (then) lacked LNG terminals. Europe needed all gas it could get in 2022, plus to build storage. Especially if colder than usual winters hit in 2020s. If sparse breezes make less wind power, nukes down on maintenance, coal emissions tough of course -- before Germany aggressively has much more renewables in 2030 -- so could get newly tight. Late-2020s could for example see less maintenance at Norway's gas platforms, pipelines, lead to a 65 mcm/day shortfall, about a 1/3$^{rd}$ of UK gas demand. To be a worry if cold snaps, low wind, or harm comes to Sudzha gas compressor in Kursk, or Zaporizhizhia nuke in Ukraine.

Sparse breezes early 2021 had hurt Europe's wind, nukes down on repairs, hydro in drought. All had meant unhappy records in 2021/22. Europe's natural gas benchmark spiked up +300%. Gas futures in Netherlands basket rose to equivalent $150/barrel for oil. Early 2022, gas rose past equivalent $500/oil barrel(!). Made Europe's gas prices then early 2022, dearest fossil by far. Ireland's electricity costs late 2021 jumped 10x in a 7-hour period on gas shortages. Gas so tight 2021 in Iberia, electricity hit $165/MWh, worst since 2002. UK electricity prices briefly rose 2x, so 7x a year prior; next day UK power hit $395/MWh. UK imported 7.5% of its power from France, as an undersea cable loss knocked out 2 GWs power from France. (Watch out, undersea cables!) On good breezes like 2022, UK can produce most of its power at times from wind, very cheaply; on few breezes, UK wind's 24 GW faceplate capacity -- could fall <1 GW. Europe's gas once was cheap: it was Russian. But 2022, Russia's gas became a question-mark; might Nord II not open -- Nord I cease? If so, meant replacing piped 150 billion cubic meters (bcm) -- with LNG by ships from US, Qatar, Algeria etc from 2022. Might mean >15 bcm is US LNG; with Europe using more nuclear. The calculus anyway did soon change, when Nord pipe was blown up by mystery forces. By 2023 Norway supplied 88 bcm gas to Europe or 30% of its supply; the US supplied 56 bcm or 20% of its gas thanks to a fast LNG ramp.

In past, simmering European fears of Russian gas were waved off by how bloody cheap it was; 40% of Europe's gas, Germany used more. Until that 'blew up'. Literally. To win approval for Nord 2 or soften targets, was maybe behind Russia's cuts; divide Europe, or prepare for war. Paradigms shifted on fears Russia may invade Ukraine -- & it did. All that as China, Japan, S. Korea too wanting LNG pushed prices on war >$15/per million BTUs. US gas rose too as all is interconnected, from $2 mm/BTUs -- to over $5 briefly, unheard of in US fracked-shale era. Europe Winter gas demand competes vs JKM (Japan-Korea Market); geopolitics meant Europe had to fill storage fast. That + a mild 2023/24 helped. But all became scary on war. Europe's storage reached >95%; but would have to refill quickly too for hot Summers, maybe freezing Winters coming say latter 2020's etc. All as US gas shortage was short in Spring 2025.

Early 2020s had thrust Europe's debilitating over-reliance on Russia gas, in a sobering light. LNG was stepping up swiftly yet underscored immediate need for more renewables, fast. GWs *more* solar/wind quickly - plus battery storage firm power. LNG infrastructure & storage up -- but better clean power wasn't yet big or firm enough. As Europe tried to wean off coal, some places too off older nukes -- many places were expanding to new nukes; competing some with renewables for finance. Wind & solar 2020s were in an awkward stage. Growing yes, but not yet near-big-enough to be a Hero. In 2020, renewables had met only 20% of Europe's electricity demand, was nowhere near enough to overcome gas troubles … yet…

Plus, a hurdle in 2021/22 was novel brief solar PV price inflation, after years of big price declines. Solar prices *rose* in 1st Quarter '22 over 1st Quarter 2021 year over year residential, commercial, utility-scale: not seen since analysts started measuring in solar in 2014. Inflation wasn't just in solar of course (nor wind) but until lately 'unheard of' here. Causes like fast-rising costs for aluminum & steel in solar frames, mounts. High silver costs in PV cells. Pricier special PV panel glass. Freight costs for shipping PV product. Labor up for assembling despite mechanizing operations. Polysilicon from sand, a key building block, saw big cost increases then (before falling again). Europe's PV prices 2021 rose by 16% over 2020. Increased costs for inputs in 2021 had also reverberated in 2022, 2023. Accelerated demand for clean energy that pushed things higher -- was also hit by project cancellations (and inflation) as well.

In US, a solar deployment target was that 45% electricity should be from PV by 2045. From a science/climate standpoint, it wasn't only possible, was maybe *required* given carbon budget. Yet such a ramp would be unprecedented. In 2014 the US had got <1% of its electric power from solar. By 2021, it was near 3%; 15 gigawatts (GW) was deployed in that year. To ramp from there, fast enough to hit 45%, would mean US must *double* its solar each year, 30 GW more installed in US each year 2022 to 2025. Then rise 4-fold/year over. To a freshened 60 GW of new installed solar installed, each and every year, from 2025 through 2030.

By 2035, on a climate crisis, US could need 1,000 GW of renewable power on grid! By 2050 a new 1,600 GW of solar on US zero-carbon grid! So more from solar -- than generated from all sources including fossils/nukes in 2021. To further Decarbonize heat too meant 3,000 GW more clean energy by 2050. Greening US transportation, buildings, manufacturing, industry. Zero-carbon power to cover every GW of electricity, plus each BTU of needed heat.

What is each 1 GW like? For comparison, 1 GW can power 750,000 US homes; roughly like a mid-sized (albeit there firm, always on) 2nd gen nuclear fission reactor. With proper support, solar & wind, yes, can grow very fast -- along with battery/storage to make that firm power. Or they may stumble & fall, if future big bills like BBB with draft $ Trillions, again and again fail. Partly too shows why there's such huge volatility here. And why across the Atlantic, small modular reactors are being looked at in a UK for low-carbon nuclear -- if its 7 big nuclear plants are cut back. Though those big reactors had made 17% of UK's costly power 2021, new 'smaller' gen IV small modular reactors (SMRs) may be seen in a standardized design emerging in China, or France. Rather tan building each reactor from scratch, as the US chose to do.

But can they also be made 100% safe? Less costly sure -- but what of less risky?!? In a 2020s on nuclear state of art, that answer's murky, dubious at best. Hence questions do swirl around advancing past current 2nd generation fission nukes latter 2020s, getting to SMRs in the 2030s, perhaps in theory safer fusion system in late 2030s. Yes, we see China, Germany, S. Korea, UK, US & others searching for core, firm baseload power. Especially on demand ramping late 2020s for new energy, given artificial intelligence (AI) and growing data centers.

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Much was happening early 2020s. In 2021 a then-US President had aimed to cut $CO_2$ emissions 45% by 2030 -- in theory doable. Yet sobering was renewables' actual growth since meant that pledges were not enough for a 45% $CO_2$ cut. Solar & wind capable of it, but on current trends we'd Not hit 45% $CO_2$/GHG reductions -- 'til far later. Broadly, that was on at least 2 factors: 1) Renewables not growing fast enough to displace coal, oil, gas. And inversely 2) Global inertia in coal, gas is not yet letting up. On war, burning coal *increased* -- it wasn't shut-down at anywhere near quickly enough in early/then mid-2020s. Solar & wind clearly are capable solutions; *these 2 have potential to power the entire world* -- many-fold over. On today's technology, & available locations, they alone could power Planet 100x over! They can make 6,700 Petawatt/hours (PWh) of clean electricity (1 Petawatt/hour= 1 million Megawatt/hours. Despite vast opportunity, the world 2019 only captured 0.7 PWh of solar, 1.4 PWh of wind. Though wind & sunlight if scaled up, could meet all our global power needs. Forever.

It's been no surprise to see they're expanding! Solar grew +39%/per year in a last decade: it roughly doubled capacity every 2 years. Wind grew 17%/year onshore; an offshore wind boom may raise wind growth higher latter 2020s. Clean energy potential is eye-opening. Sub-Sahara Africa may generate 1,000x current energy demand, on renewables alone. Australia/Chile can generate over 100x current energy demands. Even a voracious China, like US, Europe, India, could generate more than their electricity needs -- from clean renewables + storage.

US offshore wind starting from zero, might see gains late this decade. But for 45% $CO_2$ cuts, it falls short. That ought Not dissuade. New energy *can* deliver abundant, affordable change. Electric cars *may* go from a poor 2% of US car sales in 2021, to 50%+ ahead; even as China & Europe do far better. In Norway, new pure-battery EVs had hit 74% of sales(!) in 2021, 11,274 units; EVs/plug ins there totaled 95% of all new car sales! If Norway presages, then auto makers who bank on 50% gasser lineups 2030, are gambling with BK (bankruptcy). China, seeing this was 15% electrics 2021, more 2022, '23, '24 etc rising fast to EV dominance. Global EV sales far overshadowed US. China sold 1.1 million EVs in early 2021 more '22, '23, etc. In EU 1 million EVs were sold -- far better than US. Full-battery EVs made up 12% of cars registered in EU in 2022 -- vs 9% in 2021, just 1.9% in 2019. EVs & hydrids were over half the EU car market late 2022; first time more than gas/diesel powered cars. Europe led the US in clean power generation by wind/solar -- & in EVs too. Meanwhile, China was rising much faster from near nil, and it clear will be beating all soon ahead. All this while US lags.

In Western Europe, coal-use 2019 was falling -- until war from 2022 revived coal! Natural gas use may be cut ahead -- but again, not yet! Instead, gas needs made Europe's energy prices jump 2021. Fell after on big ramp in US LNG. Gas, portrayed as a 'transition fuel' may be last pariah fossil; as socially unacceptable one day, as cigarettes now. Yet there's need of it to *heat* homes, buildings, industry now, no fast-green-fix mid-2020s. Replacing boilers with heat pumps is costly -- has begun, can happen faster than expected. Renewable natural gas (RNG) blended with green $H_2$ to say 15% is another mid-term way. As is running ships & aircraft on green $H_2$, or hydrogen derivatives like ammonia (toxic so careful), methanol if green ahead. Maybe: transport hydrogen via benzyltoluene for a $H_2$ that's released more efficiently from big Liquid Organic Hydrogen Carriers (LOHC) at lower temps. All but one-side of climate coin. Other side must be big moves especially by China to cut its coal/$CO_2$/GHGs. To address the ample methane that's released to air. Clean energy gains are for naught, if coal & GHGs don't drop to near nothing. Yet huge populations in India & Africa with understandable economic aims, seeking their own development ahead, may look towards cheap coal.

So, coal's decline 2019 in rich Europe regrettably was bit of outlier. In war, it reversed and got worse as China, India, Japan, even EU coal saw terrifying growth. China early 2020s was growing renewables + EVs: great! -- yet also expanding thermal & 'met' coal to late 2020s. Notably China in 1st half 2020, added 11 Gigawatts (GW) more coal. Another say >50 GW of coal to come. Its solar/wind blunt it. Yet of all world's coal power added say 2020, China had made up 90% of that. 2022, 2023, 2024 saw speed up in a use of coal including by India, given that spiking natural gas/LNG demand had been tough for everyone back in 2021.

Not only nations at issue: 33 of world's 60 largest Banks *grew* their fossils funding in 2020. So all hopes to decarbonize world in 2020s blown apart by coal alone. In 2021, world carbon emissions had spiked to 1.5 billion tons, mostly on coal. 2022, '23, '24, were worse. Instead of coal drawdown needed according to best science to decarbonize, plus big cuts in methane -- fossils instead expanded globally 2020s. Sure there's happy words, much greenwashing. A 'US commitment' to cut emissions 50% from 2005 levels by 2030. COP in Scotland had a glowing 'blah blah blah'. But look closer. Each Paris Accord nation sets its own Nationally Determined Contributions (NDCs). Some quite lax, in China, Russia, Japan, Brazil. And games played; a UN baseline was 1990 -- not 2005 when emissions were higher. So pledging say '50% cuts from 2005' was then more like a 43% reduction. Worse, US in say 2021 (pre IRA) was on track for real cuts of only 12%, below 2005 levels by 2030 -- not even close to 43%. Games played too like counting '*not*-cutting' down trees, or seeing oceans as 'carbon sinks', or reducing emissions by 'offsets' in a mockery of reductions. Some words may inspire, others mislead. Air traffic & shipping kept out of emissions tallies(!) like methane, too, so the facts are far worse. Aircraft, shipping, methane; each has its big climate impacts and they ought not be pretended away because they're just, gosh, too hard to reduce right now.

There's Huge Gaps between *promises* to 2030, a 'blah, blah, blah' -- vs. reality of science. The data show there's *growing* $CO_2$ & GHGs worldwide 2023/'24/'25 etc led by coal, oil, gas. With no global cuts action great enough, so maybe high GHGs plateau, $CO_2$ concentrations & PPMs stay elevated >400 ppm for a very long time. Meanwhile, actions pledged around the world fail spectacularly. Mediocre actions still not near enough, to make real difference.

Consider: the UN in 2021 tallied NDC pledges from 75 of 191 nations signing a Paris Climate Agreement. Excluding China & US, it found fulfilling 75 commitments would only reduce global emissions 1% from 2010 levels to 2030. So even if NDC targets by countries are met (won't happen), there'll still be unprecedented historic emissions driving climate change. To say nothing (as we do) of uncounted methane/gas threat that is forcing deathly heat too.

IRA of 2022 helped reduce $CO_2$ some in US, one of worst offenders. And a Paris Agreement won curious fanfare supposedly holding heat to 2 degrees C (3.6 degrees F), or (impossible) 1.5 C (2.7 degrees F) of rises. Assuming science is to be believed, global $CO_2$ emissions must be cut right now, *this decade, far more* enormously: by some ½ to 2030. Actions worldwide may point to a plateau -- of coal burning, and gas, with oil maybe peaking 2030s. That's nowhere close to required reductions, and Paris arguably is already well out of date. Far bolder actions by emitters China, US, Europe, are essential. Whilst war 2022 did accelerate some helpful changes -- it also took our eyes off $CO_2$ and GHGs prize. To be clear-eyed, recent fanfare over 1.5 C hopes, or a 2.0 C target wasn't deserved. Not when Paris lacks mechanisms to enforce needed cuts. Not when there's no real Plan to meet a 1.5 C target--- and 2.0 C soon may be breached. Not when leaders talk as if mostly meaningless Agreements can head off likely(?!) catastrophe. Against needed cuts in this decade -- vs. the lack of global action -- any later-on 'net zero' greenhouse gas targets in 2050 aren't worth discussing.

We can squint, for bits of hope. In 2020 growing superior economics of renewables meant 80% of new generating projects worldwide were clean energy. Made dollars, cents/sense. Led to a 10.3% rise in carbon-free electricity generation, globally. Nicely, 91% of renewables were wind & solar. Wind @ 58 gigawatts (GW) 2019 doubled in 2020 to 111 GW. As percentage of total global electricity production, sustainable energy grew by 2 percentage points -- from 34.6% clean power generation total 2019 -- to 36.6% in 2020. *Yet was far from 100%, let alone 50%*. Numbers & the science show we're near climate precipice/s, maybe tipping points.

Overall the world electricity production pie is growing; the thing is, coal's growing too. Coal vexes via mining, burning, waste disposal, yet more's being built with financing. Thus, even as renewables' share of electricity grows, total greenhouse gas emissions continue growing as well. Worthy of note is *there's Not been a single year, yet of falling* global coal capacity… ever! Says nothing of global coal use for high heat industrial processes like in making steel, aluminum, cement. Nor of coal's big expansions 2024, 2025 etc... Nor of huge embedded $CO_2$ in products exported -- like going from Xinjiang China -- to US, Europe, and worldwide.

Greenwashing abounds. 'ESG' is an awful ugly term that can be so meaningless that it misleads – like when Big Tobacco, Big Oil companies score higher on 'ESG' than America's leading pure-play EV maker! Far better are meaningful terms like truly 'Decarbonizing' in clean transition. Instead, ill-defined 'net zero' or 'climate neutral' -- with no teeth - are bandied about. And, 'Emissions offsets' can be a shell game disingenuously counting trees, forests, seas, as natural uptakes. Coupled with distant targets like 2050, words can get meaningless. 'Carbon neutral' is proclaimed -- yet is Not Same as Zero-Carbon. True, zero-carbon -- stands well apart from net-zero. So, words are key. They can inspire -- or forestall strong actions. What's clearly needed is to *decarbonize, now* in tandem with cutting greenhouse gases: less methane, black carbon, hydrofluorcarbons. Latter is a less-noted GHG yet super-pollutant, far more climate-forcing than is $CO_2$. Shorter-lived yet potent at trapping heat -- so it near-term drives global heating in this century. Hence paths today like ending methane leaks, are smart fixes.

Science & humanity in short need unprecedented clean energy transition. Decarbonization reducing all GHGs, including the less-notorious ones if science is simply believed. Instead, we hear words that dissemble. Much as Greta says is just: 'blah, blah, blah' like to 'end coal' (later-on). It follows: No nation yet merits praise. 'Twixt words & strong actions, the void is huge. Gains so far necessary, but not sufficient. In short action to move away from $CO_2$/GHGs -- means enlisting capital too to decarbonize worldwide. Arguably, market forces do shape energy -- and markets matter deeply. Policy too. Once, markets & policies together elevated King Coal. Later on, they made oil near-the-exclusive fuel for transportation. Later still, markets & policy made natural gas so common last century, this gas dominates still today in making electric power. For making heat in industry, & in homes & business purposes.

Market forces at times, help renewables. But according to best climate science, the carbon budget says a clean energy transition isn't happening near fast enough. A shift as from coal -- to oil & gas -- once took half-a-century. We don't have half-a-century now, science tells us. This transition isn't just to flop new energy -- atop lingering fuels. Instead, it's a full flip to whole new energies only; solar, wind, storage, maybe green $H_2$. Policies could hasten that. Especially as clean gets cheaper, better; they're for sure healthier. We saw attempts from 2022 to use fossil gas as a cudgel in wartime, to freeze out Ukraine. But that cudgel, broke -- it failed. Capital markets responded fast. Now, a pace of change 2020s is of the essence. It's simple. Listening to what the science and once-healthy seas now declining are shouting -- matters like never before. We'll turn next to energy Indexes & financial markets.

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Stepping back, let's glance at ECO/NEX in a volatile 2020. Given these 2 Indexes stood out then as very top performers that year worldwide, ECO notably up +203%: why did these 2 do so well? Several factors enumerated next, may help to add a bit of colour. They imply too in down years -- these 2 volatile Indexes (as we've seen) may drop harder/faster than most!

One big factor perhaps, is our use of *decarbonization* as an organizing principle stood out. Another is: *Market Inefficiencies: our Indexes hold smaller & mid-caps not as known to mainstream analysts; fewer analysts in cutting-edge innovations like in electric cars, Li-ion, green hydrogen, fuel cells, solar etc -- may add sizable pricing inefficiencies. Few analysts in zero-$CO_2$ (and those that are, do excellent work!) on a flood of attention & price discovery, 'animal spirits' in tow, brought scope for gains. A 3rd factor may be all-too human: *Disbelief! Difference of Opinion Is What Makes a Market; deep skepticism, even shorts -- vs +12,000% gains in an equity impactful. 4th some 'ESG' (ugly term) baskets may be steeped in greenwash; for example some may have natural gas! Our's having a truer clean focus is unique & it's been consistent for over 20+ years; that it had come into favor maybe was good fortune.

We'd seen similar in ECO in 2004–2007 when once-unknown green, grabbed a spotlight. Sharp rises in tiny solar firms, electric car startups, li-ion batteries, storage, $H_2$ fuel cells. Stubborn-held (dis)beliefs maybe broke a bit -- or not. Views oft heard 2004, had included that electric cars could *never* be fast as 'real cars', nor see a 200 miles range. Nor be as pretty, nor as fun to drive. Views then often were solar & wind 'weren't real' -- vs 'always cheap' coal. Future earnings estimates given those short-term valuations, resisted penciling anew. Importantly, valuations were based *on just seeming promise, in 2004-2007. Clean energy back then was itself thought of (and it was) much too costly*. And true, after a 2007 crash on overcapacity, over high relative costs -- clean was mainly just 'promise only' back in 2007-2014 or so.

Re-thinking what's maybe possible in 2020s/ next decade, *maybe* there's new prospects? Perhaps: 1 to 5 million-mile batteries; large regions competing to build renewables & electric cars; solar-electricity costs <under penny a kilowatt/hour, perhaps a cheap green hydrogen -- that may cause a new look at valuations. Past inefficiencies in equity pricing, viewed again. To more accurately see prospects is never bad: disruption and a narrowing of gaps is an engine of growth. Clean/new displaces dirty/old. Over & over, closing gaps from 'state A' -- to 'state B' propels. At quantum-scale to our own macro visible. From state A -- to state B can push -- at macro level, up to small planet, and on to our solar system, to local galaxy. Or think financial sphere. Melt-ups redux. In ECO Index® there were 10 components all up over +1,000% from their own past 52-weeks lows then, in a brief March 3, 2020 -- to March 3, 2021:

| | | | |
|---|---|---|---|
| **Blink:** | **+2,628%** | **Renesola:** | **+1,470%** |
| **Nio:** | **+1,868%** | **SPI Energy** | **+1,356%** |
| **Plug:** | **+1,624%** | **Sunpower** | **+1,148%** |
| **Arcimoto:** | **+1,618%** | **Workhorse** | **+1,034%** |
| **FuelCell:** | **+1,476%** | **Daqo** | **+1,031%** |

10 components in any Index theme, Gains of +1,000% from 52-week lows, one +2,600% up, is perhaps a bit remarkable. Helps explain ECO rise then 6-fold+. Notable on *Speed by which clean energy shined as a Best option, and *by which policy moved towards zero-carbon. Maybe one of the biggest items too was at last some notice of *Climate Risk. It's this last factor, how much $CO_2$/GHGs can we afford, that's new to our species. Maybe a vital limit, like *C* in Physics: all others must spin around it. Squarely within our themes at ECO, NEX, H2X, WNX.
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**Some 'Bad' (Irrational?) Factors maybe at play too, in +200% Equity Gains of 2020**

Perhaps to some, there were also 'bad' (irrational) factors in 2020's gains of 200%. 'Bad,' in a sense didn't warrant such exuberance; Hydrogen ($H_2$) fuel cells come to mind. Not that they can't, perhaps sooner than hoped -- be vital. Was more didn't justify hype, 'til breakthroughs occur. But these are passive Indexes -- not active managed -- so we do not try to predict rises/falls, winners/losers. And $H_2$ fuel cells can be seen in a new H2X Index too. Early 2020s, $H_2$ was badly burdened by high costs, sparse $CO_2$ avoided, low efficiencies. But, $H_2$ *may* grow increasingly relevant. If made in classic ways from natural gas, inextricably fossil-spawned, it's not a worthy solution. That 'Blue' $H_2$ from fossils even on sequestration, can only pass a very low bar, given methane etc. Yes, big Oil is embracing a chimera of blue $H_2$ -- but, 'blue' might only compete with 'green' $H_2$ this decade, or so, or until 'til green $H_2$ scales up. Then, neither blue $H_2$ even on 'sequestration', nor ugly brown/gray/black $H_2$ made from coal/gas -- might go up against $H_2$ if made in truly cheap, renewable and scalable ways.

Best, might be green hydrogen renewably & cleanly made. Like by solar, wind, other ways ahead. Early on in 2020, Spain hoped for €9 billion spending on green $H_2$ ahead. France, €2 billion for green $H_2$. Germany looked at €9 billion by 2030. Catapult plan, 25 GW green $H_2$ at <€2 per kilogram. Saudis considered 4 GW from solar & wind, UAE too. Different, is to capture greenhouse gas/GHG methane ($CH_4$) at landfills, dairies, etc, maybe as 'renewable natural gas' (though it may prolong gas-use). Or a step further can be drop-in replacement low-carbon bio/fuels. Not as immensely scalable, but if made truly renewably -- by *capturing spilling freely* $CH_4$ -- and by using that -- then it may be partly 'meh' transition bridge.

Green $H_2$ by contrast, *may be* hugely scalable, much more plausibly now than before. Demand for green $H_2$ *could* -- just *perhaps*, grow enormously: >$70 billion this decade to 2030. Europe might see €200–€500 billion+ invested by 2050, *in theory*. Big oil's deep engineering bench touts $H_2$ & derivatives, maybe as 'green ammonia' ($H_2$+Nitrogen=$NH_3$), or liquid organic hydrogen carrier (LOHC) easier to handle than pure $H_2$ made say, by offshore wind. Visuals of wind/solar making green $H_2$ -- or 'green-ish' ammonia $NH_3$, or LOHC -- might be painted.

Cost, is the rub. $H_2$ has affinity to react, combine -- so much solar/wind power is needed for electrolysis to be able to split water. And green $H_2$ too costly vs. $H_2$ as steam reformed gas -- even brown $H_2$ has been costly in its own right. An inflection can be if 1) solar/wind costs fall; 2) green $H_2$ goes to <$1.5/kg by 2030 or better, under <$1/kg. Profoundly then $H_2$ is no longer 20 years in future. On carbon tax of $50-60/tCO2, clean $H_2$ *could* make steel, cement, power trucks, ships, planes and more. Manufacturers have reduced $H_2$ costs by over 80% in 3 years. To go next to <$1.50/kg is targeted, or cheaper <$1 may arrive in innovative new ways.

But all that's dreaming early 2020s. Green $H_2$ costing x-times too much everywhere, is seldom seen anywhere. Just 42 hydrogen stations existed in all California in 2020 – vs. 22,000 electric outlets for charging. Worse, inefficiencies. Compared to batteries, $H_2$ loses ½ going from tightly-bound water $H_2O$ – to $H_2$; then loses more from $H_2$ -- to electricity at fuel cell. A case may arise *if* cheap green $H_2$ 'time shifts' intermittent renewables, a holy grail of abundancy. Nearer term, green $H_2$ may displace some 'rock' natural gas in extant combustion systems -- but only to <15% content, to not embrittle steel. Renewable natural gas (RNG) can be used. Uncapped methane be captured, upgraded to RNG, or *truly* sequester C in stable form. Still, RNG is just defense vs. climate risk. Not great, but some help. In sum hopes for $H_2$ were partly too why clean had jumped in 2020; as equities are forward-looking. But a case for $H_2$ was hazy at best early 2020s – unlike clearer solar, wind, EVs. That said, cheap green $H_2$ was, before barely conceivable; it *may be* plausible ahead, *if* renewables bring very cheap power.

**Perhaps other unpretty factors too were at play in 2020**

Tangential factors can also highlight how better green solutions, might be. Take dismal state of the art now of 'Direct Air Capture' (DAC) for $CO_2$. DAC's is such an energy intensive non-starter today, because it needs gobs of power, burning more fossils. Only *if* DAC get sensibly low-energy, might it grow. Even less worthy, yet touted by fossil firms is so-called 'Carbon Capture & Sequestration' (CCS). CCS may extend fossils by decades, say, inject $CO_2$ back underground, to briefly get more oil. But then -- a key question is: Why?!! Why, when Not Burning that coal, oil, gas is where we ought now be heading in first place? CCS is a non-starter, and is completely unhelpful if used say for more, ugh, 'enhanced oil recovery'.

Issues too its proponents may wish to avoid. What if $CO_2$ leaks in a few centuries?? At Lake Nyos in Africa, a $CO_2$ 'burp' killed a thousand people. Far better is a stable $CO_2$ storage, eg, mineralized to be inert, safe, permanent. But, as solar is cheaper than coal now, anyways, coal + CCS is no answer! Costs to capture $CO_2$ + then pump it underground, renders coal 4x too costly!! It's why we see 'clean coal' (ha ha) in ads only -- not for real. To be compelling, DAC or CCS must *Remove $CO_2$ from air & seas *Permanently, in *Practical, *Economic Ways, *Scalable to Gigatons; be *Benign, Stable, *Carbon Negative -- not just $CO_2$ neutral. Its telling absence, so far in 2020s, arguably bolsters unironically true and honest green pathways.

Uglier still, is 'Geoengineering'. (Seriously, try to dim sun, or planet's air, or dump $CO_2$ massively in oceans without knowing effects??!). It of course must be rejected. Hydra-headed, the monster goes beyond mere possibility of a climate calamity. In the 2020s, global heating may have already be dissembling stability in once-cool planet. The 'geoengineering' specter concentrates the mind, how much better to sensibly avoid that $CO_2$ in the first place.

**Difference Between 'State A' and 'State B' may help account for volatility**

Closing gaps, going from 'assumptions' -- to 'truths' -- can help propel equities upwards. Only a few years ago, conventional wisdom had held that electric cars, like solar & wind power, were costly toys at best, forever slated for a kids' table. Regarded as unserious. Rather than thinking holistically -- society dismissed EVs as slow silly golf carts. To be vexed by smallest hills. Slow and their range terminally to be under <100 miles, so EVs always a sad joke.

How wrong! Proving old beliefs wrong, spiffy new EVs are already fast, getting vastly better. Arguably they're fated to improve! Foreseeing that even by by a bit, favors the bold. Closing gaps between state "A" (older beliefs) -- and "B" (truth) -- is disruptive, innovative, useful. It can make for delta/big changes in equity valuations -- maybe 'alpha' too in financial terms. Foreseeing such ongoing gaps, even a bit before others do, can be fruitful over and over.

It's also non-linear, non-incremental. Think of big falls back in 2008/09 when green themes crashed, again in 2021-24; they certainly can & will do so ahead. In such slumps profit margins go non-existent, can stay down for years. There's often a non-Euclidian, or non-flat geometry here. Disjointedly compressed margins, not straight lines. Solar's margins in time then did becalm; we're learning to make solar now *the* very *least-cost electricity in history!* Learned cost-reductions can lead fast to virtuous circles. Electric cars get better in most every way. Think by contrast, of heat engines (ICEs) in most all cars and trucks; unfathomably they still are all around us, spark plugs exploding fuel, pushing pistons to power vehicles. Coal is making electricity, also by a heat difference. Nuclear too = just the world's costliest boiling water. Delta is in their hot vs. cool. It's a difference of state, like temps of "A" vs "B". But that difference in heat engines, is also brutally inefficient -- unlike (clean) nature herself.

Mr. Babbage had once captured delta via a difference–engine. Mr. Turing created computers; a gap of '0's vs '1's did the work. We don't know *if or when* razor-thin PV margins might improve; solar equities maybe change vector, ever delta of booms and busts. Or, if/when a top-line issue becomes acute to our own species: Earth's physical cycles, consequences. This last point become so significant it stands out *sui generis*. Potentially climate risk might impact our societies, humanity. A possible existential threat, not yet understood. If tipping points, then maybe there's feedbacks: melt of permafrost methane bursts, clathrates. Changes that can't be unwound, no matter how hard we might beg, bargain with, or badger nature. On most topics, scientists just counsel calm. Soothingly they'll remind us that things really aren't nearly half as bad, nor half as extreme, as non-scientists or some politicians paint them.

Not so, on climate. Singularly researchers seem to be 'shouting'. Maybe conservative to heed them -- foolish to reject them. It may hit us not in a spirit of bravely looking at solutions, or boldly advancing our better natures. Instead, maybe we'll hastily try to save what can be saved: remember Summer's heat for only 3 months? Winters? Cool nights? In 2 centuries, who may recall living reefs? Sandy beaches? Healthy seas? How to cherish what we'll bequeath. Especially, as sustainable, no regrets paths can make us healthier, happier, richer, and more secure. Instead of costs of spiraling blood & treasure, disease, pandemics, despair. Better, may be to embrace a wisdom in farsightedness. To think: prevention rather than cure.

The NEX/ECO/H2X/WNX green themes include noting emerging ideas like decarbonizing. Electrifying all, low & better-zero-carbon fuels, energy efficiency including heating & cooling, circular industry. Such emerging, innovative, science-based ideas are sure to be highly volatile -- with nexus to ecology. Consider for instance then a few disruptive ideas embodied in say, 14 of the most volatile upside constituents in NEX as was seen early in 2021. Let's glance at what was Up the most, after the 52-weeks to early 2021, hence 14 biggest gainers then.

NEX back in early Feb. 2021 was at then-highs, so we avoided looking right at a peak. Instead here's figures from March of 2021 as NEX components, equities globally in new energy began falls. These % figures had moderated a bit, looking on March 3rd amidst a then -25% YTD drop. Nonetheless, like ECO's story where we saw gains up +1,000% from lows in 52 weeks 2020 to March 2021 -- here, global NEX begins by showing what had been most up. In these instances of rich gains globally, we see 14 NEX components with big deltas to March 2021. Those showing gains of at least +600% up from their 52-week lows early 2020 were:

| | | | |
|---|---|---|---|
| **Nio:** | **+1,868%** | **CS Wind:** | **+ 920%** |
| **Plug:** | **+1,624%** | **Bloom:** | **+ 787%** |
| **FuelCell:** | **+1,476%** | **Lithium Am.** | **+ 763%** |
| **Renesola:** | **+1,470%** | **McPhy:** | **+ 651%** |
| **Doosan** | **+1,465%** | **Enphase:** | **+ 649%** |
| **Sunpower:** | **+1,148%** | **Flat Glass:** | **+ 627%** |
| **Daqo:** | **+1,031%** | **Sunrun** | **+ 622%** |

Big gains in 2020/'21 in EVs, fuel cells, wind, solar -- were followed little surprise after by big falls in 2021-2024. ECO went down to touch 30s; NEX down to around 200; they could drop (much) farther yet! Falls too in H2X, WNX. In future as climate bills are vetted, stocks crash, interest rates change, on pandemics, wars etc -- themes can again plummet. Other strange, or more remote outliers may happen, a 1st US Debt default, sun-ejecting coronal mass ejections (CMEs) threatening grids, Miyake events and electromagnetic pulses (EMPs) etc. These risky, volatile, and at times-high/or low-flying themes can ever-be badly hit.

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What was of note about above's 2020's gainers? For sure, they were remarkably diverse. Some in energy innovation, scalable to go 'on offense' against climate crisis like solar & wind; PV upstream included poly, ingots, wafers, panel manufacturing. Downstream inverters, sales, installation. Had winners too in EVs, advanced batteries, materials. Plus, in highly speculative themes, hydrogen & fuel cells; biofuels were present too. New energy innovation reflects a wide-range of possibilities; that bullishness then was broad. Other gainers were 'on climate defense'. Smaller steps, extant infrastructure. To capture say, methane -- otherwise indifferently put into air like in a sewer, made then a 'renewable natural gas, far from ideal. Or get methane ($CH_4$), from $CO_2$ -- then combust that as less potent greenhouse gas vs. classic 'rock' natural gas. Or get say to lower $CO_2$ -- or near-negative-$CO_2$ -- through sustainable aviation fuels (SAFs), gasoline, diesel. SAFs were then only nascent; not 'til 2024 did California propose 200 million gallons of SAFs (when just 11 million was made) -- and not until 2035.

Still, those equity gains in 2020 *in no way* foreshadowed gains ahead -- as would next be confirmed by big falls in 2021-2024. Indeed, big rises oft auger sharp/er falls. Regression to mean, nothing certain. Latter half of 2020s *may* point towards new paths. Once upon a time, fossils magnified human power many-fold. Yet sympathy for fossil 'magic', can't mean what's bad ahead for coal and oil -- is bad for humanity. Wiser, is to move towards broad sunlit uplands we'd once enjoyed: $CO_2$ back <350 ppm, near 280-300 ppm. This choice, seminal.

30 years ago, late 1990s, paths ahead weren't clear. Solar was viable; but -- could it become cheap? Horizontal vs. vertical axis wind competed red in tooth & claw. Electric vehicles seemed possible one day on better batteries, AC motors, but *when*? Might $H_2$/fuel cells *ever be* viable economically? All Big questions, no clear answers. Barely imaginable then yet soon ahead may be electric jets; cheaper green $H_2$ & derivatives ammonia, methanol $MH_3OH$; ultra-deep geothermal; unboxed EV instead of assembly lines, to sequester $CO_2$ as mineralized rock. Much late this decade. All debatable, inherently uncertain. We likewise recall great risks that had pressed late in the last century / late last millennium; it was only some 30 years ago.

Back then to passively pool clean energy's *possibilities* into a single Index basket, made great sense -- it arguably still does. Victors unknowable, which or what competing components/tech may win the day. Hence mitigating individual single-stock risk via a basket, was compelling then: just as now, if not more so! One can't know *which* stories *may* survive in energy storage, in solar, wind, green $H_2$, in EVs, decarbonizing themes & more ahead. Which equities, all very risky -- will Crash, burn -- which might Survive. Perhaps thrive. This vexed matter bedevils. And helps to explain why a *passive Indexing* like here, is arguably rather compelling.

*The fact is, volatility is Certain. That* is a differing beast. We can state with great confidence, eg, oil prices will move *sizably* ahead. That the fossil fuels may fall long-term -- yet acute events shall be important at times. Maybe an oil/gas shock ahead, storage issue, accidents, attacks on grid infrastructure, drought, floods, heat, bitter cold, solar weather, even EMPs. Any may mean big price swings. To not weatherize against extremes = worsens Unpredictability. That is predictable, in a sense. Weather extremes stalk all fossils & nukes, that need cooling to work. Or, a stratospheric heat in changing climate may occur one-month, weaker Jet Stream next letting in super cold arctic air South, freezing temps. Or slowing Gulf Stream, ironically, may dramatically alter weather in Europe & US Eastern seaboard. In past, stability of both the key Streams: the Gulf Stream + the Jet Stream, has been crucial. Yet now on less temperature contrasts 'twixt Poles vs. Equator, that stability may falter. Fossils may be in a very-slow, long-term decline -- yet we're certain of seeing huge volatility.

Foreshadowing this, a disaster had hit Texas in 2021 when a freeze took down its electrical grid. That big blackout also showcased battles going on in a public square. What does it take to build a reliable grid ahead? Just more fossils & nukes? Or, much renewables, storage, better grid? Natural gas has dominated, yes -- yet lately it finds itself on back heels. Case in point, amidst that crisis, was an argument hastily put out during a blackout that it was the fault of clean energy – due to Texas' *wind* turbines freezing up! Whether promoted by uninformed, or instead by politically motivated opponents -- that false tale was widely circulated especially in certain media outlets. A photo image was spread of a helicopter with vat hovering above a frozen wind turbine -- claiming was a current Texas pic of flailing attempts to drop chemicals to unfreeze stuck turbines. They'd claimed it as proof that wind was the ***main, only cause*** of terrible deadly grid outages, during a freezing Winter week late February 2021 in Texas.

Was that really so? Let's start with that frozen wind turbine photo shown on TV to so many. In fact, it was an old 2013 photo by a Swiss helicopter company testing hot water drops from off boiler truck (no chemicals) in Sweden -- for a turbine lacking usual de-icing features. That compelling photo was shown at a 2015 conference -- but made for a powerful, fictional 2021 false meme/narrative. This meme was shared widely by a publicist, websites, etc: it was memorable, but clearly untrue. It stoked misinformation, was seized on by wind's opponents as 'proof' of wind's failures. The truth in Texas was very different -- but facts only arrived weeks later, after this memorable photo & its tall tale were long-played out.

Let's dig a bit into what really caused that awful Winter 2021 grid-collapse disaster in Texas. To begin, Texas' electricity grid early in 2021 was Not mainly powered (yet) by renewables; but instead by natural gas. 52% of its grid power was from natural gas in 2020 – vs. about 39% gas for all grids on gas nationwide. What was/is key is how well Forecast/Actual energy Supply -- matched Demand. That week, the Electricity Reliability Council of Texas (ERCOT) had expected 82 gigawatts (GW) of power to be available. The most expected supply percentage expected was to be by natural gas. That was huge projected 50 GW availability.

A review of just what in fact happened on Monday February 15th -- to Wednesday Feb 17th 2021 is laid out in Texas Monthly (3/3/21). As recounted there, the key problem was losing a massive, unexpected 20 GW of natural gas-fired electric power, due to hard freeze. Reasons included an inability of power plants to even obtain gas, & some plants that got it, weren't winterized to operate in such conditions: gas lines froze. So regardless of how much gas was 'given', much of that fuel couldn't be utilized, many gas plants couldn't make electric power. To be sure some amount of wind energy did go offline. From peak-pre-freeze -- to worst on Feb. 15th, wind had dropped 8 GW. But importantly, such low wind output had been forecast for that time of year: dead Winter is regularly near wind lows. ERCOT's own models expected a puny 1.89 GW from wind. Thus, as wind output did hit 0.65 GW nadir, that wasn't very far off 2021 forecasted models. (Wind soon spools up enormously in the early Spring months).

Some power plants couldn't find enough natural gas fuel, at any price, anywhere. While early wrong criticisms were leveled against wind by the Governor & Texas Railroad Commission -- they'd barked up the wrong tree. As that fascinating image/tale of helicopter hovering high bestride a frozen wind 'Texas' turbine, only confused matters. Was just Kabuki theater, a one-time narrative for opponents to rail against clean energy. Like a 2023 photo of a melted traffic light circulated online, captioned it was taken then in Texas heat; actually was from Italy a year prior, when a motorscooter had caught fire underneath that traffic light.
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That relatively small underperformance in wind vs expectations, was narrower than for coal. Latter was off by larger 5 GW from where it 'should have been' in freeze. Even supposedly unflappable current-generation II nuclear, was down somewhat like wind -- off by 0.7 GW. In all, 55% of *unplanned* capacity outage was due to natural gas. At worst 22% was in wind. 18% was coal, plus, nuke losses. Thus, each source of electricity was hit. Truth is wind's shortages were smaller (near the least) among all disruptions in that crisis freeze over 3 vexing days.

Key shortfall was in natural gas. It suddenly fell short, by hugely 20 GW less than expected -- a gap 16 GW lower than lowest-end case models by ERCOT! How/Why? Texas is a global hub for shale gas drilling! But as temperatures froze, about a third of its own gas production 'froze off' Normally it's a warmish to hot place; much equipment is left unweatherized, so tanks to divert the oil from water & from gas, during a deep freeze, became solidly blocked off.

If not frozen, could have spooled up enough to 'oversupply' gas-fired electricity to a tune of 45 GW - 50 GW. Much more than enough to make up for losses elsewhere. As laid out in that article, many gas producers did Not financially benefit. They simply didn't have product to sell in such acute shortage. Worse, some couldn't meet their contracted gas obligations for volumes promised. So, some were forced -- along with other gas producers/users to compete for meager amounts of available unfrozen gas supply as prices were then skyrocketing.

Normally gas producers sell product at around $2.50 per million British Thermal Units (BTUs). But contractually obligated to supply gas that they couldn't provide, instead some had to buy (to provide elsewhere) gas at ridiculous prices like over >$200/BTU. On Exchanges, where gas prices hadn't gone up to $200, they'd had to add a digit. Nearby in wealthy Dallas, the price of natural gas in the heart of a super-gas-abundant Texas(!) suddenly went to $1,000.

Power plants needing continuously supplied gas -- to make & sell electricity were flummoxed. They'd anticipated of course an ever-ample feedstock of gas. And had expected wholesale power rates around $24 per megawatt-hour. As gas was unavailable on freezing temperatures, chaos sandwiched them between needing to find gas right away any price, prices they charged shot up for each MWh -- from $24, to in some cases a really crazy $9,000/MWh! Reminiscent of the crazy gas pricing seen at first seen in Europe in 2022, with the start of war in Ukraine. In Texas, power producers who needed gas to make electricity, competed with gas producers needing it to meet contracted obligations of available unfrozen supplies. All got hurt. That gas trading expert well describes how differences in trading normally are in 1 penny amounts. Then instead, they were dealing with absurd gaps of $50+ 'deltas' in gas prices.

In retrospect, to see how to do all better next time, lessons can be drawn. Lesson #1 is *more* natural gas would Not have solved anything. But *winterizing -- or better yet, *weathering for bitter Cold -- and hot Summers too in key gas facilities & infrastructure can make a difference. Texas has a history of preferring light regulatory touch in electricity supply; natural gas is less burdened. But this arguably is a matter of public safety. Plus, more unregulated power markets, like this one, as it turned out were perhaps surprisingly not always cheapest.

Cold wasn't at fault, *per se*. Plenty of gas infrastructure works in deep-freezing places, when facilities are built with freezes in mind. Winterizing just 1 well might cost $100K. As only 0.06% of annual Texas gas production may freeze off in a year, few are winterized. There are 100,000 Permian Basin wells, 250,000 active in State, many marginal of little consequence. Hence there needs to be some balancing. Or, the State could continue hands-off, and just blame renewables like before (though next blackout its true fault will be better known).

More *storage* too can be suggested, too, yet of *natural gas*. In Texas' crisis *gas Storage* was a Hero. It didn't freeze like gas *production*. Another idea, *winterize key power plants; a multi-billion-dollar nuclear plant down on a pump freezing was cheap to prevent in first place, a no-brainer. Ensure *critical infrastructure gets power in crisis. Harder to address is drought. Thermal coal, gas, and nukes may *have to* shut on low water -- not only hydropower's dams. In Texas, Arizona, & West drought stalks -- broke by floods from big atmospheric rivers.

If it feels like we're playing with a teetering system bound for scrap ahead, you're probably right. What it shows, too, is what really went wrong in a 2021 Texas crisis. It wasn't loss of wind! Wind turbines can readily be winterized; it adds 10% to turbine costs but is done 'round the world. Wind energy works fine in the Arctic, in US Upper Midwest, places like Nordics far colder than Texas; in fact, wind prefers colder, heavier breezes. (Natural gas too prefers cool days, but no claims to contrary were made about gas -- as were for wind!). After Texas' freeze it later came to light a blitz campaign was fast mounted to call renewables 'unreliable' -- to deem fossils 'reliable energy'. Even though natural *gas was the most to blame in 2021.*

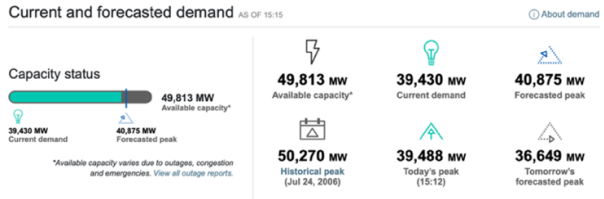
Texas' disaster bad as it was, was minutes from being far worse -- if frequency stability were lost. It did fall from 60 hertz -- to critical 59.25 -- nearly crashing the whole system. Had transformers caught fire, or high voltage lines been destroyed, it could have been weeks, months -- not days with no power! We don't realize how dependent we are on electricity 'til it's gone'. Only by shedding 7,500 MW of demand (effectively turned off ~1 in every 8 homes in State), were they able to take a first emergency step. That was twice a 2011 emergency shedding that lasted 8 hours, 4x longer than a blackout of 2006. There were 3 emergency load sheds/ rolling blackouts – still, crucial frequency stability had nearly been lost in 2021.

It boils down to: How ready are we for changing climate? Honestly, not at all. Summer 2023 Texas then saw unprecedented heat -- and some power was lost. Or a key oil pipeline from Texas to US East Coast, if severed -- could paralyze Southeastern US gasoline supply. Glance at a weather app like Ventusky: it shows swirling arctic polar vortexes in Winters. Bitter arctic air drops to nearish population centers, yet it remains North of US, Europe, Asia. We're saved by the Jet Stream's wind patterns. Yet, those too can change. Sudden stratospheric warming high in atmosphere can weaken this 'fence' protecting us. Doesn't take much to envision on the climate Jet Stream shifting, wavering, weakening: a bitter cold arctic air moving farther south. While that may not sound so harsh to hear, consequences would be. Or floods, longer droughts too from air that's warmer, so holding more moisture for occasional bomb cyclones. Those increasingly imperil big thermal coal, gas, nuclear plants, dams. Terms like 'Climate Change', 'Global Warming' – might be too benign for what can be Calamities. Better, may be 'Climate Crisis', 'Global Heating', 'Broiling' -- even a 'Global Weirding' should centuries follow of blazing Planet. Perhaps uninhabitable equator, with temps not too apart from very 'Hot Poles'. Getting there may not be slow, nor incremental. It may be in non-linear ways. Not pleasant. Not a desirable pleasant warming, made up of gradual gentle change only.

An ending Gulf Stream *can* paradoxically mean centuries+ of bitter change -- colder or hotter. Look westward -- or eastward away from North Atlantic warmed by Gulf Stream -- and it's soon frozen. Should the Gulf stream's heat conveyor fail, science is unsure if a Frozen Europe? Or, a Baked one? But impossible will be, no change at all! It's a difference engine yet again -- and here in our natural world. A Gulf Stream slowed or stopped as meltwaters dilute salinity, and/or in Antarctic overturning current, would hit ocean currents worldwide. So we all lose. Solutions present in myriad ways but clearly *more renewables, energy storage & better grid, in short greater Clean Energy and decarbonization* -- is where attention ought turn.

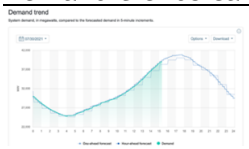
Despite benefits renewables can offer -- curiously some still strongly oppose them. For example, anti-renewables views are dearly held by some Texas politicians. Yet Summer 2023 -- not long after 2021 freeze -- they were ironically saved amid scorching heat, thanks to fast-growth in renewables. In a Texas heat of 2023 that saw 75 GWs of demand, wind+solar along with nuclear heroically met 27+ GWs, or ~40% of demand! That kept power prices cheaper than gas & coal. In 2023 zero-carbon solar/wind power in Texas with nuclear, had begun to eclipse ~40% made from gas. Yes, renewables are NOT firm. And older grids in Texas -- like many places, are still exposed. When Texas teetered on record Demand of 80 GW, if there were insufficient generation, or kinetic attack on grid, cyberattack on software, it can confound grid stability above critical 59.3 hertz. If grid is down, a 'black start' may be needed -- whether can be done fast is unknown. On new heat records, we look forward to green energy, more grid storage, better transmission, all needed. We fundamentally need a modern more stable and resilient system with more renewables fast. And yet some politicians in 2020s there were working to cut back on all the renewables, and to increase just coal/gas.

Texas is a bit similar to California, although California has lesser energy demand being a less-industrialized State. In both cases, renewables have only met about ~35% to 45% of demand, typically (40% was new high for Texas early 2020s). For California, consider 2 separate Summer days: one in July 2021 -- and one just a year later in Sept. 2022. On 2 days of heat & near grid blackout scares in California. In a sense, both were 'expectedly' hot days -- seen here July 30, 2021, and Sept 5, 2022 as State grid was in peril. As seen then, all available power sources were generating 2021 for roughly 50 GW (or 49,813 MW) of electricity. Demand was forecast to peak on that day in 2021 at about 40 GW (39,488 MW). But peril was closer than it sounds, for US balancing authorities must keep at least >6% as contingency reserves:



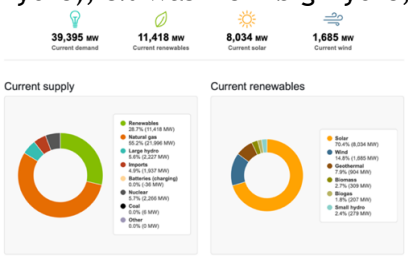

*Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.*

<u>Demand trends can be well forecast; presented here just as was expected at 3 pm:</u>



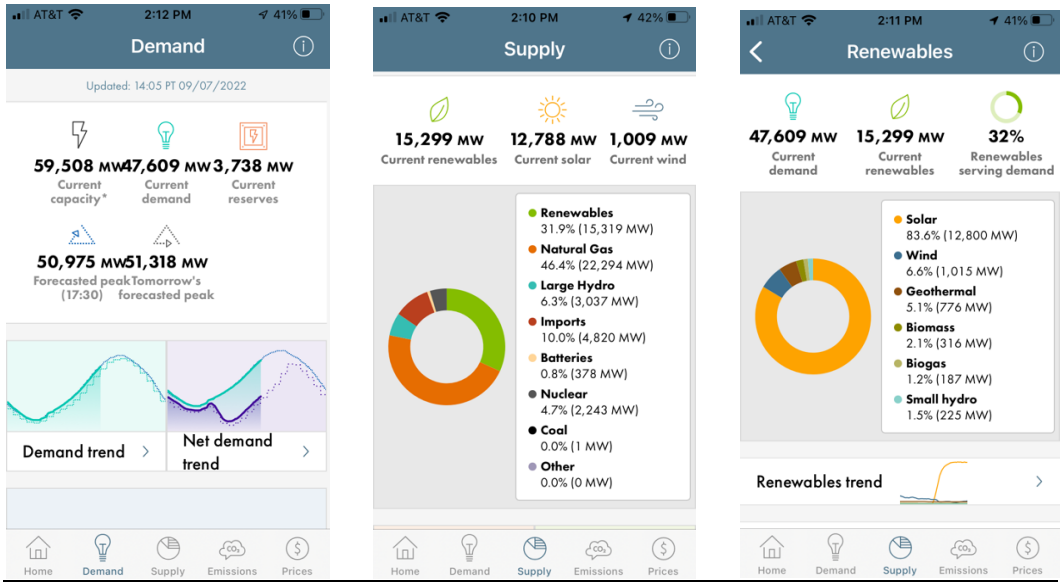

*Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.*

To meet readily-forecasted 3 pm Demand, all Supply sources were producing: a huge, key 55% of electricity demand was met by Natural Gas, 28% was met by Renewables (other than big Hydro), 5% was from big Hydro, 5% Nuclear; and 5% was Imported from Out of State:



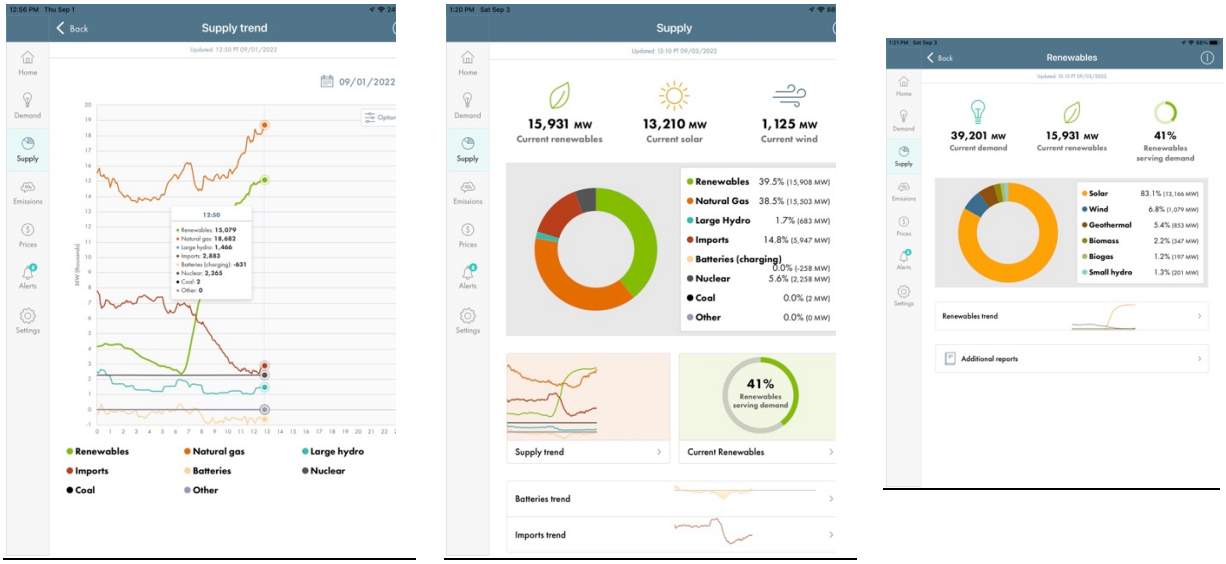

*Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.*

1 year later, Sept. 2022 again on heat, near blackouts, plants were flat-out, no maintenance. Maxed out higher, by making 59 GW. Threw everything at it but kitchen sink. Peak Demand was higher too in 2022 than in 2021, then-record near 52 GW for next day (51,318 GW at left). To meet this, Renewables (in middle) maxed making 15 GW for 32%. Renewables mostly used a hot mid-day hour were solar at 2 pm (about 13 GW for some 84% of all renewables):



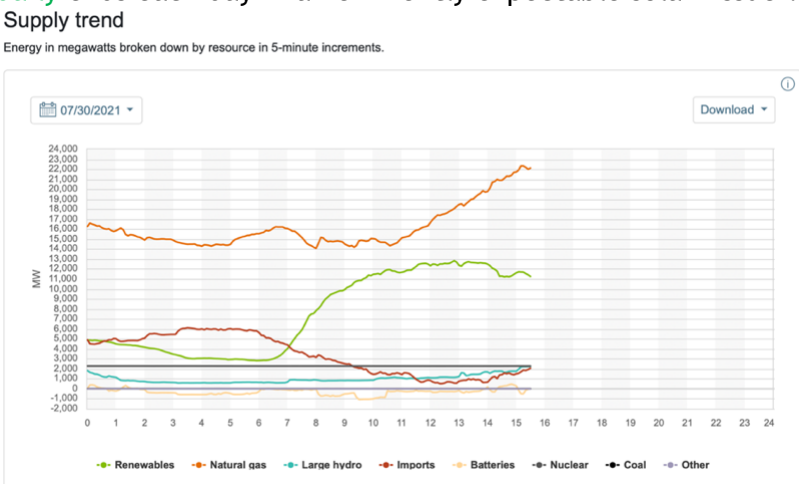

*Source: CAISO.com Today's Outlook - On Sept. 7, 2022 at approximately 2 p.m.*

In that 2022 heat wave, a wee wisp of wind on blazing summer day was 1 GW (7%); geothermal was <1 GW so only met 5%. Thus renewables were NOT Where they Need To Be! One sees below, Demand ramped fast from 8 am, Solar (left, green) went to 15 GW at start of day. But total Demand ramped higher, so Natural Gas thus rose to make 18 GW. Together that meant Imports (in much demand, by all) dropped to 3 GW; current-gen II nuclear is firm, costly, but not-nimble, and here the 1 nuke plant made 2.3 GW (met 5%-6%). As all Western US maxed out in a heat dome, California had only just barely avoided dread blackouts in Sept 2022:




*Source: CAISO.com Today's Outlook -*

A should-be expected-hot summer day in 2022 (above) had flirted with disaster. Renewables had met just 41% of California Demand. Far too low in a changing climate. Yet good news is renewables are eminently scalable. Grow solar by say, doable 5-fold, fast, so solar (above) that made 13 GW (13,166 MW) -- is, instead, solar making say 65 GW. True, demand expands too -- so grow a firm Geothermal many, many fold. Wind Energy is oft strongest at night, so grow it too 5x. Globally, 94 GW wind added 2021 had brought world wind capacity to 837 GW; in California offshore wind should grow many-fold, far more than just 6 GW, fast. Couple with green storage for nights/windless days, meet all California demand. All this on modern grid, importing solar like desert sun, & wind including in midwest. It's clear the supply arc in green, daily ends each day in an eminently expectable solar 'issue': Sun is simply setting!




*Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.*

We must expect this of course, as solar's huge renewables contribution here, green, drops hard as sun begins to drop. Of course, that's eminently forecastable! So, 11 GW of solar at 3 pm helped to meet 40 GW demand; but will fall soon very hard at sunset. Firm dispatchable natural gas generating 22 GW at 3 pm (orange, top) is sadly about to be called on to scale up to replace the 'lost' GWs from solar in an arcing, soon to plummet **green** line above.

Key going forward is to 'fix' this Not by reverting to fossils. Not more natural gas. Especially as we see big impacts of fast-changing climate, gas used as weapon in war. Oil/gas prices are set by global factors; America's shale fracking makes much oil/gas -- yet is not a low-cost saviour: gas scarcity anywhere, makes gas prices jump everywhere, even US. Europe has at times considered taxing the gains in zero-carbon wind & solar, which can beautifully stay level as fossil energy costs skyrocketed. But such windfall tax discourages new investments. And, left unsaid, real story, was how superior the renewables can be vs. fossil fuels.

Fast-scaling renewables, creates separate issues of their own. They're not firm. Drought in a changing climate & flooding, are hard on hydro. New wind patterns tough, for wind energy. Distributed generation rooftop solar -- doesn't show up in as-attractive profits for Utility-renewables. But, rooftop solar makes great/er sense nonetheless! For example, these ECO Reports have been written for over 20+ years now from a building that uses 2 solar roof systems for power. They in turn power 3+ electric vehicles (no gas/petrol needed). Solar powers cooling / heating -- via 2 heat pumps. Our electricity is solar; hot water from large passive solar tanks. All this with a battery backup -- linked to solar PV. So when local blackouts do occur, or say, gasoline prices may spike, we're always left blissfully unawares. Repeat this, millions of times over, especially given for over 20+ years it has been Saving us $$$!

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Scarily tight electricity supply is a Given, hottest days even in a wealthy Texas, California, US, Europe, Asia. In drought, even hydroelectric-rich Sichuan, China. It's a game now of catch as catch can, as blackouts threaten, pollution's left to go up wildly hot days. It's No solution! Left to hope, seen Hottest days as California's Governor must issue Emergency Proclamation to shed load -- to up generating capacity. Shed say, 3 GW power from industrial customers, who thus lose power but who are paid handsomely for that. Dirtier backup generators then used freely. Ships are allowed to burn dirtiest fuels in port, rather than use far cleaner shore-based electricity. All scary, when nearing blackouts, that threaten lives.

On California's grid, a Flex Alert allowance lets $CO_2$ Emissions spike to get Supplies as high as possible. In early 2020s was >50 GWs. Gas peaker plants run flat-out 100%, no maintenance, dirty imports come from out of State. Demand in a foreseeable Heat Wave can outstrip the State's capacity. Given efficiency strides made so far, one cannot 'squeeze much more blood from that turnip.'. Yes, California ever-adds (yay!) electric vehicles that charge at night, leveling demand (and not a threat to grid some may worry about). But in now fewer years to 2030, its 1 lone California nuclear plant making a firm 2.3 GW will close; that will mean a big ~5% loss in the State's firm generating capacity. Blackouts surely now ever-looming.

The State uses band-aids. Electrons imported from elsewhere though in demand in regional need and may be from coal, gas, 2nd gen nukes -- all hit by weather issues. All suffering more than renewables in heat waves. Or in drought: less cooling water a growing threat. As Texas showed in 2021 -- cold can knock out fossils & nukes. The grid can be knocked by deliberate attack/s too -- or by nature. Hence what will help: a newer grid, links to windier Midwest, profitably export a solar/wind bounty from California, as well. A modern resilient grid, better protects from wildfires, makes more electrons available, storage + resilience latter 2020s. Especially as droughts too loom over hydropower, gas, nukes, coal! Global change hits our planet with new extremes. Plus more remote exo-planet risks: maybe CMEs, Carrington events -- or worse scarier, a Miyake event; what MI5 in UK has called '4 meals away from Anarchy'. All are calls for stronger and shielded grid plus renewables + storage = resilience!

In sum war complicated all as energy prices are set globally. As Europe scrambled sans Russian piped gas, it paid record prices for gas from ex-Russia. Costlier gas for India, Pakistan, etc who paid 'discounted' but high prices. They in turn burn more coal, oil and that 'discounted' Russian gas. All threatened by colder winters, hotter summers latter 2020s etc. More gas to EU is not an answer; takes years to build out LNG, and its frailties remain. Yes, years too for renewables & better grid, but they alone solve much. As crises likely loom this-decade.

Used to be proponents of US natural gas pointed to it as the energy transition fuel, savior for America. But, they hadn't figured on war in Europe adding volatility, as prices are set globally. True, fracking in America helps reduce natural gas price spikes, as does filling US oil storage. Still… take say, Sept. of 2022: US natural gas had already more than doubled in that year -- which hit utilities hard. US electricity nationally in that Fall of 2022 averaged ~15 cents/kWh, up 7.5% over a year earlier. CPI for electricity costs was up 16% over year prior; largest spike since 1981. Some US regions saw much worse. Like in New England, residential electricity went from 10.67 cents -- to 22.57 cents/per kWh. Due to rises in gas costs, utility wholesale power costs tripled from 2020, to $130 per megawatt-hour. On war, weaponized as suddenly very expensive natural gas was an Achilles Heal, worldwide. A take-away is it doesn't need to be this way. Nor reliance on that gas, nor on China for the key minerals. In 2020s we keep being 'hit over the head' by climate/and war; both unlikely to go away.

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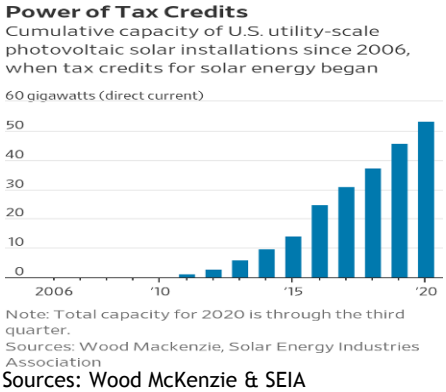
Those who'd shaped a 2022 IRA had thoughts to source & process vital minerals in US. Build new green industries at home. New domestic energy storage, given China especially. Wanted pro-US trajectory for mining & processing in IRA to reflect that. To give tax credits for stand-alone energy storage (before had needed to be coupled to solar, so 2021 fully 93% of storage was tied to solar). Developers could benefit from extra ITC, if say, 40%+ components made in the US. Another 10% if sited in areas once in coal, oil, or gas. All that was in previous draft bills. With 2022 IRA incentives, an aim was that key minerals should begin to be sourced from within US, or in North America. Biggest US EV makers might start building even late in this decade, new US plants for processing lithium, even if it's mined elsewhere.

That took a page partly from solar's handbook, which grew 10,000% in capacity since 2006 thanks partly to tax credits. Tax credits, once crucial to solar -- can help grow storage, batteries, grid, post-2022. True, earlier 'omnibus' BBB bills with $ Trillions had failed. But some language was carried over from BBB. Solar once, had needed both cheaper panels & favorable (tax) policies to light a fuse, prime a pump. Both. This chart shows how fast solar grew after, thanks to tax credits post-2006. Solar is different now (and China a major issue) -- but like all else in energy, earlier tax policies here had once greatly mattered:



Sources: Wood McKenzie & SEIA

Storage credits that once had needed linkages to solar, were of little help. With 2022 IRA unleashing storage alone, much may change. In 2020 there were just puny megawatts (MWs) of deployed storage in US -- while hundreds, thousands of gigawatts (GWs) were/are needed. No doubt storage will scale more speedily post-IRA. Repeat it for new storage technologies.

Relevant too, is tax policy that can help bring about moderately green 'lower-$CO_2$' lithium for batteries, that's cheaper to boot. Where naturally hot lithium brine occurs, geothermal power from hot brine may also make lithium hydroxide, without water waste. Freed from sun-intensive evaporative ponds, needs no sulfur. Co-locating batteries + and EV makers -- like poly plants + solar PV makers -- with decarbonizing as one organizing principle can build in lower-costs and efficiency. A better circular economy elevating new zero-$CO_2$ solutions.

That Senator's thumb on IRA hadn't helped high-income electric car buyers; it excluded too non-US EV manufacturers from subsidies. Batteries made of materials sourced overseas or processed there were excluded. Building US mining & minerals processing capacity will take decade+. There's other issues too: tariffs on China PV and anti-circumvention had dominated 'in the weeds' PV news in mid-2020s; over 90% of global solar wafer capacity was in China. An issue thus for US PV buyers then was whether panels were 'built' in China -- or finished in Vietnam, Malaysia, etc given tariff Uncertainty. But there was some green light to grow. And new hopes permitting, access to grid could at last be better streamlined mid decade.

**Useful *Non*-Correlation between our clean WilderHill Indexes -- versus the Fossil Fuels**

ECO/NEX and now too H2X/WNX -- show good *non*-Correlation vs all fossil energies. What an example of diversification! There may be differences at times, eg when clean alone gains... Or sometimes, clean falls hard -- dirty fossils up at times like this and last decade. Yes, all are *energy* themes -- yet clean can march to distinctly different drummer vs. coal, oil, gas. Take say a vantagepoint at start of this decade looking back from there: an interesting thing happened. Dirty energy in few years to 2020 was worst performing sector of S&P500 in 4 of a prior 6 years; it was down -30% in 2020 -- when clean energy roared. (In S&P500 'energy' is mainly still the fossil fuels). In sharp turnaround, fossils jumped in 2021, after long doldrums. Then a past several years were notable for all of energy, so look a bit more closely.

Consider what transpired, as Covid crash first hit everything hard in 2020. At first it dropped markets worldwide, to then nadir March 2020. Thin slice of S&P500 in energy (so mainly in dirty fossils) was strongly down by -51% in Q1 2020 -- while the whole S&P500 was down then 'only' by -19%. Partly that gap was due to the 500 Index's market cap weighting methodology. Just 1 very big component in a market cap weighted S&P500, say Apple, may potentially be heftier than all its then-2020 dirty fossil fuel energy names / weightings, combined!

That major Index is slowly' greening', albeit at snail's pace. A key electric car firm was added to 500 in 2020 -- already America's 4th biggest company -- and it curiously was listed in the 500 as 'consumer discretionary'. A solar inverter firm was only added in 2021. For all energy in general, as we'd noted back in 2020, (dirty) energy then was just 2.5% of S&P500 but it once had been far bigger there: was 7% in 2015, 11% in 2010; bigger 16% in 2008. In 1980 dirty energy was 7 of S&P's top 10 by market cap, 25%! By contrast in 2020, 28% was in tech, up from 18% in 2010. Some observers 2020 had hoped that EV maker's addition to 500 might have come earlier-on in 2020, to be 1.4% of the Index. That would have been significant for the $4 Trillion in trackers. But it was then passed over, and added only afterwards for Q4 2020.

Drilling deeper let's consider oil & gas behemoth Exxon. In 2020 the Dow Jones announced it was dropping Exxon from its leading ~30-stocks Dow basket. Why? Apple was splitting 4-1 and *price-weighted* Dow Average needed component/s to better keep up with other baskets. (Dow had sizably lagged in its performance to then). So new representation was chosen -- but not from fossils. Instead, they added in 2020, 3 tech-heavy names. Dow Industrials dropped Exxon that various incarnations was in since 1928; long-serving Dow component, no more. Only Chevron in oil stayed. (Due to prior few years perhaps when dirty energy had then fallen -- yet it would soon rise big in 2021 as energy became bigger slice of S&P500 after 9 of its 11 sectors fell, and energy gained +14.3% in eg Sept 2021; in retrospect then Dow maybe should have kept in both fossil fuel names -- which really later jumped up 2021 and 2022).

Make-up of Indexing baskets matters. As battles quietly going on, can influence hundreds, thousands of Billions of $ dollars. Back in 2018-2020, a then-Administration's Dept. of Labor on ERISA wanted to know of 'discernable trends' in how retirement funds were being invested in energy (FAB 2018-1). There'd been sizable outflows from fossils -- to sustainable energy themes. It's been reported fossil industry & climate skeptics were an impetus trying to slow inflows to 'ESG' (Environment, Social, Governance) -- better thought of, as decarbonization investing. They'd perhaps hoped to see 'non-pecuniary' goals like climate change, get subverted. The new Administration moved in 2021 away from that, even explicitly pointed towards green themes as important. Still, it's useful to recall how a stealthy attack occurred (and failed) against clean energy 2018-2020. Tried again in 2023 in Congress -- vetoed.

Real-world Returns for clean energy in a 2018-2020 window were Up, hundreds of percent, hardly 'non-pecuniary'! ECO was up +300%, when traditional Indexes were up more modestly +85% (Nasdaq), +40% (S&P500), +25% (Dow). Fossil gas was then *Down* -60% yet would spike -- and then fall. Interestingly too fossil gas vs. clean energy *both* non-correlated with broad Indexes last decade. So maybe was No surprise to see billions of dollars flowed to 'ESG' (again an awful term!), broke records as green assets in 2020 were up 2x vs. 2019, to $246 billion in 2021. Decarbonization may grow yes, *but will surely be hugely volatile too, oft down.* And yet. Attention to climate (IB 2015) saw an unworthy Federal attack 2018-2020 reportedly by fossil interests and skeptics on ERISA. At State-level 2022, Texas moved to divest from funds it felt had somehow 'boycotted' oil -- if new energy was just in their name (like NEX)!

Of note Texas' war on what it considered fossils-boycotting by big global Banks could cost its Taxpayers a Huge $22 billion! Seen in recent research, a Texas community wanted to issue 30 year Municipal Bonds so went with an attractive winning bid of 4.0808433% by a major multinational investment Bank. But the State halted that deal; it claimed that big Bank was 'boycotting' fossil fuels. That Bank responded they were not 'boycotting' fossils -- they had $33.5 Billion invested in them! They were simply aiming to Reduce Their Carbon Footprint via green new energy too. Yet Texas' leaders blocked the deal. As a result, studies in 2024 showed Texans as a result paid a much higher 0.41 percentage points interest rate for Bonds -- it can costs its taxpayers a Huge $22.5 Billion over 30 years! Talk about cutting off their noses to spite their face! Or being hoist by their own petard! 'ESG' (ugly term!) however is different -- from our focus on Clean Energy, the 2 not to be conflated. In sum if proposed rules/attacks like by Texas sought to prevent any look at $CO_2$ or climate risk by deeming it 'non-pecuniary', then that's a bit curious given these quite glaring Performance facts in this window:

**<u>In 2018-2020 a Clean/Climate theme (top) -- then Left Traditional Fossil Fuels far behind:</u>**


*Source: finance.yahoo.com*

An artificially narrow window above, yet makes point of highlighting differences from fossils. March 2020 to March 2021, ECO had ranged 46 to 286, rising 6-fold. Global NEX had ranged 150 to 630, up 4-fold. As was said of clean equity's gains 2020 by a brilliant man, "How strange…. Well, back to work". Then crashed. Doubtless future crashes like 2021-2024 lay ahead. In 2021 China aimed to go from 11% solar/wind generation -- to 16% by 2025. Wind developers jumped on expiring subsidies – put in 72 GW of wind 2020, 3x that of 2019 (solar up 60%). But because their fund for subsidies early 2021 hit a cumulative 320 Billion yuan (USD $50 Billion) shortfall, it briefly proposed writing-off some sums. In response a big wind developer's stock fell -30% in 4 days, soon rebounding once proposal was dropped. Point is regardless of certain ongoing volatility, decarbonization has begun figuring in finance.

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In 2022, then 2023, then a 2024 etc smitten by diseases, wildfires, temperature extremes, blackouts, we increasingly saw mounting evidence the global economy is a wholly owned subsidiary of the environment. Yet to notice climate, doesn't mean smooth sailing ahead; no nation has yet risen to the occasion. And for host of reasons volatile ECO, NEX, H2X, WNX will surely fall at times, *hard!* Each nation has its own issues… just one problem as a practical domestic matter, has been America lags behind badly in producing lithium, nickel. In Rare earths too that in fact aren't so rare, yet are needed in motors, turbines & strategic uses. As a Senator observed in 2021, "We don't produce any of the rare earth minerals, or very, very, very little of any rare earth minerals that it takes to make a battery. We depend on other sources of the world … that we seem to want to be out of sight, out of mind, and we just say, 'Well, we have an electric vehicle." Or take nickel used in batteries, electric cars, grid. In 2022, nickel had spiked briefly on just a short squeeze going from $20k -- to $100k/ton.

This 'ain't our first Rodeo' seeing the US fall badly behind, when it needn't have done so. We saw solar manufacturing decamp from Japan/US/Germany -- to China 2 decades ago -- on too to cheap Vietnam, Malaysia, Thailand. By 2020 the 3 biggest PV makers had their HQ in China. It's seemingly happening again in crucial batteries, EVs. Such needn't occur. And the IRA is changing things -- including its notable Section 45X. But a US in 2021 had only 3 big battery factories. Tesla's Gigafactories point a way, yet we may see, say, only 10 big battery factories in US in 2030; should be many more. Meanwhile, these 'US factories' may be S. Korean etc-owned factories, just built within US. The IRA should help these be US-owned factories. By 2030 so in less than ~5 years, China is smartly on track to have 140 big battery factories! Europe maybe 17 big factories. On projected US EV demand, it should be 20+ US battery factories in 2030. Not inspiring 2021 saw only half, 10 were on track to be running 2026. They should have been in planning 2021, their construction already have begun back in 2023.

So, US is far behind China in green manufacturing, even behind a more committed Europe. If the US had expected 200+ electric & hybrid car models 2024, it should have been producing far more rare earths minerals for motors. Rare earths in quantity for wind turbines too. Lithium for batteries is a different beast; rather abundant in Earth's crust, not to be confused with rare earths (also, not rare). Rare earths are used eg for magnets to generate electricity in spinning wind turbines, or to take amps of (clean) electricity & to convert that into lovely electro-motive power pushing new EVs, trains, aircraft, large ships at sea, etc.

As said by Mr. Nikola Tesla regarding his amazing discoveries, later applied in potent magnets, wind turbines, AC electric motors, *"I would not give my rotating field discovery for a thousand inventions, however valuable… A thousand years hence, the telephone and the motion picture camera may be obsolete, but the principle of the rotating magnetic field will remain a vital, living thing for all time to come."* Unlike more pedestrian parlour tricks by comparison, these rotating fields of rare earths are awesome; make possible unmatched blue-sky advances. Myriad powerful technologies today harness these fields to work their magic.

For all that, mining clearly means a range of harsh environmental, and social impacts -- all to be handled solemnly. Ideals like 'green lithium' are tough, but at least a 'greener' lithium from hot briny waters & zero-carbon geothermal power better than water-intense evaporative ponds and sulfur. So too is avoiding mining's bankruptcies upending cleanup. Ecologically sensitive places surely must be always protected from any, and all mining. Meanwhile, some disturbed places more amenable. Places like West Virginia welcome sourcing minerals from ample disturbed sites, and extant waste piles of old mines -- creating good jobs.

**Global Clean purer-play NEX – vs. a competing Not-so-Clean theme in Big-Caps:**

Consider next many big differences as between Global NEX with its trackers in US & Europe -- vs. a differing, competing, global 'just-cleanish' energy Index also with US, Europe trackers. That other, global Index has several characteristics that has set it well apart from NEX. One, long was that other Index was maybe fine choice if wanted a concentrated basket made of big caps only; narrow with little to no energy storage, no electric vehicles, no green $H_2$ etc. Because that other basket was so highly concentrated in big caps, skewed to a not-so-clean -- it differed very much from NEX made of clean, pure-plays in diverse solar, wind, EVs, energy storage, $H_2$, etc. And if theme went down -- that big-cap other Index was oft down less; versus cleaner, purer-plays NEX often down more. There's also several more contrasts too.

For example, the clean zero-carbon ratings in NEX are far better, and more deeply green -- than in that other 'only-cleanish' Index. NEX is also steeped in diverse new energy innovation -- so it's unlike an older GICS (Global Industry Classification System) 1999 nomenclature that put other global basket very heavily into brown, what GICS calls "Utilities". But, if one wanted only a not-so-clean, narrow concentrated, mega-caps basket, more liquid on big names, little energy storage, or EVs -- then that other basket was surely a fine choice.

Yet consider too, the most key divergence is: Performance. Briefer periods, the NEX vs. other Index trade leadership back & forth a bit. Short-horizons 1 Index may lag other sizably. Other time frames are oft a wash, no clear leader. In 2023 & 2024, NEX did out-perform that other 'not-so-clean' Index; the NEX is down less, -10% -- vs. other down -50% (perhaps as on times to the upside NEX may do better). Over these long periods, this key fact clearly stands out: *the Global NEX (via tracker here in gold) is very strongly is Outperforming vs.* ***other Index,*** also for a global clean energy theme **(as seen via its tracker bottom in black).** This persists for lengthy periods, whether since near tracker inception (seen here), or the past 20 years etc. This chart captures both Indexes via live trackers, for all data from start of that other Index (it went live after the NEX) with tracker so for 2009 -- to end of 2024. Interesting to see how divergent performances are, for the 2 Indexes/tracker funds. *In sum the global NEX, here in gold clearly does far 'better' -- although both end well-down here in this period:*

**NEX tracker (gold) vs. not-so-clean global energy theme (black): 2009 – to end 2024:**


*Source: Bigcharts.com*

As seen above, clean NEX has Outperformed, does some 20%+ 'better' -- *though both down*. **NEX** may go up much more strongly rising periods; yet NEX drops hard/er too in downturns. Why, perhaps? 5 factors may help explain why that other theme, is here far behind the leader **NEX** for global clean energy. Perhaps it's because other non-NEX basket long was / or is:

* Heavily Restricted to (not-as-clean) just bigger-caps -- so far fewer themes & stocks;
* Was Heavily concentrated in top 10; had been 30 names total (much more post-2021);
* Heavily skewed by having to use a modified-market capitalization style and weightings;
* Was unable to hold so many stories: it eg long missed across storage, EVs, H2, grid, etc;
* Less Diversified across stories/ nations -- & it also has relatively dirty themes represented.

Nothing wrong with that other theme *per se*. *For example that other Index did much better in down years, like 2021-2024!* Also it's a good contrast -- purer vs. less-clean global energy themes! For other differences as between purer global NEX -- vs. other global energy basket, the NEX launched/went live first, 2006 -- before that other Index. Seen say early 2021, NEX had 125 components. That other global basket instead, for years since its inception, long had had only 30 components to 2021. Just 30 didn't allow real clean energy scope at all. So, wasn't possible for it to then capture stories across EVs, green hydrogen, storage etc etc.

Weighting styles, matter greatly too. That other basket used market cap weights modified by 4.5% cap, at times exceeded. Generally, at any rate, just 10 names in that other tracker might earlier make up ~half its total Index weight!! In truth global clean energy reflects far more than just 10 names, of course. Concentrating that way meant biggest few, might push up fast if momentum narrowly did well -- or might pull down. Shorter periods, say past 1 or 5 years -- these 2 Indexes can trade leadership back & forth -- but long periods, NEX has done significantly better. Equal weighted NEX, eg early 2021 had far greater 125 names so far wider reach. And helpful NEX equal weighting let more & smaller names be heard: each has a voice. With No Overweighted Top 10. Given such huge performance gap long periods, it seems equal weighting may allow passive NEX (& tracker) to better capture far more -- especially small & mid cap inherently clean purer plays. *Please note though: neither approach is 'right': they're simply 2 very differing methodologies*. 2 varied ways for global clean stories to be captured. That other concentrated only 'cleanish' style allowed few-clean names, biased towards big caps -- while NEX notably has always been purer, cleaner, more equal, wider-ranging.

As a practical matter that other Index's tracker helpfully has a notably low expense ratio -- though at times it's swamped by performance difference. Its heavy-trading gives liquidity. Overall then, 2 takes on a fast-growing theme. Equal weight NEX truer to clean -- vs. a big cap less-clean other skewed to Top Ten & brown Utilities. Quite useful in real world having 2 such differing benchmarks for an-emerging global story. But, that other Index also did face vexing issues given how it was first designed/built. One arguably was excess concentration. Its tracker faced real liquidity risks, given that design. As growing sums flowed in, AUM, a few concentrated names in a tracker there might overwhelmed even 'mid-sized' big stocks. That in turn, might *distort share price/s, and/or *take far too many days for its tracker to 'fill' at the rebalance given regular let alone above-average trading $ values, or ADTV.

After doing public consultations in 2021, that other Index made numerous understandable changes for Q2 2021 & going forward. From a fixed 30 only components, it added at first very big 52 more -- and it could go towards 100+, total unlimited. With no ceiling, it was again becoming bit more like the NEX; this made sense given new energy's a growing story ahead. Such could allow too, for that other Index to better reflect an evolving story over time.

However, problematically, that other could & did then add *Non-Pure-plays - outside clean energy*. Less closely adhering to *clean* energy theme, instead only in 'cleanish' energy, less pure. A huge difference from 2021, vs. the purer NEX. That other Index might have in fossil fuel/natural gas, or nuclear; it changed after 2021 since can be bigger yet be browner, while its big-caps mean it declines less in down markets -- yet moves up less in rising ones!

Mid-2021 that other global Index could & did hold non-clean names. Just 3 examples were 1) that other Index added at a big 5% weight in 2021 a utility getting only 8% of its earnings from renewables; fracking natural gas on near-enough pipe to go New York to Paris & back, can't be clean nor sustainable for decades at soonest. 2) They also added another dirty energy name too, that also can't be in NEX as it's heavily in natural gas and in nuclear too; so not eligible for NEX that's instead for global *clean* energy. 3) That other Index added too another utility also ineligible for clean NEX as it generates electricity from oil, even burning diesel (among last US Utilities to do so)! In 2020 only 35% of that utility's power was from renewables though its in a region blessed with sunshine & wind. Later that other Index did another market consultation to allow more changes, but notably, it explicitly still allowed in much gas(!) just weighted bit less. It kept unfortunate 'Carbon Intensity' score metric. That faulty metric allows inclusion of dirtiest fossil fuels by distorted false numeracy. *Clearly fossil fuels and certainly coal, don't belong in a green energy basket. Nor* should they be in a global *Clean Energy* theme. So, that other Index though it fixed some distortions, arguably made changes post-2021 that allowed itself to become maybe, dirtier. Did so again 2022, more gas & nuclear names -- thus arguably only sort of, kind of, in global 'clean-ish' energy.

We recall years ago as small cap funds grew popular, how big inflows had made it hard for active funds generally to hold small equities. Even a $1 billion(!) market cap stock was liquidity risk from inflows. So the 'small cap' definition inched up, towards a >$2 billion floor or more(!) to accommodate growth. Some definitions got thin, diluted from target concept -- not pure. A ramification of fast-rising popularity of 'small caps', was it got harder to hold equities outside of big, as inflows grew in active Funds -- and passive Indexes. Consider then green thinking today. Green 'words' may see tremendous interest. There's an upswing of activity. In 'net creations' especially for ETFs in decarbonizing themes. Yet one result may be as investors open their Prospectus to see Holdings, what's in funds, they're very surprised by what's inside! Confounding, is many so-called 'ESG' funds that hold coal, oil companies! Perhaps names steeped-in-nuclear. That clearly should & must be fixed. Greater truth and an understanding of green aims arguably ought to prohibit any questionable inclusions.

Arguably, a priority should be to stay true to clean/green. Not be pushed into brown energy. Otherwise, prior focus on good targets like robust zero/low-carbon may drift off-theme. How in the world, can coal, oil be included in a true green (or less-green 'ESG') basket?!! Or, make a claim of 'ESG'??? They can't. But an unfortunate way is via a 'carbon-intensity' metric. It allows a big fossil producer, say on *Revenues* of say 70% oil & 30% natural gas -- to massively ramp its gas to say be 60% natural gas, 30% oil, 10% biofuels -- and claim clean'! $CH_4$ /natural gas spews a bit less $CO_2$ per kWh -- vs. oil or coal -- with $$ profits from gas really the dynamic. Nothing zero-carbon of course, but 'carbon-intensity' schemes can lend false numeracy via profits, a seeming quantitative rigor, when the opposite is true. Left side of that equation is correct: carbon footprint can be measured in tons of $CO_2$ as Scope 1, 2, 3. But right side of equation, 'intensity' grafts 'value', revenues in Dollars, Renminbi, Euros. *Yet air cares not a whit 'how profitably' each $CO_2$ molecule was made* -- more *revenues* - or less! But sadly, the (ahem, intended) upshot is that dirty fossils and companies can get a free pass.
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What 'carbon intensity' wickedly does, is lend fossils a fig leaf. Sounding quantitative, yet lets polluting firms claim 'green' going from oil -- to gas. Sadly, clever marketing, enables fossil firms entry into 'kind of clean' (really brown) basket 'ESG' funds. On ill-conceived notions like 'revenues'/per ton of $CO_2$ -- that makes carbon 'intensity' slippery indeed. So subtle, it's pernicious. Consider a startup solar firm, tiny $CO_2$ emissions, negative revenues; it won't score well 'carbon intensity' on few sales. By contrast, a huge fossil firm massively growing brown gas sales, gobs of revenues, scores well. Awful $CO_2$ eclipsed by swelling profits, for better $CO_2$ 'intensity' scores. Something's patently wrong with that picture.

For how a passive clean Index performs, return to Weighting Methodologies. Interestingly, we saw that the *equal-weighted* NEX has far outperformed since inception -- vs. that other *market cap* weighted Index. For equal-weighting's benefits, consider the Chart below:

Much better real-world results are obtained by Equal-weighted NEX -- vs that Market-cap weighted Index over long periods. As was observed by *The Economist*, at right in 2021, a model portfolio constructed Green Index seen here when straight Equal-Weighted, very nicely doubled; it went up swiftly from 100 to over 200 in 2020; thus went up over +100% … But its Market cap weighted version, instead went up much less, from 100 to about 160, or 'just' +60%. In their 'Climate Finance: The Green Meme' (May 22, 2021) they reported:


Source: The Economist (2021)

> *"Since the start of 2020 our portfolio when companies are equally weighted has more than doubled; [but] when firms are weighted by market capitalization, our portfolio has jumped by more than half. The reason for that difference is that many green firms are small -- their median market capitalization is about $6 billion -- and the tiddlers have gone up the most. The smallest 25% of firms have risen by an average 152% since Jan. 2020. Firms that derive a greater share off their revenue from green activity, such as EV-makers and fuel-cell companies, have also outperformed. Greenest 25% of firms saw their share prices rise 110%."*

Describing how 2020s inflows are increasingly into green & 'ESG' themes, they state:

> *Unfortunately, the [ESG] boom has been accompanied by rampant 'greenwashing.' This week the Economist crunches the numbers on the world's 20 biggest ESG funds. On average, each of them holds investments in 17 fossil-fuel producers. Six have invested in ExxonMobil, America's biggest oil firm. Two own stakes in Saudi Aramco, the world's biggest oil producer. One fund holds a Chinese coal-mining company.…*

*The Economist* makes 2 very good relevant points above: 1) It's dismaying to see big oil & coal names in any 'ESG' fund, especially 2) global in clean energy Indexes or funds. Beyond this, Europe SFDR/BMR aims to help rectify that. And in NEX/H2X/WNX, is floor $1m average daily trading value (ADTV)/$750k continuing components, look at severe risk ratings, ***and*** carbon. In sum the NEX/ECO & new H2X/WNX are green, avoiding a 'greenwashing' pitfall.

Of minor note, is a sharp thematic volatility seen here, isn't necessarily due to *Global* aspects. Consider say *global* NEX -- vs a *US-listings only* ECO. These 2 have industry's longest track records (20+ years, 18+ years) -- so put aside a moment that separate other global Index. Glancing just at NEX/ECO, a few thoughts come to mind. One, is US-listings-only ECO basket *can* be hugely volatile too. Seen head-to-head, day to day eg in first 6 weeks of 2021, the NEX tracker saw a sizable 14 days with + or -3% or more daily change/day to March 15. Yet US-listings-only ECO tracker saw even more: fully 24 days with sizable + or - 3% change/day.

So, *global* is not necessarily = volatility. But technology & innovation themes, may somewhat. There's risks in new energy solar, wind, EVs, $H_2$ & fuel cells, as seen in other clean energy baskets too. And fast-moving Europe *may* seek more $H_2$. Continental Europe lacks its own gas reserves (it's no Texas). Was long over-dependent on Russia. Post-2022 it seeks green $H_2$ on security, climate concerns too. Says nothing of how equities may perform (maybe *down* like in 2021, or up like 2020). Just reflects a very risky, volatile theme, always uncertain. Whether it is domestic US listings -- or listings worldwide in clean/new energy innovation.

Of interest is that in 2021 International Renewable Energy Agency wrote not $10 Trillion (Tn) -- nor $100 Tn -- but a startling $131 *Trillion* might be needed in clean energy by 2050 to avoid heating over >1.5 degrees C. So more than $100 Trillion has been suggested. Gas use had spiked in Europe 2022 on horrific war; yet gas use *may* peak late years this decade. In its place, electrolyzer capacity for green hydrogen *may* go from puny 0.3 GW 2020 -- to say 5,000 GW. With $H_2$ feedstock a 'green ammonia' -- or methanol/$CH_3OH$ (but not from fossil fuel gas; that's greenwash). Europe potentially *may* latter 2020s become a green $H_2$ leader. And China may ramp nuclear -- even sadly as it only reduced its coal use a bit (if at all) mid-2020s.

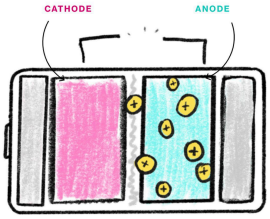
Great uncertainties abound, giving rise to volatility, tremendous risk. Myriad sub-themes *may* see advances: some incremental, some may be non-incremental, perhaps disruptive. Advanced green energy storage & batteries plainly merit focus 2020s, areas ECO & NEX have had exposure to for over 20+ years. New attention also for Hydrogen Economy, Wind Energy. As China continues to be a major presence across all these themes in the 2020s.

Energy storage, is a big deal, world fast needs far better, cheaper, and much more batteries. A fine piece in Bloomberg Businessweek was useful, well-illustrated ('The Hidden Science Making Batteries Better, Cheaper and Everywhere.' April 27, 2021; we side note Bloomberg New Energy Finance was an early partner here in the global NEX Index). Excerpting from their useful, nicely-visual piece, we relay several good illustrations from it below.

First what's called 'lithium ion' battery has a constellation of materials besides lithium. Like, Iron, Nickel, Manganese. There's much effort in moving to little or no cobalt. While different chemistries each favor varied characteristics, all batteries basically, consist of *Cathode, *Anode, *Separator, *Electrolyte. The anode was largely settled as graphite, maybe silicon -- maybe say nickel niobate (NiNb2O6). But that's changing too in shifts away from any nickel; maybe towards say newer pure lithium anodes ahead also replacing graphite -- or… ??

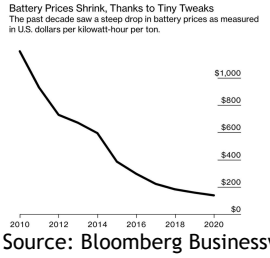
A few chemistries dominate at Cathode. Particular traits/materials are selected for strengths favored: batteries are in fact named for materials at cathode. Traits balanced might be: cost, energy density, weight, calendar longevity, cycle life, fast charging ability, temperature range etc. Favoring one trait, seeking say a better energy density, might come at the cost or trade-off of eg, reduced cycle life. Or higher performance may be traded away -- to get cheaper, though heavier with less potent material like iron (although this changing too).

a) 4 basic battery parts:




Source: Bloomberg Businessweek

Battery prices are falling hard:

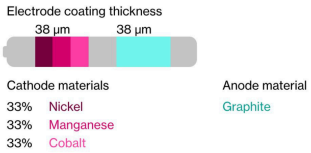



Source: Bloomberg Businessweek

b) Nickel Manganese Cobalt (NMC) in a Zoe:


Source: Bloomberg Businessweek

NMC Composition back in 2012:

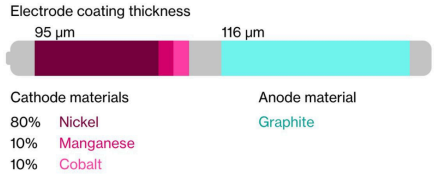



Source: Bloomberg Businessweek

c) NMC as seen in a Nio:


Source: Bloomberg Businessweek

Then, much Nickel, little Cobalt = thicker:

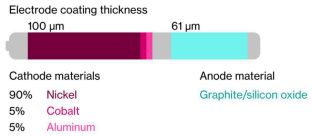



Source: Bloomberg Businessweek

d) Tesla 3 has used NCA:


Source: Bloomberg Businessweek

NCA, light strong battery, no manganese:

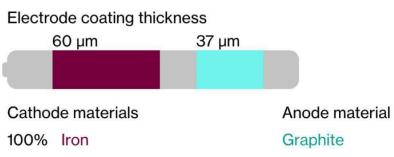



Source: Bloomberg Businessweek

Popular was NCA, or NCM with 8:1:1 ratio of Nickel, Cobalt, Manganese. So, a 'lithium' battery may mostly be nickel by weight. LFP's cheap iron & phosphate eliminates vexed cobalt, costly nickel. So LFP is gaining. Especially low-cost uses. Heavier LFP iron once hadn't performance of NCA, but it's safer & LFP is improving fast. (We'd had an early electric bike here 2001, LFP chemistry). Its market share went from 6% in 2020, to 30% in 2022. LFP may be in buses as its ~30% lesser range and big weight are non-issues; cheap, it maybe went <$100kWh(!) back in 2021 in China. In price-conscious EVs, it can be charged more fully to 100%, less fire risk. Consider 2022 pricing wars meant 80 pounds of nickel in NCA electric car battery, added over $1,750 in costs. Concerns over Russian nickel, in a short squeeze had sent its price from $10,000/ton -- to $30,000/ton -- then briefly on short squeeze to $100,000/ton(!). Hence looks lately at novel new LFP anodes that may let iron perform at near nickel levels.

e) Electric Buses using LFP lower-cost iron:


Source: Bloomberg Businessweek

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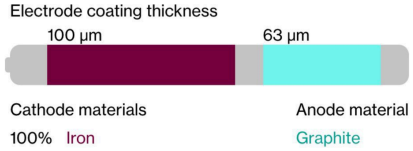
f) Modern LFP, less-energy dense:


Source: Bloomberg Businessweek

Thicker Electrode is less costly using iron – and graphite in anode might be replaced:




Source: Bloomberg Businessweek

Efforts ongoing for all: better cathodes/anodes/electrolytes in cell phones, ebikes, EVs etc. Depending say, if energy density -- or lower cost is desired, it's certain all will keep evolving, improvements ahead. At one world-class top EV maker, iron in early 2020s had let it improve profit margins sizably -- over spiffy/costlier NCA (nickel, cobalt aluminum) performance cells. A huge LFP supplier in China (where else?) seeing great competition, gives some leverage to the many EV makers that may consider yet more low-cost, good new iron LFP options.

Figuring out how to add a bit more silicon at anode, without swelling, has promise. Farther ahead exciting metallic lithium batteries could be -- should be -- very impressive. Here fire risk was untenable in early 2020s since 'dendrites' can penetrate electrolyte. But new-generation solid-state batteries tantalize. The drumbeat of wistful ever-on horizon solid-state batteries hopes, long so-elusive, *may* be getting closer. Possibilities of non-incremental advances towards solid-state batteries later in this decade may make one hopeful.

Research showed a self-healing hierarchy of instabilities, *may* fortify separator at cathode/anode, so no puncture. Liquid electrolytes maybe replaced by a solid-state core for ultra-high current densities. With fire-safe boundary, energy/power density might improve, shorten charging times dramatically. Lithium metal anode with $LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$ cathode showed 82% capacity retention @ 10,000 cycles! Not long ago a standard was 80% capacity @500 cycles, after which a Li-ion battery was 'dead' if for EV purposes. So early EVs once had 200-mile range, as on 500 charge/discharge cycles that range meant acceptably a 100,000 mile electric car battery. After, pack may have 2nd life uses like stationary storage @ 80% as acceptable. Instead, up to 10,000 cycles may be possible on solid-state batteries, *perhaps* in production latter 2020s. Designed with help of AI(?). That may be like going from vacuum tubes (and we recall building radios with these early 1970s) -- to using far superior solid-state transistors (in late 1970s). Solid-state *might* be game-changing in batteries. Or, it not happen.

New ideas may include a dual battery that incorporates both LFP for everyday shorter drives and more costly nickel-manganese: lesser cycles that can go farther if longer range is needed. Or sulfur batteries, this molecule maybe hosting more than lithium; or bipolar designs that end a need for casings; Near term may make sense to shift from nickel -- to iron in batteries. Making batteries from abundant, cheap iron is good strategy. Unlike nickel -- iron is non-toxic, benign. Iron's the most abundant metal. Not on Earth in pure elemental state, in a sense it's a bit like $H_2$ (a reactive energy carrier, the latter in water, hydrocarbons, carbohydrates). Pure, elemental iron is only found newly arrived from outside our planet, like in meteorites. Once on Earth, iron rapidly corrodes in air: it rusts. The 4th most common element in Earth's crust, it's likely that our planet's core is mostly iron. Being so abundant on Earth, and in our solar system too, one hopes (like $H_2$) to find many uses in energy. So ubiquitous & benign, it has been adopted by life, adapted to for over millions of years. Iron unsurprisingly, is essential to life. It's vital for instance in plants -- making their chlorophyll needed to survive. Animals depend on iron too, for carrying oxygen via hemoglobin in bloodstreams, that makes blood red. Maybe AI can help apply it in newer batteries, with better cathodes/anodes!

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Iron is so basic to our planet's backstory, its likely life was fated to use it abundantly. A star like our Sun burns by fusion. Starting with lightest element, hydrogen -- then it fuses to 2nd lightest helium, releasing both light/heat. Over billions of years of fusing, stars create helium atoms, and then in turn fuse on towards heavier carbon, oxygen, silicon. In supergiant stars, iron is their terminal stage as stars age. Given it's such a stable atom, once a star's core becomes iron, it begins to die (giving life in turn, after death). Reaching terminal iron core, no further energy can be released by fusion -- for it takes up energy. More energy would be required than released, so may go supernova (or brown dwarf in our case). Resulting explosion spews immense iron, oxygen, carbon atoms etc into space. If and when gravity later coalesces the elements in what may become planets, asteroids etc, that iron is easily found.

So iron is, quite literally, everywhere! We see it in Mars' red-tint from iron. Iron deserves our thanks for Earth's vital magnetic core, that molten core gives a magnetic shield protecting life from intense solar radiation that otherwise kills. Miners already are looking at making a new 'green' iron ore for steel. Or in a 'two-fer', maybe using it for batteries too. Maybe new gigawatts of green electrolyzer capacity, with Europe & Asia (not yet a US) leading.

So much is possible. One interesting idea, may be iron-air batteries discharging power as they take in oxygen, making rust. In turn charging by using electricity to change back from rust to metallic iron -- releasing oxygen. On super-abundant benign iron, they may be cheaper & readily recycled. Anyway, recyclability of lithium-ion batteries is an area too where so much progress is needed. Of interest perhaps ahead, zinc-ion batteries resist degrading. Or a zinc anode. If we reverse engineer, Design for X with benign, abundant, low-cost, eco-friendlier materials prioritized, that helps win a storage game especially in big ramp up.

Expect battery technology advances, help from AI. Fundamentally differing from a greenwash that only dresses up carbon, in spiff-names. Beware of greenwash, perpetuating dirty. Please be aware too, some phrases can mislead just a bit. As noted, a lower 'carbon intensity' isn't actually same as actual low-$CO_2$ -- but instead, is based on a rather duplicitous profitability. Or, say strongly-scoring E Pillar 'ESG' number -- doesn't correlate necessarily with low-$CO_2$. An oil & gas producer may 'lower emissions', meaning in its own operations (scope 1) only -- ignoring scope 3 emissions; or it may regard that efficiency as responsibility of buyers. Or 'carbon credits', or 'offsets' game true emissions reductions. For example 2000 to 2008, some 12.4 million offsets were created in 3 dirty projects growing oil extraction(!) -- sold as supposed carbon offsets (that process thankfully no longer can creates credits -- but the ugly offsets still traded). Often artful dodging, like 'net zero', 'sequestration' or 'offsets' coupled with distant promises of 2050 -- that divert from true goals: real decarbonization now.

Lest that disappoint, an optimist might suppose that gaslighting, greenwashing or dissembling, are perhaps last gasps of a waning industry. That fossil interests see writing on the walls. That solar & Wind, vs older fossil fuels -- like faster driving EVs, vs gassers -- arguably can be recognized as a superior technology from start -- and gets better from here! That green has 'won' in one sense, if given enough time. So next decades importantly fill in the blanks. That late this century, if that is in a 'mid-term', perhaps incumbent natural gas no longer can compete with batteries + other storage. That maybe $H_2$ gets nearer to be economic on gas' spikes. Very risky to suppose it, but just maybe, perhaps green $H_2$ *might* viably become cheap, provide industrial heat. As always these are very risky ideas, for the volatile baskets capturing evolving themes. And yet, on climate, $CO_2$ already over 425 ppm, we likely are then too late. Even an innovative-rich 21st century, this scenario misses a carbon-budget ceiling.

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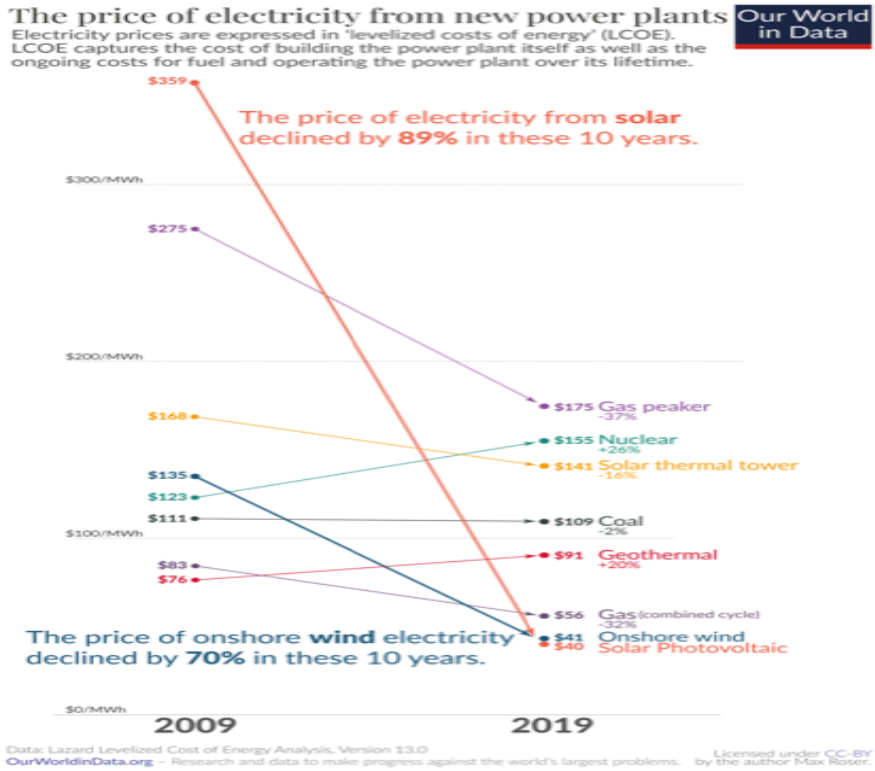
For optimism, consider that long term, PV may wallop traditional dirty energy ahead on costs; PV pricing plummeted 89% in 10 years to 2020, as solar, wind & storage costs dropped hard. Then fell more. Coal/oil by contrast, grew-costlier: they pay for fuel. Fossils are bound to be costly to operate, given their fuel costs -- plus must pollute and are powerless to reduce such folly by much. Unsustainably, too, they've created 87% of global emissions of $CO_2$. Estimates are that their air pollution alone has caused 3.6 million deaths every year. That's 6-fold more than the annual for war deaths, terrorist attacks, and murders combined!!

Coal, the most harmful energy source in 2020 generated 37% of electricity + the most $CO_2$. Natural gas 2nd worse, then made 24% of our electric power, also generating much $CO_2$. Coal's costs were mainly flat last decade, then spiked 2021 in an energy crunch. Meanwhile gas costs dropped sizably in a fracking era, going down low mid-2010s -- shot up 2021 in a gas shortfall (outside US), then fell again. Still any price drops there are dwarfed by renewables; solar costs fell by -89% -- and wind costs were down -70% as seen here from 2009 to 2019:




Source: Roser, Why Did Renewables Become So Cheap So Fast? Our World in Data (Dec. 2020).

Fossils & nuclear a bit poorly-situated 2020s as long-term US electricity paths ahead. They're vexed by eg *Fuel costs, *Wastes (nukes must store for centuries plus!), & *High Operating Costs, hundreds+ of employees for costs that don't decline. And fossils, face $CO_2$. At carbon-free nuclear, each non-standard big new plant costs *much* to build on risky old technology -- opposite of cheap solar/wind/batteries. Smaller nukes can have a firmness, dispatchability going for them, but then renewables with better storage should have that ahead too.

In a coal plant, fuel costs may eat up 40% of operating costs. Natural gas fuel costs declined 7 or so years to 2020; that trend was broken 2021/22, when gas spiked, Natural gas rose far higher in Europe (and Asia). Coal too as carbon trading meant significant new costs.

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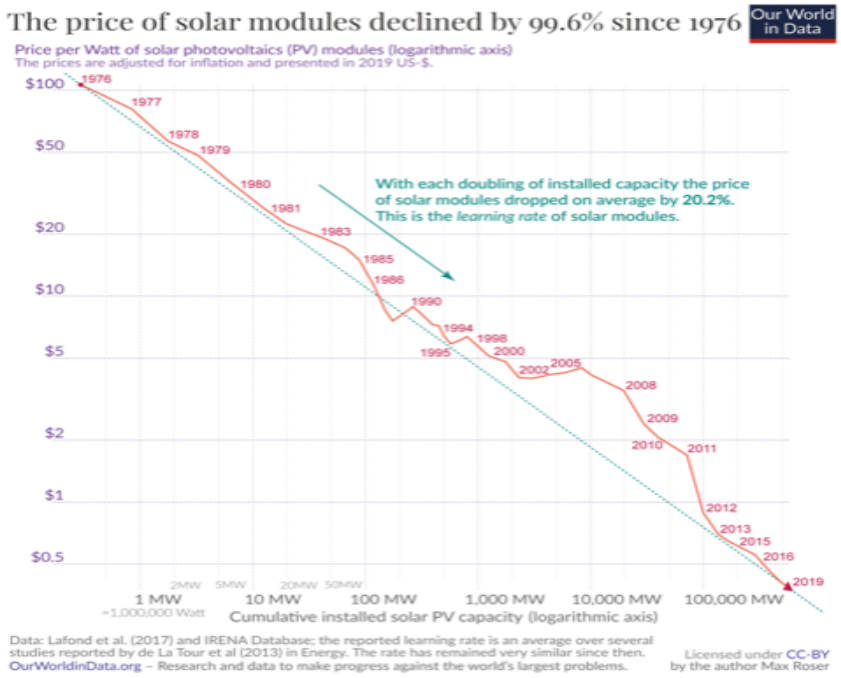
Renewables solar, wind geothermal -- instead will always enjoy *zero fuel costs. Relatively-speaking, *closer to zero* Operating Costs. How horrible for fossil fuels & nuclear to compete with that! Only by amortizing their sunk costs at already-built coal, gas & nukes, can they hope to reduce costs significantly until extant plants age-out. Compare like for like, and new solar/ and wind simply are more affordable on levelized costs/LCOE -- than new dirty.

That Report found 1 early, super-pricey, solar cost-point: in 1956 solar had cost $1,865/per watt(!). So just one 300-watt solar panel today, installed theoretically on rooftop, could have cost $500,000+ at that rate! Of course, unaffordable back then. Applied nonetheless in space applications, solar kept getting better. Prices fell very fast. *So, with solar power, costs are all about Technology*. Like modern chips in computers, we've grown far better at cramming lots of performance in, ever more cheaply. It's a virtuous circle that goes like this, Ever Greater Deployments = Prices Falling More = Newly Competitive; fresh markets open up = so Demand increases again, ever more. Repeat that, over and over and over again!



Source: Roser, Why Did Renewables Become So Cheap So Fast? Our World in Data (Dec. 2020).

Solar prices thus fell enormously -99.6% since 1976(!) on technology. In 2022 US tariffs on PV made in China were temporarily stopped so enters US freer, cheaper still. Fossils -- by contrast -- are Not all about technology; they may be doomed in long-term even apart from carbon. Costs declines in wind too make it impossible for dirty to catch up. How can coal, oil, or gas hope to keep up for decades with this lovely curve? They can't if economics is a metric.

But fossils have immense inertia, influence, capital, and lobbying to keep deploying it. No doubt they will continue -- especially natural gas given it is still dirty, but the least so. Able to provide firm baseload, and can be sourced from stable, friendly nations in the west. Thus not go gently into that good night. Also, carbon-free nuclear has a very notable role yet too in energy transition. In sum, it's no wonder solar & wind power make up most power plants newly built today -- along with growing new storage. In green baskets, storage too is crucial. Consider: how specifically an Index is constructed, the constituents that can fill it, and the substantive direction that it aims for, are as we'll next address -- all very significant.

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Very meaningful are initial choices made by & for an Index. They shape it, and that vision in turn impacts later performance mightily. Passive baskets are informed by/and at a theme's creation. Let's look at a well-known 'FTSE 100'. Based in UK, often 'Footsie', this Financial Times Stock Exchange Index is made of 100 largest blue-chip firms on London Stock Exchange. Bit of a prosperity gauge for UK's economy, it's among a most widely used, short-handed measures for how well Britain's stock market and her firms domiciled there are doing.

Consider then when market value of just 1 US company, Apple, overtook that entire market cap weighted FTSE 100 in late 2020, that was bit of a shocker. Some 40 years since FTSE 100 was created in 1984, some thoughts now come to mind about its vision & construction. To be sure, there's been *some* real growth in that basket's returns over past 4 decades.

But not very much, really. Initially its 100 companies in 1984 had a market value about £100 billion -- with that Index begun at 1,000. By end of January 2021, it stood around 6,400; that annual gain over 37 years was just +5.1% -- or +7.6% annually including net shares issuance. (By Fall of 2023, it stood not greatly higher, at 8,300). This (not so great) return was as No straight climb. As noted in MoneyWeek in 2021, it had peaked in 1999 earlier at 6,930. Later it passed that 2016, next in 2018 at 7,877. But in Jan. 2021 at 6,400, it stood out as only +11% higher than where it had been some 15 years prior. In March 2022 it was at 7,500, up a mere +3% from where it was 5 years prior. It would hit 8,000, in Feb 2023. But a stronger growth rate was seen from 1984 to 2005 when it had had a much better return compound average growth +12.5% (real terms +8.5%). The 2005 through 2020 annual growth rate had been much slower, at only 2% better than the inflation that then was at +4.7%.

This was over a period when US technology & innovation equities, had positively boomed.

What can account for a lugubrious showing by FTSE 100? One factor is that its big components at start had included BP, in oil & gas. Recall how poorly US oil & gas energy companies fared say in S&P500 for years. Terribly, is how they'd acquitted themselves then to late 2020! It's not been BP, per se, but rather maybe partly then was bit about oil & gas in that regard.

As a market cap weighted Index, it *could* auto-adjust for the awful returns in $CO_2$ heavy oil. When once-biggest firms declined, lower prominence, then that could have let faster-growing smaller firms instead take leadership positions. But a problem here has been, that the rest of that Index is literally 100 largest firms, similarly they've been in slower areas too like mining (was 8 names in 2021, but it had been 12), retail, tobacco. Not in innovation or technology. Therefore, it's not been similar to S&P500 (that has added a 1st EV maker). And surely 'ye olde' FTSE is not at all similar to an innovation-heavy US Index like say popular Nasdaq 100.

What was in FTSE 100 in 2021? Royal Dutch Shell was near its top. Of 277 past components in FTSE 100, many were retail, like Boots (health beauty retail), old energy like BOC now part of Linde. Banks, once UK giants in FTSE, faded. British American Tobacco and Imperial both in tobacco – thankfully do not enjoy any great prospects like in technology/innovation.

There's been some names related to health/biotechnology like AstraZeneca. Some in tech like Aveva, Rightmove in web-based real property. But in recent years to say 2024, FTSE 100 returns clearly had lagged far behind Wall Street/US broader Index baskets like a NASDAQ. And while ECO & global NEX crushed FTSE around clean energy gains of 2019/2020, the huge volatility in NEX and ECO also meant they fell well below FTSE in 2021-24 down years.

As pointed out, a part of FTSE 100's issue is an absence of organic growth in its components. Sage plc is in enterprise software, Next plc clothing retail; but much entered 100 by mergers & acquisitions -- not a great long-term ramp for growth. More innovation-heavy Nasdaq 100, Nasdaq Composite -- or S&P500 are different. As seen in MoneyWeek, S&P had 19 technology stocks in 2005 -- when FTSE 100 had but 1. In 2020, more tech names joined FTSE 100. Still, by contrast, US Indexes reflect considerably more tech. The mid caps & small caps FTSE 250 did enjoy some momentum at times vs. a FTSE 100 -- but the FTSE 100 wins about below.

In this chart below, the 1 performer much at top in earlier part of past 5 years to end 2024 -- was an NEX tracker in light blue, ending last -20% down. Mid-cap FTSE 250 in green finishes middle, down about -6% in these 5 years. Above the other 2 much of the time, NEX **tracker** -- after spiking up +175% then crashes and ends below both FTSE variants. What a difference in Volatility! Ending at top, steadiest (Less-techy) and in red, is FTSE 100 up +7%. To be sure tech themes are always very risky: at times they do drop very hard. More Conservative themes may well = less risk. Some periods clean energy tech *may* outperform -- others clearly it is awful. So much so one must be wary of a bubble -- and recall that NEX, like ECO, and like too the also risky volatile H2X & WNX -- can and will at times surely 'drop like a rock':

Past 5 years to end 2024 for steadier FTSE 100, FTSE 250 vs volatile global NEX tracker,

Source:YahooFinance.com

Some ways, FTSE 100 is similar to FTSE 250 -- other ways different. As name implies, latter is top 250 by market cap listed in London. From 1985 to Jan. 2021, it returned a better +8.5%. That had put it ahead of a large cap FTSE 100 that was up too, but @3.6% less per year. Of course that was in hindsight only. It's impossible to say, beforehand, what Indexes, like which companies, will do well ahead. In FTSE 100, big older energy firms in 2021 had made up 9% of it, plus mining/materials 13% -- a hefty 22%. By contrast those 2 old themes were just 5% of a US market basket; 10% of Europe. In the US, tech was 28%, plus healthcare was 14% of S&P500; in a continental Europe-wide Index (ex-UK), they were too 10% & 16%. By contrast those 2 were just 1.3% & 10% in UK. To quote The Economist from 27 Nov. 2021, "The London Stock Exchange (LSE) increasingly looks like a care home for old-economy companies, rather than a cradle for new-economy ones. Less than 2% of the FTSE 100's value is accounted for by tech firms, compared with 40% of the S&P500's." Tastes change; Britain's Statistics Office in 2022 did remove coal, and men's suits from its basket for its consumer price index, and put in (Covid!) antibacterial wipes, and sport bras. In sum, an Index's rules, construction, & goals, like it's definitions can and do vitally shape a theme. They matter hugely. Let's look at a recent past, and maybe possibilities ahead in a world that's fast changing.

**Physics Can Favor Elegant, Clean New Solutions:**

Burning fossil fuels to make electricity, is both extremely inelegant and dirty. Looking at a world as it is and what's needed, can reveal possible better paths ahead. For instance, not yet being sufficiently looked at, is a huge potential in Geothermal. Maybe utilize lithium-rich hot brine both for firm, clean power & also 'lower-carbon lithium'. Ultra-deep, geothermal -- could be done from anyplace on earth! And US big oil names could lead here. For example Salton Sea in California hosts Geothermal resources; it might produce both a firm baseload -- and lithium needed for extraordinary number of EVs to be built in the US. Could mean good new jobs. So, one must ask, Why Not!?? If one looks with a scientific eye, at energy, today -- at how it is harnessed, and how it is put to use, then new ideas reveal themselves.

As green thinking *may* flower. Perhaps like never before. Consider electric vehicles; Carnot's Limit helps explain why electric cars were/are destined to outdo traditional oily cars, 'gassers'. Today's best gassers are inefficient, sadly archaic at best. Diesel fuel or gasoline-burning heat engine cars/trucks only lets them reach silly theoretical bests, just near a 40% efficiency. Typically, car engines are sadly near just 20% efficient(!). Huge, heavy SUVs anchored down by non-torquey gasoline heat engines, are relegated to stay so slow, they may suffer from oft silly model differentiation being like on their number of cupholders.

Unsurprisingly 2020s is seeing outpouring of fresh-faced electric vehicles globally. Equity markets in 2010s, had under-appreciated what new lithium-ion batteries -- lashed to efficient (>90%) torquey AC motors, could do. Next up is better, cheaper batteries after 20+ years of non-linear enhancements. But EVs are also bound near-term to often be too-costly, premium products in the first decades. As a consequence there's often big volatility (down / up too) -- with strong *non*-correlation between EV equity pure plays -- vs. broader markets.

Or, consider, big thermal power plants today. And what Mr. Carnot observed back in 1800s. Today's sad, natural gas turbine plants oft only reach efficiencies in 40%s. 'Cutting-edge' combined cycle gas power plants, bump up against theoretical efficiencies in 60%s. How silly! How ineffective, what a plainly dottery old way of achieving electric power generation! As we'd learned 100 years ago from Mr. Einstein, later in quantum science, flat to increasing entropy (disorder) gives Time -- a second law of thermodynamics -- and Time moves in one direction (centered on basic C, velocity of light). Notable too is time's arrow, and what we've learned in the past (like how to make PV ever-cheaper), generally isn't unlearned.

In work for which Mr. Einstein earned his Nobel Prize, we saw light acts as both wave + particle in discrete quanta; we've learned to harness photons in solar PV better over 50+ years. Researching wavelengths, newer solar panels will enjoy maximum efficiencies higher still, vs. silly old heat engines. And since fuel (sunlight) is free, that doesn't so much matter! On time's arrow, gifted by entropy, we've learned how to harness Mr. Sun's free photon packets, at ever-lower, better, less costs per watt. Unlike fossil fuels, there's learning curve ahead. Profoundly it shall push hard and ever-downwards on solar costs, at times very rapidly.

It goes deeper. For centuries Newtonian Physics seemed to explain 99% of a world around us. We'd built entire industries, societies; fortunes-made around it. Nothing in our human-made world could approach C, velocity of light. And so, its approximations of how the real world actually worked, had served us well enough -- and yet, it was actually really quite wrong. In a metaphor, fossils served us for centuries. We 'learned' and advanced within their limits, on those constraints we still accept today (like accepting pollution, inefficiencies).

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One aspect of we now 'know' about energy, was maybe wrong. That on power plants' costs, we've built them as big-enough -- but never bigger. We'd never build a fossil or a nuke plant way too/'overly big'. Yet like Newtonian physics, what's 'known' can mislead, as Einstein showed. Quantum strangeness, besides Einstein's brilliant equations, weirdly is reality too. To harness ahead say, quantum entanglement like in fast charging EVs in future. Quantum has already led to cell phones, GPS, Lasers, MRI Imaging. Computers will use quantum effects not-known until recently, from 2025. Ahead may lay speedier computing, quantum kernel algorithms. Revolutionary ideas: beyond Einstein-Podoleky-Rosen paradox, 2 entangled particles linked in real-time share information. A recent Nobel Prize was won closing Bell's loopholes. From 2025, new ways to share information via quantum-entangled pairs of photons, quantum teleportation on optical fibers sharing conventional data C-band. We progress as we learn. Einstein built -- not so much Newton – as on James Maxwell's electromagnetic waves, kept constant C/ speed of light. Space is not true vacuum; virtual particles can briefly snap in & out of existence. A wonderful Dr. Richard Feynman's Rules of probability are very weirdly, profoundly deterministic. All fresh tools well-derived from the actual truth.

A point being, in this case, in clean energy, too, we can learn fresh innovations that at first seem strange, yet may be embraced -- given *it's how the world actually works.* A few sacred old ideas may be thrown out, this is progress! Jarring yes but is leverage for how we advance -- including in energy innovation. Especially as we move (one hopes) faster towards truer zero emissions free of $CO_2$ -- truly too No methane, or GHGs, for softer, natural energy paths.

Lashing Li-ion batteries to AC motors for electric cars, is but one recent example. So too ahead, may be novel thinking on solar: oversizing this renewable, may actually save money -- thanks to advanced storage! Feels weirdly brain-spinning to oversize solar farms. Yet just 0.3 per cent of world's land, 450,000 sq km of 150 million sq km, may power the globe. Not far from amount of land used in 2020s by coal, oil & gas infrastructure; those dirty energies use 126,000 sq km. Just 100 miles by 100 miles of solar could power the US. If solar grows super-low cost, 'over-sizing' solar may compensate for needed storage. Oversizing solar -- as fuel is free -- may mean No penalty like over-sizing a nuke, coal or gas plant. Such cheap solar may in time be shared widely via grid, or green $H_2$. Ever over-size a costly nuclear plant? 'Fuggetabouddit'!! A nuke is costly, inflexible, vexed as waste must be stored for centuries -- so that's cul-de-sac of an idea. Makes no sense on current, costly, 'old' 2$^{nd}$ gen nukes.

Intriguingly solar/wind *will* get cheap. And since electricity must be used, as its generated -- we try to avoid oversizing or costly 'curtailment' (shutting renewables off); yet wasted 'extra' wind power had 'cost' UK consumers GBP 806 million (USD 1Bn, EUR 942m) in 2020/21; 82% of 'excess' wind in Scotland. In 2022, curtailment in Spain jumped to 715 GWh, from 67 GWh year before 'costing' 1.1 billion Euros. First part of 2024, California had to shut off 2.6 million kilowatt hours solar; its renewables went beyond demand some part of day, near 100 days into the year. But, add a long-duration storage, or green $H_2$: that may avoid overcapacity, brown electrons. If abundant renewable electricity maybe becomes very, very low-cost.

Apart from such ivory-tower academic musings, let's soon return to finance, stock markets, applied capital & decarbonizing in climate crisis. Where solar/wind despite green credentials, like much else new, has fallen in markets – and suffers too from unneeded, undesirable, emotionally-trying applied setbacks. We'll touch on an emotionally-fraught troubling notion next, one wholly unnecessary and shocking of late. This is possibility of acutely-unwanted, not needed, maybe forced labor for making solar etc in a unique region.

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This issue is allegations of forced labor in Xinjiang Uyghur Autonomous Region, northwestern China. Xinjiang does much silicon manufacturing: for polysilicon (poly) in solar PV worldwide. As poly prices plummeted for years to be cheap commodity; 3/4s of 2021 global PV polysilicon was from China. Of that, > ½ in 2020 was from Xinjiang. In 2021 there was not clear evidence of forced labor in silicon manufacturing. But on grave allegations it must be looked at very seriously, and there was a US legislative response. Several companies were listed in a 2021 report as having Xinjiang-regional content. A couple used poly that was widely in US and in global products – and seen in active/passive funds. One in 2021, was in some 135 mutual funds; another in 165 mutual funds. Again, the mere possibility warrants serious attention. What's tough is there'd been so far then, no independent confirmation. Solar companies all strongly denied a connection to it. And there's surely No need for forced labor, anywhere. In response a US Solar Energy Industries Assn. sought 2021/2022 to ensure no forced labor in any part of the solar chain. Stronger protocols for ensuring Zero forced labor.

Nonetheless 1 firm was downgraded 2021 to Neutral rating on possibility. Again, no evidence, but without clarity, US and others can & did act on the gravity. 2 solar firms did emphatically condemn forced labor, said don't use it in their factories, is "morally repugnant", that they have "zero-tolerance" for forced labor in Xinjiang or factories across supply chain. While the US did not at first call out specific Xinjiang manufacturers, possibly-abusive labor had raised warning flags. Just a possibility of such labor, has got to be of great concern. By early 2020s solar PV was being withheld from release at US border; several named firms were then called out specifically in varied industries, https://www.dhs.gov/uflpa-entity-list

New rebuttable presumption language 'guilty until proven innocent' was passed into US law 2021 in UFLPA (Uyghur Forced Labor Prevention Act) -- but with long lead time to prove an Absence of forced labor. Allowed say traceability protocols, or moving to source materials all outside Uyghur region. In a less-thorny transparency matter, the US named companies non-compliant with a 2020 Holding Foreign Companies Accountable Act (HFCCA); they could face US delisting ahead -- if their auditors aren't subject to inspection by the US Public Company Accounting Oversight Board (PCAOB), https://www.sec.gov/hfcaa The US brought on-site inspectors to China for on the ground inspections, investigations on whether mainland China/ Hong Kong firms provide requested, timely, unredacted documentation to PCAOB via its CSRC. Discussions were started aiming for China/US Agreement to resolve this topic and avert delistings in future, see eg, https://crsreports.congress.gov/product/pdf/IF/IF12212

In conclusion, a burden is on Xinjiang-based materials: solar, wind, quartz, textiles etc etc to prove Absence of forced labor. Plus, companies may be removed, others not added to themes -- on a possibility of forced labor; indications can lead to removal. It is an unnecessary risk, one to be watched closely, with moral implications. Xinjiang products now have that burden to prove No Forced Labor in supply chains; some firms may opt to relocate away from that coal-powered region. Traceability services, 3rd party Independent Audit Verifications may arise -- as GWs of solar PV were kept from entering US on UFLPA. Europe is looking into this as well. Separately, China's Auditors subject to inspection -- or may lose access to US capital markets under HFCAA, https://www.sec.gov/hfcaa In sum forced labor mustn't ever seep into supply chains, anywhere. Looking ahead one coming issue is transparency; also ending-*all-coal-use* in manufacturing; decarbonizing upstream manufacturing, everywhere. Green circular manufacturing has begun of late, as seen for instance in the Nordics. Yet even they've had to look at places where electricity is the most cheap available, and all costs less.
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Much lately is changing -- yet trends are about the same. At very start of 2020s, nine of every ten PV panels, was made in Asia, the planet's biggest PV factory 2020 was in Anhui, China; its capacity 60 GW modules per year, going up in 4 phases. Yet from a separate, independent view of what's needed, to bring down global $CO_2$ emissions fast, that scale was only a start. Still wildly small, if 60% of globe's electricity demand must soon be met by solar alone. Only a couple years later, 1st half of 2020s many nations had reacted to its 'monopoly' and were taking action via tariffs etc, to counteract China's dominance across clean energy: in solar, batteries, lithium, strategic minerals, processing etc -- along lately in EVs too.

China's enormous growth appetite did not abate. Towards early/mid-2020s, world's biggest PV manufacturer -- based in China of course -- was 120 GW in size. Put aside a moment *where* that PV was/is made, or by whom – so the politics -- and PV global growth saw installation capacity go to 600 GW added in 2024. China alone, was about 330 GW or some 56%. May seem a lot -- yet such increases in global PV installed capacity on climate were too slow. On that rather 'meh' rate, simply takes too many decades to get to 60% of electricity from solar.

Given where we could/should be on $CO_2$ & climate, war & energy security too in 2020s -- solar must even faster become very, very cheap energy. Wind too. So arguably, we'll need Policy to encourage that ramping even faster. It's a hand $CO_2$ forced on us all. With carbon levels already over 425 ppm there's nowhere near enough installed manufacturing capacity to ramp solar, & wind fast enough. Hence a need to speed matters. China has the most installed solar energy by far; European Union 2nd and growing; and US was a sad poor third. As emphasized, none of these in the mid-2020s were yet anywhere near where they needed to be.

Or think wind, where Europe has led. And wind power is a crucial compliment to solar. Texas is a big State, good-sized amounts of wind generation, though it was not (yet) a new energy Innovation Incubator for wind tech. In oil & gas, Yes! such as with its shale fracking tech. But a Texas that's open to some green innovations -- with its fewer regulations/ more flexibility -- is not leading-edge in wind tech. Though vulnerable on climate, Texas' grid intentionally lacks too US interconnections, was left antiquated to avoid unwanted federal action.

Or seen per capita, outside Texas demand for wind is rising fast/er in America's Midwest. In 2022, Iowa at the heart of the US (and an EV hub a century ago) had made 60% of its power from wind; in 2024 that rose to 65%; was not hard to envision conservative Iowa 100% by 2030! It's generating more electricity by wind -- than any other source. Conservative Kansas was then near 50%. Oklahoma made over >30% of its power by wind in 2022, like more Liberal states Colorado, New Mexico, Nevada, Vermont. Offshore wind might/should come to Great Lakes, US Gulf coast, West US coast: all maybe offshore wind powerhouses ahead.

Or, to focus on rather recent solar in Europe, consider a 2020 Report (so pre-war in Ukraine) from Solar Power Europe and LUT University on: "100% Renewable Europe: How to Make Europe's Energy System Climate-Neutral Before 2050" (2020). https://www.solarpowereurope.org/wp-content/uploads/2020/05/SolarPower-Europe-LUT_100-percent-Renewable-Europe_Summary-for-Policymakers_mr.pdf

They make some major observations there, with notable conclusions. Startling observations include that to move fast/and soon, will cost less than moving slowly. That relying on solar & wind to power Europe, is now feasible. Think for a moment what a BIG change that is.

Almost every sentence in their initial paragraph, next, was unimaginable a decade ago:

*"It's possible for the EU to become fully climate neutral by 2040, complying with the ambitious 1,5 C Paris Climate Target, and without any tricks, like carbon sinks, but just by going 100% renewable. ….*

*… Solar PV and wind represent the two main pillars of the energy transition, supplying over 90% of power demand in the long run. …*

*Clearly the transition to a climate-neutral energy system comes at a cost; however, perhaps surprisingly, moving slowly does not make it any less costly. The most cost-effective way of achieving climate neutrality by 2050 is a 100% renewable energy system. According to the modelling in this study, total cost of achieving 100% by 2050 is 6% lower than the cost of inadequate action in the less ambitious … scenario, which only reaches 62% renewables by 2050, thus missing both the targets of the European Green Deal and the Paris Agreement.*

Many points above challenge the conventional wisdom, so are worth unpacking. Start with the idea moving *more quickly* to decarbonize, will cost *Less* than status-quo incremental adds of solar & wind. In part thanks to renewables getting cheaper, their 'Leaders' scenario shows greenhouse emissions can fall 60% from 1990 base to 2030 (in then 10 years) -- reaching zero by 2040. All a decade ahead of 2050. By contrast, more conventional wisdom would have seen Europe reaching only 53% emissions cuts by 2030. And note this Solar Power Report assumes No (current generation) nuclear, not due to its risks but rather due to its higher costs.

Their Report recommends policymakers begin immediately creating a framework targeting installed 7 TW of solar power -- plus 1.7 TW of wind as well to be reached before 2040. That assumes 2 factors: starting an upswing soon as possible -- and grow PV manufacturing abilities fast. With $CO_2$ a pressing issue, we may need to build 100 factories worldwide, each one capable of making 60 GW PV like factories going up mid-2020s in China. Ramping to around 7 TW extant solar in 2040. This is theoretically possible -- but dubious as we're mid-2020s -- and on antipathy to China having *more* control of PV, it is unlikely. Raw materials can ramp. We also find ways to make PV more cheaply, efficiently. The US in World War II had ramped weapons & materiel productivity like never before. Only now, this time, it's the world coming to our own rescue. $CO_2$ had been rising fast at a rate of 1 ppm/year at a first Earth Day. Lately scarily, it was rising up by 2.5+ ppm/year. That number's only growing, accelerating.

2 scenarios presented were of a *Moderate approach -- and a *Leadership one that's quicker. Former meets only the 2 degrees C heating goal of Paris. Latter meets a more robust, better 1.5 degrees C goal. Again, it's a matter of when this ramp begins, so angle of departure. And as noted we are soon (already?) exceeding a Paris Agreement dream of 1.5 degrees C max heating. But interestingly, stronger & sooner the action, the more $$ is saved over time!

Moderate path doesn't achieve 100% renewables 'til 2050. By contrast Leadership path gets to 100%, 10 years sooner, by 2040. Better to move fast. Under it, Southern Europe makes vast amounts of solar power: in Spain, Italy, & Eastwards. As Northern & Western European regions mainly use their wind, natural resources of Denmark, Norway, Sweden, Finland, etc. Similar approaches taken in both Moderate and Leadership scenarios, just differing rates. Seminally, Europe does have enough renewables potential to meet entire needs by 2040. Electrification of everything. About 63% solar, 30% wind on a Leadership path. As for costs, stronger Moderate path costs *less* over time -- than a Laggard approach. Meanwhile a Leadership path starts harder, sooner, and beats Moderate path. Unlike the child's game of rock, paper, scissors -- in this Policy Framework there's a clear winner: start now, go very hard, very fast.
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**Why a Major Oil Crash Happened in 2020 -- followed by Oil Spike After**

2024 the US was producing more oil, 13.3 million barrels/day, than any country in history! Oil then fetched high-ish 'healthy' price for producers, near $75/barrel. But wasn't always so. Let's look back, intriguingly, to 2020, to a remarkable world oil crash. Some called that crash illogical, yet it arguably unfolded with explainable logic of its own. 4 years prior, it began as oil *Demand* collapsed at onslaught of Covid early 2020. Businesses froze globally. Quickly, surplus oil began backing up worldwide, we'd forecast it here in Q1 2020 Report. That Demand Destruction swiftly grew so large, where to store all the 'excess' oil was a real question -- especially as oil 'prices' in an artificial sense, unsurprisingly soon went briefly negative.

At start of 2020 the world was producing 100 million barrels/day, so-matching needs. Demand & production were expected to (only) grow. Indeed, in only 2 of a prior 35 years had demand for oil to then dipped -- only a brief bit. Yet suddenly from March 2020, monster demand collapse from Covid loomed large; perhaps down -25% or more. Normally on slight slackening in demand for whatever reason, supply can be slightly curtailed. Excess stored, mopped up. But instead Saudi Arabia & Russia had *ramped* production up, wrestling for market control. On an important day March 9th, crude prices plummeted -30%: greatest one-day 'fall off cliff' in oil of roughly past 30 years. In March, US benchmark West Texas Intermediate (WTI) crude fell -60%, for an historic drop, from $60 down to $20. One big factor was Saudi/Russia ramp; also *Demand was* dropping tremendously by -25% or more as world economies gummed up.

A fear then, was by Ides of March 2020, America's crude price might yet drop even under $20/ barrel, absent intervention. There might then be 1.8 billion surplus barrels of crude, yet 'only' 1.6 billion of tanks storage capacity. Oil <$50 vexes, under $30 threatens America's oil industry, both shale & conventional. Producers from tiny to huge are a diverse lot, yet all felt pain. Texas in 2020 had 174,000 wells of most any imaginable kind -- some so curious as to be hard to believe. Latter Q1 2020, the White House embarked on unusual path for any American President. It tried to rally nations to *raise* crude prices. A hope among many in industry was to get prices up above $30, a bare floor for many. Particularly, indebted shale producers. Oil near just $20 was maybe going lower on demand destruction. It could go briefly (in markets) near zero in theory maybe on volatile futures contracts trading. Storage was filling, nearer 'tank tops' and so fixes were badly needed as a bridge until activity bounces back.

E.g. May 2020 front-month WTI contracts would expire late-April. So, if a -25% less demand was not met by production cuts, fears grew of 'tank tops' as in landlocked Cushing, Oklahoma. May contracts would need to be unwound fast, by traders with neither a desire, nor capacity to take crude delivery; it pushed front-end WTI oil briefly under zero, some -$37 by April 20th. That brief (artificial) move in finance, wasn't really a great surprise! Not too much should be read into such an 'artificial' -$37 close. Contracts many months out were less distorted. But WTI oil near $20, showed US/global oil markets in distress. Even a better global benchmark, the costlier North Sea Brent crude briefly dropped down near $20 by late April. Not near zero, yet oil @$20 meant production cuts worldwide. Perhaps 1 million oil patch jobs lost, expertise may potentially disappear. Rig counts may fast drop, wells shut-in, bankruptcies -- some wells perhaps might not be (expensively) re-started. Maybe forcing some US shale producers to shut in, pain perhaps was an initial aim, like 2015. But this time, oil's ramp in supply began, just before pandemic's demand destruction. That, on Covid, made disorderly consequences greater than was initially expected. Come 2024, oil again would be in a 'desired' $60s-$90s -- with US then biggest oil producer in the world! But that all of course was unknown to oil industry, back in a panicky 2020/2021. And later from 2025, a question was if US production increases, & maybe tariffs/trade wars, could again impact oil prices in big ways.

A 2014-16 a strategy to open spigots to stifle competition, had failed then in a thriving oil-hungry world; impacts were muted. Oil did drop to $50 briefly. Yet excess was absorbed. Was not enough fall to kill-off new American shale; shale reserves can fast bounce-back, putting something of a high upper cap on prices producers fetch. Their playbook may have been that in a world awash in oil, in 2020, only lowest-cost conventional producers could survive. Later on, raise prices, post-shale bankruptcies. It's long said the cure for cheap oil, is cheap oil -- as is seen again & again. More market-share re-captured by those lifting oil the most cheaply -- by conventional means. If competing shale capacity is gutted, 'too-low' prices of $20-$30 might disappear. Very unlike clean energy where lower prices can go lower & lower, without a floor of oil. Also unlike clean energy; oil's choke points can hit oil hard eg Strait of Hormuz as ~25% of all oil trade passes via it; or Strait of Malaga as about 75% of China's energy imports pass through it; Suez Canal, or Bab El-Mandeb strait; or Taiwan Strait as obvious geopolitical threat, or a Panama Canal that's facing drought so low water levels on climate risk.

Thus in 2020 on pandemic + on tank tops, oil went under <$20. Quickly reviving economies & getting oil demand back, was essential. Oil-rich nations may ideally want crude prices nearer $80 - $110. To let them better balance their own books, their national budgets. But, regaining firm demand came first. Proposed conventional oil projects were anyways often uneconomic, without oil at least >$50. Plus, for some nations it's vital to realize, pump crude while richly valued. Vast underground reserves held too long, look increasingly like maybe stranded assets one day. As such they may be wary of sharply diminishing value on CO2 / climate concerns -- or electrification. Ascent of electric vehicles or changed economics. Meanwhile, US oil firms that might want oil prices around -$80, would soon face big production ramps from 2025.

Globally back then industry faced pressing fears in Spring 2020: Of Inland wells for instance without a Port or storage nearby, nor distribution pipelines -- so having to sell excess crude at unthinkably low-prices. Lacking close off-takers might mean dreaded tank tops. In Canada for instance, inland wells far from its ports were lifting heavy crude that's then hard to move; suddenly, mounting product upended all, raised fears of runaway cratering. Vast demand destruction further benighted industry's evaporating storage, changing everything. This was the 'logic' behind the oil industry's (real) fears and crisis back then in Spring 2020.

So, April 2020, OPEC+ with Russia, agreed to production cuts of 10 million barrels/day. With 25 or 30 million barrels of demand gone -- the cuts could have been more. Saudis in agreeing to cuts understandably felt fellow producers should do so too, reducing their own production. And Russia, understandably felt US by only 'organically' cutting -- that is, just producing less on low prices -- rather than cutting capacity, was as different as width can be from length. Given global demand was so much lower, the situation was vexing for oil everywhere.

But the U.S. can't cut production by diktat. Anti-cartel laws mean apart from say, a Texas Railroad Commission (rather like a mini-OPEC, since long before OPEC) ordering rare cuts in proration, it's not an option. So, with wink and nod, Saudi & Russia agreed to 10 million cut. Even that unprecedented big move was just a (necessary) patch-up fix. Yet it made headlines. Concerns held by some technical oil-watchers, was it was 2x smaller than hoped-for. And didn't start until May 2020 -- so made possible the April 2020 scenario when lower-grade crude went narrowly, briefly cost-negative, at less than zero. Even at desirable light sweet crude, cuts of 10 million barrels/day did Not match up exactly to ~25 million barrels/day suddenly no longer needed. But, it was hoped demand would rebound hard in 2021. And WTI Index due to landlocked Cushing fears, proved not as 'useful' as the Index for Brent Sea Crude (that stayed positive with $20 bottom then) -- or even Oil Indexes like in the UAE.

It was about getting past an immediate crisis, re-starting oil demand in 2021. Crude might then rise organically -- on demand rebirth or even inevitable heat waves or cold snaps stoking demand. Free markets are how the US and its prices work, rather than by fiat, so paths were envisioned to stimulate rebound. If US States soon re-opened. If Covid is increasingly endemic more like seasonal virus even if immunity is conferred only for one flu season, if effective vaccines arrive, or better yet, if robust vaccines for Covid ably can treat new variants too, there were thus hopes for some return to demand rebound towards normalcy.

A fascinating side effect of plunging oil was that old-school coal -- long the cheapest energy although still dirtiest -- briefly in 2020 became relatively costly. Fracking pushed down natural gas / oil prices strongly. Natural gas, at -90% cheaper, became in 2020 very attractive for making power. Unsurprisingly and one after another, US coal-fired power plants closed.

Thus, when benchmark Brent crude fell Q1 2020 to $26/barrel, with Australian coal at $57/metric ton or roughly equivalent by analysis to like $27 oil, broadly-speaking, crude oil was cheaper than coal. True: coal/oil don't directly compete. Thermal coal is burned in power plants -- unlike crude used for gasoline, heavy oil for asphalt etc. Levelized costs (+ fuel) for solar & wind had fallen too, so they were relatively attractive -- vs old coal. In sum, dirty energy was briefly getting both much less desirable, and relatively more-costly.

It wouldn't last. Surest path to oil rebounding in 2021 would be if economies revived, demand returned. Production cuts could linger, eat up slack. Oil's crash had uncomfortably gotten near upending more in an oil patch. Key hub Cushing's 4 huge tanks nervously grown full-ish. Pipelines to forward crude had slowed to closer like storage that could have meant a kind of oil constipation, backed-up to producer. Had 5,500 miles of pipes for refined product from Gulf Coast to mid-Atlantic stopped accepting gasoline, no contracted-off-taker, a fascinating and scary April 2020 might have yielded a much different 2021. It didn't: for as many in the oil patch had fervently hoped, oil demand rebounded latter 2020. On fast-reviving economies, and production cuts by OPEC+ largely complied with (Iran pumped freely). So, a 2020 that had begun with oil tops on lips, gave way to a 2021 with tops largely unnoticed. Then to war in 2022, demand surged -- or at least, prior oil/gas surpluses no longer any concern.

2022 was much changed: oil, especially gas went new directions. Russia shut supply, changing a great deal. Before, renewables were rather unaffected by oil & gas. But with oil/gas pricey, growing clean energy/storage/even $H_2$ was an aim. Storing small amounts of electricity had been simple if little's needed; push water high, release it as power's needed; plus some batteries. But early 2020s looked different. Vastly more was needed, so far more batteries, infrastructure for innovative storage, grid etc. For immense scale of what's sought, consider Texas. In 2019 it had just 5.5 GW of solar that met only 1.35% of State electricity demand, wind power met healthier 17.5%. Its 5.5 GW of solar 2019 was a start. Were Texas a nation, that PV would have ranked 5$^{th}$ - after China (30 GW), EU (16 GW), all US (13.3 GW), Japan (7 GW) -- ahead of say Vietnam at 4.8 GW of PV in 2019. By 2022 Texas' wind + solar was over >35% of its needed power at 27 GW, and it was growing faster yet in the mid-2020s.

But the US like all others, are nowhere near a finish line. Very generally, one could think of US needs ahead as being like seeing 20x the renewables capacity that had been extant in the early 2020s. More too is needed for industrial processes, like green heat in steel & cement. Tremendous increases in solar capacity plus new wind capacity. A big, say 1,300 MW (1.3 GW) Texas solar farm that went online in 2023 was just a start. Far more energy storage needed too from scratch. Enormous new needs, that aren't readily measured even 'x-fold'.

## Consider $CO_2$: A Topic Gaining Importance

For 20+ years our emphasis in the Clean Energy Index® Reports has been on *Solutions*. Not $CO_2$ -- nor climate *per se* -- but rather solar, wind, EVs, storage, etc as ecologically & economically smarter paths. Climate's been a big driver, yes -- but $CO_2$ wasn't core theme in Index Reports. Lately however global heating, weather extremes are coming in worse than what models have foreseen. In short, $CO_2$ may become even an existential risk, so let's address it directly.

For just one sample of this remarkable science here, a 2020 article in Proceedings of National Academy of Sciences warned that in a span of just "coming 50 years, 1 to 3 billion people are projected to be left outside climate conditions that have served humanity well over the past 6,000 years." On trends and in particular $CO_2$ & population changes, a narrow temperature niche our species has long required is projected to change more in just a next 50 years, than in a past six millennia! See Chi Xu, Timothy Kohler et al, *Future of the Human Climate Niche*. PNAS (4 May 2020). https://www.pnas.org/content/early/2020/04/28/1910114117

We give increasing pages here to climate & to $CO_2$ in clean energy's story. To decarbonizing, if in an ugly term 'Environmental, Social & Governance/ESG' (just 'E'). First here note: $CO_2$ has long been a hero to our species -- in moderation. Earth without $CO_2$ might have had near 0 C surface temps. Instead, it's warmth thanks to $CO_2$ in tiny concentrations under 300 ppm, long meant that greenhouse gases naturally gifted us average temperatures near ideal for us, 58 degrees F. We'd habituated ourselves to thrive in that 'cool' for over 10 thousand years.

Late 1950s regular $CO_2$ monitoring began and modern readings were already up from what had long been near 280 PPM. Say, to 315 PPM. By 1988, scientists became alarmed as planetary warming due to increases in $CO_2$ reached 350 ppm. Worriedly, a world conference held in that year called for reducing from that very high 350 figure, downwards by -20%, by 2005.

By 1992, a global compact was reached. Signed in Rio, a UN Framework Convention on Climate Change lacked specific cuts. Looking back, nebulous agreement to try to act was real failure -- was nowhere close to task. $CO_2$ continued rising sharply. For Rio had only *implied cuts,* like calling for global emissions to be -20% lower in 2005. Instead, $CO_2$ as it turned out only grew -- going +34% *higher by 2005*. Looking back, it went on rising, another +22% higher in 2017 -- to over 425 ppm in mid-2020s. That's higher than in at least a last 3 million years. Maybe the highest in last 12 million years. So mere aspirational words absent robust action, has woefully not achieved what's been needed on decarbonization for reducing grave climate risk.

Yes, more specific 'cuts' were laid out 5 years after in a 1997 Kyoto Agreement on climate. Yet $CO_2$ went on rising, more sharply. Been a mockery of $CO_2$ action. International agreements were again tried in 2009, but that Copenhagen event failed. $CO_2$ levels continued increasing, temperatures spiking. A 2015 Paris Agreement was roughly more of the same. $CO_2$ still a fast uphill scary climb. By 2020, only 3 countries had met early Paris terms: the Marshall Islands, Suriname, & Norway which made up only 0.1% of emissions globally. In short theirs is still No cause for optimism. A gathering in Glasgow 2021 meant to take stock, speed progress -- failed. Truth is despite flowery words, there's been woefully little action. In sum commitment Isn't there. That's why it's arguably going to be crucial to see *clean energy (*unsubsidized?!)* soon is cheaper than fossil fuels; *that there is some recognition of science; and *an acceptance that decarbonizing away from fossils -- to clean paths while also creating wealth/ new jobs -- is hardly a radical path. Instead, it seems sanest approach to our common future.

There's bits of optimism re: progress of late. Near-term to 2100s, intercomparisons of 56 climate models indicated some most awful possibilities, *may* be less likely. Barring say, feedbacks like of methane, clathrates, water vapor, permafrost, & hoping for no other mal-contributions, then models' of scariest ~9 degrees F by 2100s *may be* less likely on recent understanding. (Less than 9 F from here, as there's been warming to mid-2020s). Those models assumed higher fertility rates, widespread coal, failure on renewables; things aren't that bad. Such models may be realistic, but worst-case predictions of an unlivable 9 degrees F warming so soon, hopefully very unlikely. On the other, hand, studies in 2021 showed that eg, carbonate/limestone permafrost in Siberia if thawed, may potentially yield enormous methane, via fractures. Methane can be *even more climate forcing*, in the near-term.

If we regard a-highest end, Representative Concentration Pathway (RCP) 8.5 unlikely, heavy $CO_2$ emissions in that band improbable -- then we should also regard lowest RCP 2.6 too mas unrealistic. It assumes a widespread embrace of renewables already far greater than seen, and No use of coal (ha ha). Neither, especially latter, was close to accurate in mid-2020s.

*Yet, lower-end of that wide, heavy-emissions RCP 8.5 band, seems scarily still feasible*. It foresees, arguably, a catastrophic rise near 7 degrees F as possible, as soon as 2100s. Even 'lower-end' RCP 8.5 possibilities ought concern nations & leaders, greatly. RCP 8.5 is one factor in predictions of massive loss of the inhabitable human climate niche by the 2100s.

A next 'lower' RCP 6.0 seems rather closer to where we're trending -- on today's present (in)action. It foresees roughly near 5 ½ degrees F warming by 2100s. Under it, global emissions peak some 60 years out, in 2080s or so, then decline. ($CO_2$ in atmosphere rises, stays high, drops only slowly as it accumulates). Coal plants would be built in Asia as they are -- but soon may be regarded as things of the past in RCP 6.0. Electric car adoptions do accelerate.

It assumes a $CO_2$ equivalent to about 850 ppm, or about 2x now. For data nerds like ourselves, this translates to radiative forcing of 6.0 $Wm^2$ post 2100, or 6 watts/square meter in RCP 6.0. (RCP 8.5 translates to 8.5 $Wm^2$). This reflects incoming solar energy -- pushed far out of balance in our altered Earth-atmosphere system. Consequences of that, may go on as dire for our species *over centuries, millennia* ahead, yet seems about what one might 'hope for'.

Next, very, very ambitious, is a hoped-for RCP 4.5: emissions peaked in ~20 years to 2040s, then fall fast. $CO_2$ not long ago was stable at 280, now 425 & rising fast, rises in this view to 'just' some 650 ppm -- unlikely and has it then stopping/peaking there. Much decarbonizing is assumed to have been undertaken (far more than now planned), $CO_2$ in time dropping. That *may* be possible, although it's a huge stretch. And arguably highly unlikely, on $CO_2$ already some 50% greater than near 280 ppm pre-industrial, rising fast. The 4.5 is very improbable, as hundreds of coal plants are *being built now* in 2020s, each with a life of 20 years or more. Hence operations going into 2040s and after, unless they are prematurely shuttered.

With renewables making only some 25% of electricity in many places though growing; coal burning widely including in industry; cars using oil -- ambitious RCP 4.5 with 'only' horrid 2.7 C or 4.9 F of heating is perhaps an unlikely bet. Worse, is likely. That said 'unexpectedly' seeing ice sheets destabilize, heatwaves, floods, tornadoes, drought etc, *may* catalyze action. Sudden, scary events may yet hasten faster action on climate. Models too inevitably getting more complex. Until recently they'd ignored say, ice sheet destabilization. But if a big pulse of melting occurs, change visibly underway, skeptics melt away too. Especially since clean energy is fast becoming *the most economical choice*, while creating jobs to boot.

**A Decarbonized Power Grid by 2040, Climate Neutral World by 2080**

Imagine a few years hence. Europe & US on low-cost solar (though much of it made in Asia), wind & vast new energy storage efforts etc, 1st reach 100% net carbon free power by 2035. Much of world later got there ~2050. Electric vehicles have scaled faster than expected! Green $H_2$ came to industry, richer nations grew climate neutral by 2060. China on much new nuclear got there by 2070, meeting targets. Rest of world by 2080, though with much fudging like on 'sequestration' claims, and on hopes that the Earth still has thriving 'natural sinks'.

That moderately ambitious timeline, is absolutely do-able. Unfortunately, the science also implies that on inertia in $CO_2$ -- this scenario destroys the global low-lying megacities due to sea-level rise, climate crisis. It blew right past 2 C Paris goal (say nothing of maybe in-2020s-dead 1.5 C aspirations) -- and it put us unbearably on to 5 C, even 6+ C degrees hotter.

That's not alarmist. It's just where science dispassionately points us. Maybe unbearably hot -- growing hotter. Many centuries of sea level rise. It's possible that rise in just a few centuries destroys Florida, New York City, DC. Inundates much of US Eastern seaboard, the US Gulf Coast, parts of US West Coast. While indigenous peoples had long predated in today's City of St. Augustine in Florida -- if one considers it 'founded' in 1565, or 450 years ago -- then we're likely nearer end of that first US City, than to its birth. Nearer to deaths of Miami, Florida, or New York City, or New Orleans etc etc -- none having another 400 more years ahead.

Imagine just ~70 years hence. Note then, that projections by an Intergovernmental Panel on Climate Change (IPCC) for sea level rise in year 2100, may misleading. For end of century rise may be unwinding then at far more rapid accelerating rates, than what was projected by IPCC. Getting that so wrong, has meant that lax policy today allows for too much $CO_2$, methane, inertial heat to build unduly. Which can then neither be halted, nor unwound.

The idea that actual sea levels in 2100, could be greater than IPCC projections is well laid out in 2020 piece, 'Twenty-first century sea-level rise could exceed IPCC projections for strong-warming futures' by M. Siegert et al., One Earth (Dec. 18, 2020). Their first paragraph nicely lays out cogently clearly big ideas that scientists may now find mainstream -- yet these same thoughts should be viewed by the public, policymakers and politicians with alarm:

> Since around 1850, the concentration of atmospheric CO2 has risen from ~280 to over 415 parts per million (ppm), resulting in a global mean temperature rise of ~0.9 C -- 1.2 C. Even if human-caused emissions are reduced to net zero by 2050, global temperatures may rise to more than 1.5 C above their pre-1850 levels. Global CO2 emissions are still on the rise, however albeit with a slight coronavirus disease (COVID-19) dip, and analyses of current policies suggest that greenhouse gas emissions will continue on an upward trajectory over the coming decades. This keeps strong warming futures, which exceed 4 C by the end of the century and continued warming thereafter, well within the realm of the possible.

Wow, near-term, end of century could possibly be 4 C hotter than today. On strong warming, the seas in 2100 may be quite higher than the usually accepted IPCC range of 0.61m -1.10m, what the public thinks of as roughly 1-3 feet of rise. In particular upper end projections are unduly taken by policymakers as maxing about 1.1 meters (3 feet) higher in ~70 years to 2100 -- and yet that's in fact **not a** true ceiling at all. Moreover they could be rising then fast.

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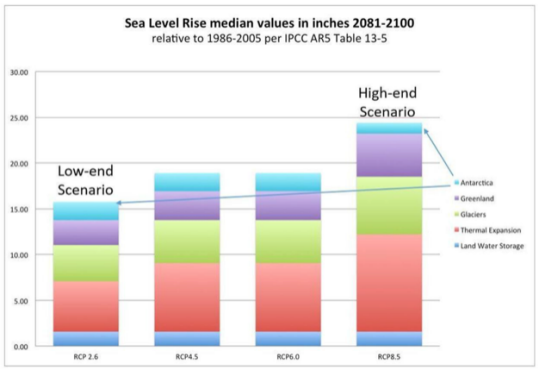
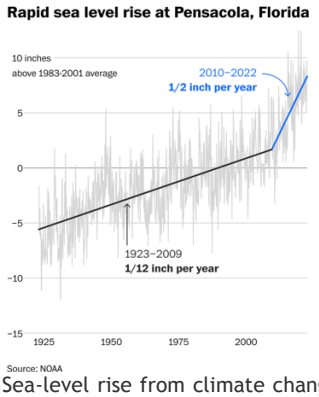
Uncertainty now cloaks Antarctica's immense dynamics. Computer models may thus exclude mechanisms -- if the machinations are hazy. Shorn of major details, these data suggest global rise may go *well over* 1.1 meters at 2100, above 3 ft. Difficulty modeling ice/glacier dynamics in short, potentially has left out Antarctic contributions. It removed complex & cascading effects. Especially in higher heat scenarios where we're trending. IPCC's higher-end curiously indicated *least* rise from Antarctica, even RCP8.5, high heat scenario in IPCC AR5 (at left). A 2024 piece in Science by Judd, Tierney imply greater climate sensitivity -- than has been modelled. Here's a Gulf of Mexico 10 mm/year from 2010-2022 in Pensacola, Florida:




Source for chart at left: J. Englander. See also, J. Berandelli, 'Sea-level rise from climate change could exceed the high-end projections, scientists warn'. CBS News. Dec. 23, 2020. Chart at right for sudden rise of 10 mm/year 2010 -2022: NOAA 2023.

Next few centuries have to be deeply concerning. Scientists understand a crucial fraction of airborne carbon already emitted in the industrial revolution, plus this century and likely next, can persist for thousands of years. In short, the $CO_2$ released in a relatively brief window from just 150 years ago, to mere 1-2 centuries ahead, even if emissions are drawn-down next few decades, may have committed the world to inertia of hugely rising seas. Impacts ahead from that unstoppably rising rate, going on for maybe centuries, perhaps for millennia.

Science suggests many tens of feet of rise is possible on $CO_2$. Accelerating rise, maybe locked-in perhaps going on for thousands of years. Past rises long ago seem to have happened in non-linear ways, at times moving quickly. A meltwater pulse on $CO_2$ coming from natural causes, at rates less than now, caused seas to rise between 50 ft and 80 ft, in just 400 -- 500 years.

That's to say, massive ice sheets having once retreated very swiftly before, might do so again. Especially as 'we engage in pulling all kinds of climate levers' releasing $CO_2$, methane, other greenhouse gases at rates never seen before. Global reshaping is what we're talking about. So put aside for a moment, noisy political debate. Ignore too other impacts, say new diseases, the storms, famines, droughts, tornadoes, collapsing ecosystems. Follow-on impacts that spread like ripples on a pond. Earthquakes that may follow unburdened melting glaciers, that can affect distant tectonic plates. Just focusing on impacts of seas rising, is enough.

Climate & ocean inertia is something we've written about (such as, Scientific American, Oct. 19, 2016): observing for example how problematic models project scenarios of climate change forecast only to year 2100. At times just to 2050. As a result, public discussions have been mostly framed as "X degrees warming", & "Y feet sea level rise" just to end of century only. That year 2100 end-point has accidentally but notably limited our thinking. It causes us to miss striking impacts that may go far beyond -- because of that artificial, near time horizon.
https://blogs.scientificamerican.com/guest-blog/exposed-the-climate-fallacy-of-2100/
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Politicians from Miami, or State of Florida no doubt, want for their homes to exist centuries ahead. Same for New York City, Boston, London, Shanghai, Amsterdam, Mumbai and so on. Yet their leaders are still discounting to near-zero, staggering losses these places *may* face ahead. That's due in part, to relying on a near-term and distorting 2100 horizon.

Anything like a sea level rise going on potentially for centuries, or thousands of years, essentially means "forever" on our human time scales. These new data imply we're possibly creating a kind of forever legacy, one that potentially can't be forgotten nor fixed, no matter how far ahead we conceive of humanity. Flooding -- not just at coasts, but eroding the ground upon which innumerable buildings sit, first as sinkholes then more dissolving near coasts.

And so, we do ourselves a dread disservice by consistently framing just very near-term 2100 as essentially last, final year of impacts. We think in blinkered ways decades out, while our foot is pressing hard on heating's accelerator, with serious impacts maybe millennia out.

How, then, can we think about climate and seas in truer, science-based time frames?

One way is to address sea level rise over the longer term, from a scientific perspective.

These data show a 'recent' rising warming which started from 20 millennia ago, had crucially brought the Earth out of its last ice age. Air temperatures sharply rose over a period from last ice age, to roughly the steadier-modern-climate that commenced some 11 millennia ago. From that point, on, both $CO_2$ levels and air temperatures then sharply leveled off.

Sea levels that had started 400 feet lower than today, didn't stop rising at temps leveled however. They *continued rising long past air temperatures had reached their plateau*, rising another 8,000 years, so climbed another 150 feet -- to today's height. Oceans thus did not achieve now-current state we all know as modern coasts, maps, 'til roughly 3,000 years ago.

This mere sliver, in geological time, of climate stability over a past 11 or so millennia had dearly helped human societies and cultures to flourish. But a lesson ought to be, seas are acutely sensitive to $CO_2$, and temperatures. They can have inertia that lags carbon cycle, climate systems. That means that today's oceans *could* go on rising for very long periods after $CO_2$ may be steadied -- even if humanity takes determined actions to slow $CO_2$ rises worldwide and decrease emissions. This thorny fact is not widely appreciated nor understood.

Combine $CO_2$ persistence with inertia of seas, and *potentially* it can mean sea rise *goes on* for a millennium, or for millennia+, though that's 'unimaginable' to many. Despite our hubris, there's no off switch to halting seas. No matter how much in the future we may wish it.

Opportunity to go on ignoring such a plausible dynamic according to accepted science, grows vanishingly small. There's already been in 2020s, flashes of near 1.5 degree C increases in global temperatures of late. That rate of change alone, seems close to what were the greatest natural variations within this time frame to have occurred over the past 10,000 years.

So current rates of change ought be very concerning. It took a long time -- from 21 millennia ago, to 12 millennia ago, for atmospheric $CO_2$ levels to jump by 80 parts per million. Go from ~190 to 270 ppm. In that span, global temperatures rose on average hugely, by 7 degrees F. We're on track to maybe repeat that increase (or more) -- over far far briefer period.
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For where we're going on $CO_2$ already at 425+ ppm & rising fast, think first: the Pliocene. Earth 3-5 million years ago once had a forested arctic: we might reach Pliocene temps 'soon'. Of course, it'll take a lot longer for flora & fauna to react, reach an equilibrium. Means vast changes ahead with mass-extinctions. Those hotter temps happened million of years before we humans evolved in a once-comfortable 230 ppm world. Could then get hotter still, like the Miocene: 400-600 ppm when coasts of today were submerged. Interestingly at 'just' a 400 ppm Pliocene, Greenland's ice sheet was gone on only 'modest' warming. And note millions of years ago, those $CO_2$ changes had naturally taken thousands of years to occur. Tens of thousands of years+, to slowly rise or fall. By contrast in a single human lifetime now, we're exploding $CO_2$ by astounding 100 ppm and more(!). So, plants & animals only are beginning to react. Cascading extinctions are unavoidable. Thus, it's Not Only The Fact of Great Change -- but rather also The Extreme Pace of Such Change that's bound to be deadly.

Before a Miocene of 5-23 million years ago, much before a Pliocene 3-5 million years ago -- there were long periods - millions of years where a hot Earth cooled before humans appeared. PPMs/ temps fall. Down from Miocene's 400-600 ppm (at times 2,000 ppm from volcanoes). That cooling eventually gave way to hospitable carbon levels, temps we could evolve in at nearer 230 ppm. Key then, was our planet's ability to pull $CO_2$ out of atmosphere over very long periods of time, via Earth's natural 'rock thermostat'. Specifically, $CO_2$ was absorbed as by rocks, but only over many millions of years. Taken up as by calcium carbonate in oceans.

Long cooling post-Pliocene lowered $CO_2$ -- let glaciers form. Today's flora & fauna evolved over a hospitable, cool Earth we'd known until very recently. Again, millions of years needed to go from that hot Pliocene. That's now being explosively undone. In just 250 years of fossil fuels we're dramatically destroying cool. Vanquishing glaciers. Ending ice sheets that required a vast, vast cold period to form in the first place. There's no reverse switch. Hence this may become (or probably already is) a climate crisis; maybe an emergency tougher to fix.

Trying to pull $CO_2$ from air & oceans may soon be touted by some, as a necessity. Even though it is a bargain with the Devil, consequences unforeseen, likely to disastrous. Different from renewables that better prevent harm in the first place; there's a variety of potential (some not so awful) ways to do this -- if done right -- a few may make some sense. Of course, it mustn't be done in ways extending fossil fuels. And mustn't be done say, by treating oceans like an open sewer, injecting carbon there like we've been abused the air for centuries.

Rather as noted, any direct capture or sequestration should best *Remove $CO_2$ from air & seas *Permanently, in *Practical, Economic Ways Scaling to Gigatons, carbon made *Benign & Stable, done in ways *Carbon Negative -- not merely carbon neutral. If meeting those criteria such technologies *may* conceivably be included say, in Indexes. Yet in early 2000s, no such technologies existed. None: safe, ecologically benign, nor scalable: basic requirements.

Conceivably, innovations may arise. New Prizes given for clever ways to pull $CO_2$ from air, or incentivizing better, not-bitter, action ahead. Perhaps $CO_2$ may be turned to carbonates, to benign solids such as building materials stable for many thousands of years. Perhaps 2 pounds of carbonates for every pound of $CO_2$. That can be a lot on 30 billion metric tons pumped into air each year. Like abalone that makes shells from $CO_2$ on dissolved mineral ions in seawater. But this would have to be safe, fast, require very little energy, be ecologically benign, no easy task! Or in a single step a non-thermal plasma conversion of $CO_2$ at room temps and say, at 15 PSI pressure, rather than requiring 500 degrees F and over 150 PSI. This is a riddle that may not soon be solved. And so, it's likely then that climate impacts may be baked in.

What does all this mean, for sea level rise on current trends?

An international panel back in 2013 had given scenarios for rise this century, straightforwardly on expansion due to warming oceans. Back then, they'd only allowed for small influence from runoff due to marine ice-sheet instability, MISI, primarily on assumption that Antarctic ice sheets were too stable, too vast to irreversibly shrink during this century. That report had an optimistic low-end $CO_2$ scenario: little rise. It assumed strong actions would be taken later in this century to reduce $CO_2$ emissions, predicated estimated just 1 foot of rise (0.3 to 0.6 meters) by 2100. A high-end estimate on current trends, with little action this century to reduce $CO_2$, foresaw about 3.5 feet of rise at 2100, rate increasing rapidly one third - to over half an inch (8 to 16 mm)/year last 2 decades this century. Such rate later on in this century, could be up to 10 times what was the 20th century average rise. But it still does Not start to approach what had occurred around end of the Ice Age, when seas rose rapidly.

Since that report, we saw a regional jump in Gulf of Mexico of over 10 mm/year, 5 inches from just 2010-2022 in Pensacola Florida; it may be due to thermal expansion in hotter Gulf or slowing maybe of Gulf Stream. While globally, newer papers on ice-sheet dynamics show prior understanding was incomplete; MISI mechanisms may be much more extensive in the Antarctic. The enormous Pine Island Glacier in Antarctica, for example, looks to be thinning, retreating at quickening rate. Like cork in a champagne bottle, it holds back far greater rise. Mechanisms in newer models show mass loss by unstable retreat may potentially become significant, sooner than expected. Some early collapse maybe starting at Thwaites Glacier. Unexpected collapse of say Antarctic marine ice sheets could cause previous upper estimates of sea rise, to be well-exceeded, not long after (before?) end of century. Although timescales are profoundly uncertain, rapid rises *may* occur in relatively short period ahead, say over two to nine centuries. Or as Gulf of Mexico 2010 to mid-2020s indicates with rises seen half an inch per year albeit on different mechanisms, like ocean currents, we are in for surprises.

A subsequent paper shows marine Ice Cliffs may be become instable too, MICI a mechanism for more rapid retreat through 2100 -- certainly after artificial 'terminal years'. Numerous more papers lately showing sea levels could start to rise much more than was forecast in prior lower-end scenarios. These data imply more than 40 feet of rise may potentially come just from Antarctica in half-millennium to 2500, in accord with higher-end scenarios for $CO_2$.

$CO_2$ can/will make a complete failure of efforts to pour $ billions, $ Trillions into armoring coastlines. One can imagine enormously long expensive walls, say 10 feet high, topped in a couple centuries. One can't even imagine bigger seawalls able to handle what may be oceans going up 50 feet, 100+ feet higher and rising without pause. The point here is 2100 shouldn't be regarded as a terminal year. Nor, 1-3 ft of sea rise. To do so, is just folly, wrong-thinking. Life goes on, people do not end there, it's one year in an artefact human calendar: the world's seas will not suddenly halt rising then. Things may be wee bit better -- or wee bit worse at times due to heating next centuries; maybe a whole lot worse threatening survival of human civilizations: but it's pretty certain that on a hot Earth they won't get a whole lot better.

Scientists are natural skeptics, not prone to dramatizing their findings. But cause for abundant hope is fading. That ought to stretch our thinking. Listening to the Sea, and so to science, ought adjust our thinking about what's wise. Paleoclimate records indicate that in meltwater periods, or termination of glacial period, seas perhaps rose at astounding rates 10 feet per century and more. There's no reason to say it can't happen again. Or rise by faster rates to 220 ft max height ahead. Given aggressive $CO_2$ trends, that must be considered.

Keep in mind what such big rates, scales of change, may mean. A difference of 'just' 7 degrees F had separated our recent "ideal" climate for us -- from an extreme ice age. In a refresher, the Ice Age not that long ago had ice sheets over Canada, Northern US, Europe, Asia. The US Great Lakes were born of great sheets retreating. Meltwater retreat shaped Long Island NY, Cape Cod MA. Huge impacts were thus wrought by just a 7 degrees F 'delta'. Ice had stood a mile tall over some of North America(!) making continental shapes that we know today.

Just imagine then, another 7 degrees F change -- but instead -- of global *heating*. Certainly, that will alter land, seas, & ecology in scales, ways hard to fathom. Looking back to Earth's record it's conceivable on a temperature rise of "only" 2 to 5 degrees F, seas could rise fast in non-linear ways, say going 15 to 65 feet higher. Drowning so much today, like great State of Florida. In a thought experiment, 5 degrees F of warming is imaginable, on current $CO_2$. So, it is reasonable to see seas fast going up 60+ feet higher. No seawall could stop that. It renders the shapes of whole countries as we know them, today, a distant memory.

Mechanisms by which it happens are easy to fathom. Greenland's ice sheet has stored up 'only' 22 feet of potential sea level rise, over say some 10 millennia. However, Antarctic ice sheets store much more: 150 ft. of potential rise. In past years East Antarctic ice sheet annually gained some 175 trillion pounds of thin new ice (precipitation). But West Antarctic annually lost much more, 275 trillion pounds of critical ice. Plus, Greenland has averaged 600 trillion pounds of ice lost yearly, like 10 billion trucks a year carting ice away.

On $CO_2$ and inertia, we're heading to conditions unknown in human history. Earth will exhibit changed states that only can be guessed at. For instance ice melt makes Earth slightly alter movement on its polar axis. Length of days is changing, as ice melt redistributes mass of water towards bulging equator. So too, groundwater withdraw. Small changes in Earth's spin may not seem troubling, yet shows magnitude of change from tiny $CO_2$ molecules. The Gulf Stream long keeping Northern Europe far warmer, than 'it otherwise would be', may be slowing.

A century, even just decades from now, science strongly implies people may look back on recent year 2021 with then-record-breaking heat, irony of flood & droughts, bitter cold snaps, rapidly disappearing sea ice, gradual rising seas -- as having been a cooler, far more desirable past. One that can 'never' be recovered. When seas rising by 2 inches per decade (faster in 2021, than 50 years prior) were *yet then, so much less*. If there's irreversible collapse in Greenland, and/or Antarctic, far more rapid rises happen -- making a better past a memory. One where a jet stream & gulf stream existed. It's impossible to say just when, such things might occur. But given fast rising heat, and more $CO_2$, it is certain change will happen.

Yes the growth of clean energy installations in 2020s, 'felt' like progress; it was more than many were prepared to give. Maybe felt too, like clean was replacing fossils, 'fast enough' -- though it wasn't: not on the science and physical $CO_2$ budget of burning fossils. The dollars in an IRA seemed huge -- yet were dwarfed by scale of Global efforts needed: $100 Trillion of spending worldwide. Science says that we may (likely) be in for unbearably hot future. Killing much Life. Maybe lasts less than say 1 million years, even under a hundred thousand years -- yet ending us. End of our cultures, societies, maybe our species. All for silly reasons, really. On no good reason we've chosen not to go clean fast. Of course, no doubt, it's uncertain. Solutions costly. Yet climate may mean catastrophic change. Maybe, for most everything, everywhere, all at once. Our rampage in oil, gas, coal may be a mutual suicide pact, for we know probable outcomes. It's as if we are determined to wage intended war, on all other life on this planet -- which makes it a bit hard to cheer our own species on.

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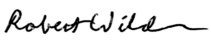
**Conclusion:**

The Clean Energy Index® (ECO) began Q1 at 43.23, and ended Q1 at 33.10, down -23%; its low so far this year was March 31st also at 33. Despite hopes that inflation might slow, Fed pivot, it has persisted and hit this interest-rate-sensitive theme hard. When rate cuts didn't arrive, clean energy so the ECO Index® touched last year's low in the Fall. Then late last year ECO briefly gained some with -- or perhaps bit due to(?) the president's re-election to a 2nd term; we'd seen that in their 1st term from 2017 to 2020, this ECO theme moved dramatically. Or looking back last few years, ECO gained +58% in 2019. Remarkably it rose +203% in 2020, about the best performance of any Fund, anywhere. Unsurprisingly perhaps, after such gains, it fell by -30% in 2021, -46% in 2022, -22% in 2023, -30% in 2024. Thus big declines followed big gains. Seen broadly this inflation, perhaps too trade wars, even recession -- also threaten to undo a soft landing, overshadow decarbonization that might favor renewables ahead.

Deletions from ECO to start Q2 2025, were: Altus, Chargepoint, Sunnova, & TPI Composites -- there were no ECO Additions for Q2 2025. At the Global Clean Energy NEX Index for Latter part of Q1 2025 rebalance, the Deletions were: Ameresco, Archer, Brookfield Renewables, Neoen, REC Silicon, Xinyi Energy -- and the NEX Additions for Latter Q1 were: FSP Technology, FuelCell Energy, and SES AI. At Hydrogen Economy H2X the Deletions for Latter Q1 2025 were: Brookfield Renewables, Dae Myoung, Neoen, TE Connectivity, Voltalia -- and the Additions here were: Aker Carbon Capture, SK IE. At Wind WNX, the Deletions for Latter Q1 2025 were: Brookfield Renewables, Covestro, JL Mag, Neoen, Shinfox Energy, TE, Voltalia -- and Additions for Latter Q1 were: Cadeler, LG Energy Solution, Tocalo Ltd.

As always, we welcome your thoughts and suggestions.

Sincerely,



Rob Wilder
rwilder@wildershares.com



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## Appendix I: ECO Index (via independent tracker PBW) components in descending % order infra-Q1 on 2/12/2025, about ~6 weeks before rebalance to start Q2 2025. 67 Stocks**:

| Name | Weight | Itron Inc | 1.49 |
|---|---|---|---|
| Amprius Technologies Inc | 3.01 | Energy Vault Holdings Inc | 1.49 |
| MP Materials Corp | 2.45 | Navitas Semiconductor Corp | 1.49 |
| **Altus Power | 2.26 | Gentherm Inc | 1.48 |
| NEXTracker Inc | 2.12 | MYR Group Inc | 1.48 |
| XPeng Inc ADR | 2.07 | Quanta Services Inc | 1.47 |
| Monolithic Power Systems | 1.97 | Rivian Automotive Inc | 1.47 |
| American Superconductor | 1.96 | SolarEdge Technologies Inc | 1.44 |
| ESCO Technologies Inc | 1.96 | JinkoSolar Holding ADR | 1.44 |
| Array Technologies Inc | 1.94 | Ballard Power Systems | 1.43 |
| Darling Ingredients Inc | 1.91 | First Solar Inc | 1.42 |
| Preformed Line Products Co | 1.87 | Ameresco Inc | 1.42 |
| Gevo Inc | 1.86 | Albemarle Corp | 1.42 |
| Enovix Corp | 1.83 | Canadian Solar Inc | 1.42 |
| Eos Energy Enterprises Inc | 1.77 | Lifezone Metals Ltd | 1.41 |
| Solid Power Inc | 1.69 | Enphase Energy Inc | 1.37 |
| Corteva Inc | 1.68 | Sunrun Inc | 1.31 |
| Lithium Americas Corp | 1.67 | Tesla Inc | 1.31 |
| Sigma Lithium Corp | 1.66 | **Freyr Battery | 1.30 |
| OPAL Fuels Inc | 1.65 | Shoals Technologies | 1.29 |
| Sociedad Quimica y Minera | 1.65 | Wolfspeed Inc | 1.21 |
| REX American Resources | 1.63 | Hyliion Holdings Corp | 1.14 |
| Standard Lithium Ltd | 1.63 | FuelCell Energy Inc | 1.10 |
| ReNew Energy Global PLC | 1.59 | EVgo Inc | 1.08 |
| Advanced Energy Industries | 1.58 | LanzaTech Global Inc | 1.05 |
| Archer Aviation Inc | 1.58 | Plug Power Inc | 1.04 |
| Universal Display Corp | 1.58 | ChargePoint Holdings Inc | 0.93 |
| QuantumScape Corp | 1.57 | Sunnova Energy Int.l | 0.89 |
| Brookfield Renewable Corp | 1.56 | Fluence Energy Inc | 0.70 |
| Bloom Energy Corp | 1.56 | Emeren Group Ltd ADR | 0.48 |
| Bel Fuse Inc | 1.55 | Atlas Lithium Corp | 0.47 |
| Ormat Technologies Inc | 1.54 | Blink Charging Co | 0.37 |
| Joby Aviation Inc | 1.53 | TPI Composites Inc | 0.27 |
| NIO Inc ADR | 1.51 | | |
| ** Lithium Argentina AG | 1.51 | | |

Some strong representation above in *Batteries & component materials, *Solar, *Power electronics.

** Altus Power (AMPS) agreed to sale early 2025; was removed from the Index at the rebalance
** Lithium Americas Argentina (LAAC) had name/symbol change early 2025 -- to Lithium Argentina (LAR)
** T1 Energy (TE) had a name/symbol change in early 2025 - previously was Freyr Battery above

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## Appendix II, ECO Index for the Start of the New Quarter:

**INDEX (ECO) SECTOR & STOCK WEIGHTS FOR START OF Q2 2025. 63 STOCKS.**
Each stock freely floats according to its share price after rebalance.
*Stocks below $200 million in size at rebalance are *banded with a 0.50% weight.

**Renewable Energy Harvesting** - 11% weight (6 stocks @1.75% each + 1 *banded)
*Array Technologies,* ARRY. Solar, tracker mounts follow sun through the day
*Canadian Solar,* CSIQ. Solar, vertical integrated solar manufacturer, China.
**Emeren,* SOL. Solar development, Europe, US, China, global pipeline.
*First Solar,* FSLR. Thin film solar, CdTe low-cost alternate to polysilicon.
*JinkoSolar*, JKS. Solar, wafers through solar modules, China-based OEM.
*Nextracker,* NXT. Solar trackers, optimizing PV daily performance yield.
*Ormat,* ORA. Geothermal, also in areas of recovering heat energy.

**Energy Storage** - 24% sector weight (15 stocks @1.56 each + 1 *banded)
*Albermarle,* ALB. Lithium, specialty materials in batteries for energy storage.
*Amprius Technologies*, AMPX. Silicon anode batteries, greater energy density.
**Atlas Lithium,* ATLX. Lithium, battery metals nickel, rare earths, graphite.
*Chemical & Mining of Chile*, SQM. Lithium, large producer in energy storage.
*Enovix*, ENVX. Silicon-anodes, 3D for improving new lithium-ion batteries.
*Lithium Americas,* LAC. Lithium, deposits in the State of Nevada in US.
*Lithium Argentina AG*, LAR. Lithium deposits in Argentina; has China nexus.
*Nio Inc,* NIO. EVs, China-based maker of premium vehicles, battery as service.
*Quantumscape*, QS. Battery, solid state lithium-metal energy dense fast charge.
*Rivian,* RIVN. Electric vehicles, trucks and commercial fleets, charging
*Sigma Lithium,* SGML. Lithium, in planning & pre-construction, sites in Brazil.
*Solid Power,* SLDP. Solid electrolyte battery, Earth-abundant materials.
*Standard Lithium,* SLI. Lithium, from brine in U.S., vs. traditional ponds.
*T1 Energy (TE)*. Solar manufacturing, also in batteries; formerly was Freyr.
*Tesla,* TSLA. Electric vehicles, pure-play across EVs, advanced energy storage.
*Xpeng,* XPEV. Electric vehicles, advanced mobility, swappable batteries, China.

**Power Delivery & Conservation** - 18% sector (10 stocks @1.75% each + 1 *banded)
*Ameresco,* AMRC. Energy saving efficiencies, net zero $CO_2$, decarbonization.
**Blink Charging*, BLNK. EV Charging, among bigger EV charging networks.
*EVgo,* EVGO. EV Charging, DC fast-charging Networks, renewable power.
*Itron,* ITRI. Meters, utility energy monitoring, measurement & management.
*Monolithic Power,* MPWR. Chipmaker, better efficient power management.
*MYR Group,* MYRG. Grid transmission, distribution aids solar & wind farms.
*Navitas Semiconductor,* NVTS. Gallium Nitride GaN fast charging EVs.
Preformed Line Products, PLPC. Grid products & transmission OEM, solar.
*Shoals*, SHLS. Solar, for electric balance of system, wiring, combiners.
*Universal Display,* OLED. Organic light emitting diodes, efficient displays.
*Wolfspeed,* WOLF. Electrifying power, Silicon Carbide SiC, converters.

**Energy Conversion** - 22% sector weight (13 stocks @1.69% each)
*Advanced Energy,* AEIS. Power condition: inverters, thin film deposition.
*Archer Aviation,* ACHR. Electrifying aircraft, vertical takeoff & landing.
*Ballard Power,* BLDP. Mid-size fuel cells; PEM such as in transportation.
*Bel Fuse,* BELFB. Transformers, power supplies, circuit protection, AC/DC.

*Bloom Energy,* BE. Stationary fuel cells, not-yet cleanest/renewable fuels.
*Enphase,* ENPH. Microinverters, also energy storage systems and software.
*ESCO Technologies,* ESE. Power management, shielding, controls, testing.
*Gentherm*, THRM. Thermoelectrics, heat energy, battery management.
*Joby Aviation,* JOBY. Electric aircraft, cleaner, more energy efficient.
*Lifezone Metals,* LZM. Low-carbon battery metals, Nickel no smelting.
*MP Materials,* MP. Rare Earths, domestic U.S. source Neodymium, NdPr.
*Plug Power,* PLUG. Small fuel cells, for eg forklifts; drop in replacements.
*SolarEdge Technologies,* SEDG. Inverters, solar optimizers, inverters.

**Greener Utilities** – 14% sector weight (7 stocks @1.92% each + 1 *banded)
*American Superconductor,* AMSC. Wind, grid conditioning; superconductors.
*Brookfield Renewable,* BEPC. Renewables hydro, wind, solar; energy storage.
**Energy Vault,* NRGV. Gravity energy storage, is longer-duration but limited.
*Eos Energy,* EOSE. Zinc batteries, a safer li-ion alternative, longer-duration.
*Fluence,* FLNC. Battery storage, for renewables and digital applications.
*Quanta Services,* PWR. Infrastructure, modernizes grid, power transmission.
*ReNew Energy,* RNW. India renewables, among largest there in solar & wind.
*Sunrun*, RUN. Residential solar systems, PPA, lease or purchase rooftop PV.

**Cleaner Fuels** – 11% sector weight (6 stocks @1.66% each + 2 *banded)
*Corteva,* CTVA. Canola oil, renewable in sustainable aviation fuels (SAFs).
*Darling Ingredients,* DAR. Renewable biodiesel, sustainable aviation fuels.
**FuelCell Energy,* FCEL. High temperature fuel cells, uses a variety of fuels.
*Gevo,* GEVO. Biofuels, decarbonizing chemicals, new aviation fuels, RNG.
*Hyliion,* HYLN. Enables variety of fuels or waste heat, efficient linear engine.
**Lanzatech,* LNZA. Carbon to more sustainable fuels, material bio-recycling.
*Opal Fuels,* OPAL. Renewable natural gas RNG, CH4 from landfills, dairies.
*Rex,* REX. Biofuels, adding CCS sequestration, But Not in advanced biofuels.

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***Appendix III:*** **WilderHill New Energy Global Innovation (NEX)** via independent tracker (PBD) on 12 February 2025 -- about ~2 weeks before next Rebalance for Latter Q1 2025. 110 stocks:

| Name | Weight | JinkoSolar Holding ADR | 0.9 |
|---|---|---|---|
| Eos Energy Enterprises Inc | 2.1 | Darling Ingredients Inc | 0.9 |
| Archer Aviation Inc | 2.1 | Flat Glass Group Co Ltd | 0.9 |
| Bloom Energy Corp | 1.7 | Terna Rete Elettrica | 0.9 |
| LS Electric Co Ltd | 1.5 | Nordex SE | 0.9 |
| Lucid Group Inc | 1.3 | Rexel SA | 0.9 |
| Core & Main Inc | 1.2 | Enphase Energy Inc | 0.9 |
| Grenergy Renovables SA | 1.2 | United Renewable Energy | 0.9 |
| XPeng Inc ADR | 1.2 | Legrand SA | 0.9 |
| Wasion Holdings Ltd | 1.2 | ITM Power PLC | 0.9 |
| LS Corp | 1.2 | AcBel Polytech Inc | 0.9 |
| Gevo Inc | 1.2 | Verbund AG | 0.9 |
| Rivian Automotive Inc | 1.2 | Mercury NZ Ltd | 0.9 |
| Tianneng Power Intl | 1.1 | NIO Inc ADR | 0.9 |
| Kempower Oyj | 1.1 | Scatec ASA | 0.9 |
| Tamura Corp | 1.1 | Acciona SA | 0.9 |
| Sanyo Denki Co Ltd | 1.1 | Signify NV | 0.9 |
| Ballard Power Systems Inc | 1.1 | GS Yuasa Corp | 0.9 |
| SMA Solar Technology AG | 1.1 | Energix-Renewable Energies | 0.9 |
| Aker Carbon Capture ASA | 1.0 | Blue Bird Corp | 0.9 |
| China Datang Renew | 1.0 | Wacker Chemie AG | 0.9 |
| SolarEdge Technologies Inc | 1.0 | Corp ACCIONA Energias | 0.9 |
| Xinyi Solar Holdings Ltd | 1.0 | Ganfeng Lithium Group | 0.9 |
| CS Wind Corp | 1.0 | Ta Ya Electric Wire & Cable | 0.9 |
| Prysmian SpA | 1.0 | Chung-Hsin Electric & Mach. | 0.9 |
| Delta Electronics Inc | 1.0 | Voltronic Power Technology | 0.9 |
| Teco Electric Machinery | 1.0 | Brookfield Renewable Corp | 0.9 |
| Doosan Fuel Cell Co Ltd | 1.0 | Hubbell Inc | 0.8 |
| HD Hyundai Electric Co Ltd | 1.0 | Kingspan Group PLC | 0.8 |
| Alfen N.V. | 1.0 | Allis Electric Co Ltd | 0.8 |
| HA Sustainable Infrastru. | 1.0 | Motech Industries Inc | 0.8 |
| SPIE SA | 1.0 | Nibe Industrier AB | 0.8 |
| Enlight Renewable Energy | 1.0 | Yadea Group Holdings Ltd | 0.8 |
| Xinyi Energy Holdings Ltd | 1.0 | Array Technologies Inc | 0.8 |
| QuantumScape Corp | 1.0 | Ecopro BM Co Ltd | 0.8 |
| Neoen SA | 0.9 | Shihlin Electric & Engineer. | 0.8 |
| Sociedad Quimica y Minera | 0.9 | Universal Display Corp | 0.8 |
| Vestas Wind Systems A/S | 0.9 | Toyo Tanso Co Ltd | 0.8 |

| | | | |
|---|---|---|---|
| Canadian Solar Inc | 0.8 | EDP Renovaveis SA | 0.7 |
| Lotte Energy Materials Corp | 0.8 | Orsted AS | 0.7 |
| Phihong Technology Co Ltd | 0.8 | Solaria Energia y Medio Amb. | 0.7 |
| Plug Power Inc | 0.8 | Elia Group SA/NV | 0.7 |
| Innergex Renewable Energy | 0.8 | Sunrun Inc | 0.7 |
| Itron Inc | 0.8 | Landis+Gyr Group AG | 0.7 |
| West Holdings Corp | 0.8 | Ameresco Inc | 0.7 |
| First Solar Inc | 0.8 | Sino-American Silicon | 0.7 |
| Fortune Electric Co Ltd | 0.8 | Wolfspeed Inc | 0.6 |
| NKT A/S | 0.8 | NFI Group Inc | 0.6 |
| RENOVA Inc | 0.8 | ChargePoint Holdings Inc | 0.6 |
| Ormat Technologies Inc | 0.8 | NEL ASA | 0.6 |
| Verbio SE | 0.8 | EVgo Inc | 0.5 |
| Ceres Power Holdings PLC | 0.7 | Green Plains Inc | 0.5 |
| Nexans SA | 0.7 | Sunnova Energy Intern. | 0.5 |
| Boralex Inc | 0.7 | REC Silicon ASA | 0.3 |
| Shoals Technologies Group | 0.7 | | |
| Samsung SDI Co Ltd | 0.7 | | |
| Atkore Inc | 0.7 | | |

There's strong representation above from *Batteries; *EVs & eVTOLs, *Fuel Cells, *Grid/ Efficiency.

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***Appendix IV:***
***WilderHill New Energy Global Innovation (NEX) - for Latter Q1 2025. 107 Stocks.***

| Name | Description | Sector | Currency | Activity |
|---|---|---|---|---|
| Acbel Polytech | Green energy electronics, PV & EV, power supply. | ECV | TWD | TAIWAN |
| Acciona SA | Sustainable infrastructure, separate is renewables. | RWD | EUR | SPAIN |
| Aker Carbon Capture | Carbon capture, in blue hydrogen, waste to energy. | ROH | NOK | NORWAY |
| Alfen NV | Electric Vehicle charging, smart grid, energy storage. | EEF | EUR | NETHER. |
| Allis Electric | Transformers, power transmission, smarter grid. | ECV | TWD | TAIWAN |
| Array Technologies | Solar, ground-mounted axis sun trackers. | RSR | USD | US |
| Atkore | Electrical cable, conduit systems, pre-wiring. | ECV | USD | US |
| Ballard Power Systems | Fuel cells, PEMs used in transportation and more. | ECV | CAD | CANADA |
| Bloom Energy | Stationary fuel cells, distributed but non-renewable. | ECV | USD | US |
| Blue Bird | Electric school buses, US size types A, C, D. | EEF | USD | US |
| Boralex | Renewables generation, operates wind, hydro, solar. | RWD | CAD | CANADA |
| Canadian Solar | Solar, vertical integrated solar manufacturer, China. | RSR | USD | CANADA |
| Ceres Power | Fuel cells, high temperature steel units. | ECV | GBP | UK |
| Chargepoint | EV charging, an early leader with global presence. | EEF | USD | US |
| China Datang Renewable | Wind, among largest listed wind operators in China. | RWD | HKD | CHINA |
| Chung-Hsin Electric Mach. | Fuel cells, H2 dispenser, micro-grid maker, Taiwan. | ECV | TWD | TAIWAN |
| Core & Main | Electrical metering, power utilities upgrading. | EEF | USD | US |
| Corporacion Acciona En. | Renewables, one of world's biggest, wind, solar etc. | RWD | EUR | SPAIN |
| CS Wind | Wind energy, both onshore and also offshore. | RWD | KRW | S. KOREA |
| Darling Ingredients | Renewable diesel, sustainable aviation fuels. | RBB | USD | US |
| Delta Electronics | Power systems, EV chargers, fuel cell development. | ECV | TWD | TAIWAN |
| Doosan Fuel Cell | Fuel cells, high temperature and hydrogen, S. Korea. | ECV | KRW | S. KOREA |
| Ecopro BM | Battery materials, cathode and precursor for Li-ion. | ENS | KRW | S. KOREA |
| EDP Renovaveis SA | Wind power, among the largest producers, Iberia. | RWD | EUR | SPAIN |
| Elia Group SA | Smarter grid, high voltage transmission Europe. | EEF | EUR | EUROPE |
| Energix Renewable En. | Wind & solar, producer Poland, US, elsewhere. | RWD | ILS | ISRAEL |
| Enlight Renewable | Solar & wind, clean energy storage infrastructure. | RSR | ILS | ISRAEL |
| Enphase | Inverters, micro-products for solar panels, storage. | RSR | USD | US |
| Eos Energy | Zinc batteries, longer-duration and safer than li-ion. | ENS | USD | US |
| EVgo | EV charging, an early leader in fast charging. | EEF | USD | US |
| First Solar | Thin film solar, CdTe alternate to polysilicon. | RSR | USD | US |
| Flat Glass Group | PV panel glass, solar engineering & construction | RSR | HKD | CHINA |
| Fortune Electric | Transformers for power transmission, switchgear. | ECV | TWD | TAIWAN |
| FSP Technology | Power supplies, inverters, and microgrids. | ECV | TWD | TAIWAN |
| FuelCell Energy | Fuel cells, high temperature can use various fuels. | ECV | USD | US |
| Ganfeng Lithium | Lithium, produces compounds, metals, for batteries. | ENS | HKD | CHINA |
| Gevo | Biofuels, renewable fuels, drop in RNG, and SAFs. | RBB | USD | US |
| Green Plains | Biorefining, lower-carbon fuels, renewable SAFs. | RBB | USD | US |
| Grenergy Renovables SA | Solar & storage, integrated project developer. | RSR | EUR | SPAIN |
| GS Yuasa | Battery technologies, also lithium for EVs, Japan. | ENS | JPY | JAPAN |
| Hannon Armstrong | Energy efficiency, capital & finance for infrastructure. | EEF | USD | US |
| HD Hyundai Electric | Transformers, circuit breakers, smart ships. | EEF | KRW | S. KOREA |
| Hubbell Inc. | Electrical equipment, grid infrastructure, utilities. | EEF | USD | US |
| Innergex Renewable | Renewable power, run-of-river hydro, wind, solar. | ROH | CAD | CANADA |
| ITM Power plc | Fuel cells, uses PEM technology; also hydrogen. | ECV | GBP | UK |
| Itron | Meters, Utility energy monitor, measuring & manage. | EEF | USD | US |

| | | | | |
|---|---|---|---|---|
| JinkoSolar | Solar, wafers through solar modules, China OEM. | RSR | USD | CHINA |
| Kempower Oyj | Fast chargers, EVs, cars, trucks, aircraft, vessels. | EEF | EUR | FINLAND |
| Kingspan Group plc | Efficient Buildings, insulation, conservation, Ireland. | EEF | EUR | IRELAND |
| Landis+Gyr Group AG | Advanced meters, modernizing grid, Switzerland. | EEF | CHF | SWITZER. |
| Legrand SA | Electrical, energy & digital infrastructure in buildings. | ECV | EUR | FRANCE |
| Lotte Energy Materials | Rechargeable battery materials, elecfoils in batteries. | ENS | KRW | S. KOREA |
| LS Corp. | Cables, wind power transmission over distances. | RWD | KRW | S. KOREA |
| LS Electric | Smart grid power transmission, wind, solar, storage. | ENS | KRW | S. KOREA |
| Lucid | Electric Vehicles, premium, higher-voltage, range. | EEF | USD | US |
| Mercury NZ | Clean power, 100% renewable hydro, geothermal. | ROH | NZD | NEW ZEA. |
| Motech | Solar, cells and modules manufacturing. | RSR | TWD | TAIWAN |
| Nel ASA | Hydrogen, in fuel cell vehicles, renewably, Norway. | ECV | NOK | NORWAY |
| Nexans SA | Cables, for grid power infrastructure. | EEF | EUR | FRANCE |
| NFI Group | Fuel cell and electric drivetrains, for large buses. | EEF | CAD | CANADA |
| Nibe Industrier AB | Heating, cooling, sustainable technologies, Sweden. | EEF | SEK | SWEDEN |
| Nio | Electric Vehicles, design, manufacture, premium EVs. | ENS | USD | CHINA |
| NKT A/S | AC/DC cables, grid infrastructure improvements. | EEF | DKK | DENMARK |
| Nordex SE | Wind turbines, based in Germany/Europe, worldwide. | RWD | EUR | GERMANY |
| Ormat | Geothermal, works too in recovered heat energy. | ROH | USD | US |
| Orsted A/S | Sustainable wind, also biomass, thermal, Denmark. | RWD | DKK | DENMARK |
| Phihong Technology | EV chargers AC & DC, power supplies, Taiwan. | ECV | TWD | TAIWAN |
| Plug Power | Small fuel cells, e.g. in forklifts; drop in replacements. | ECV | USD | US |
| Prysmian SpA | Cables, renewable power transmission, global. | EEF | EUR | ITALY |
| Quantumscape | Lithium metal batteries, solid state, quicker charge. | ENS | USD | US |
| Renova | Wind, Solar, Biomass, power generation in Asia. | RWD | JPY | JAPAN |
| Rexel SA | Electric conversion systems, energy storage, cables. | ECV | EUR | FRANCE |
| Rivian | Electric trucks and vehicles, fast charging network. | ENS | USD | US |
| Samsung SDI | Batteries, innovative energy storage, EVs, S. Korea. | ENS | KRW | S. KOREA |
| Sanyo Denki | Power supply, cooling systems, solar management. | ECV | JPY | JAPAN |
| Scatec ASA | Solar, hydro, wind, storage, green methanol, global. | RSR | NOK | NORWAY |
| SES AI | Lithium-metal batteries, in EVs, eVTOLs. | ENS | USD | US |
| Shihlin Electric | Grid transformers, EV powertrains, motors, chargers. | ECV | TWD | TAIWAN |
| Shoals Technologies | Solar, electric balance of system, wiring, combiners. | RSR | USD | US |
| Signify NV | Lighting, systems increasing efficiency, Netherlands. | EEF | EUR | NETHER. |
| Sino-American Silicon | Solar, semi-conductor silicon wafer materials, Taiwan. | RSR | TWD | TAIWAN |
| SMA Solar Technologies | Inverters for solar, industrial scale storage, Germany. | RSR | EUR | GERMANY |
| Sociedad Quimica Chile | Lithium, a key element in advanced batteries, Chile. | ENS | USD | CHILE |
| SolarEdge | Inverters, panel-solar optimizers, micro-inverters. | RSR | USD | US |
| Solaria Energia | Solar, renewable power generation, Iberia. | RSR | EUR | SPAIN |
| Spie SA | Energy sustainability, decarbonization, design, build. | ECV | EUR | FRANCE |
| Sunnova | Residential solar and energy storage installation. | RSR | USD | US |
| Sunrun | Residential solar, leases, PPA or purchase PV. | RSR | USD | US |
| Ta Ya Electric Wire | Power cables, wires, magnet wires, Taiwan. | ECV | TWD | TAIWAN |
| Tamura | Transformers, battery chargers, power modules. | ECV | JPY | JAPAN |
| TECO Electric Machinery | EV motors, wind converters, in electrifying all. | ECV | TWD | TAIWAN |
| Terna Rete SpA | Transmission of electricity, increasingly is renewables. | EEF | EUR | ITALY |
| Tianneng Power | Hydrogen fuel cells, batteries for wind and solar. | ECV | HKD | CHINA |
| Toyo Tanso | Graphite, used in solar, wind, H2, LEDs, SiC, more. | ECV | JPY | JAPAN |
| United Renewable Energy | Solar, also energy storage, hydrogen and fuel cells. | RSR | TWD | TAIWAN |

| | | | | |
|---|---|---|---|---|
| Universal Display | Organic light emitting diodes, efficient displays. | EEF | USD | US |
| Verbio Vereinigte BioEn. | Biofuels, manufacturer supplier to Germany, Europe. | RBB | EUR | GERMANY |
| Verbund AG | Electricity supplier, hydro, a large provider for Austria. | ROH | EUR | AUSTRIA |
| Vestas Wind Systems A/S | Wind, turbine manufacturing & services, Denmark. | RWD | DKK | DENMARK |
| Voltronic Power | Power conversion, solar inverters, EV charging. | ECV | TWD | TAIWAN |
| Wacker Chemie AG | Solar polysilicon maker, a leader in Europe. | RSR | EUR | GERMANY |
| Wasion Holdings | Advanced metering, electrical and fluids. | EEF | HKD | CHINA |
| West Holdings | Solar, Japan-focused residential, commercial PV. | RSR | JPY | JAPAN |
| Wolfspeed | Electrifying high power systems, SiC, GaN. | EEF | USD | US |
| Xinyi Solar Holdings | Solar, ultra-clear glass products, China. | RSR | HKD | CHINA |
| Xpeng Motors | Electric Vehicles, internet and autonomous features. | ENS | USD | CHINA |
| Yadea Group | Electric scooters and motorcycles, electric bikes. | EEF | HKD | CHINA |

| | | | |
|---|---|---|---|
| 107 stocks = % Weights Latter Q1 2025 | WEIGHT EACH COMPONENT % = | | 0.9345 |
| | | 0.93457 | |

Additions for Latter Q1 2025: FuelCell Energy, FSP Technology, SES AI.
Removals for Latter Q1: Ameresco, Archer, Brookfield, Neoen, REC Silicon, Xinyi Energy.

| 107 Stocks for Latter Q1 2025. | | # |
|---|---|---|
| Energy Conversion | ECV | 27 |
| Energy Efficiency | EEF | 25 |
| Energy Storage | ENS | 13 |
| Renewables - Biofuels | RBB | 4 |
| Renewables - Other | ROH | 5 |
| Renewable - Solar | RSR | 21 |
| Renewable - Wind | RWD | 12 |
| | | 107 |

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## Appendix VI:
## WilderHill Hydrogen Economy Index (H2X) for Latter Q1 2025 (61 components):

| NAME | Description | Sector | Activity |
|---|---|---|---|
| Aker Carbon Capture | Production of green / and blue H2 and its derivatives. | HG | NORWAY |
| Alfa Laval | Heat exchangers for green H2 production, electrolyzers. | HS | SWEDEN |
| Arcadis NV | H2 network, Netherlands, Europe, in planning. | HI | NETHER. |
| Asahi Kasei | Alkaline water electrolyzers, supplier of all components. | GH | JAPAN |
| Ballard Power Systems Inc | Fuel cells, H2 in buses, trucks, trains, backup power etc. | HT | CANADA |
| Belden | DC power from fuel cells, or intermittent wind & solar. | FC | USA |
| Bloom Energy Corp | Fuel cells, high temps can use variety of fuel sources. | FC | USA |
| Ceres Power Holdings PLC | Fuel cells, high SOFC temperature allows variety of fuels. | FC | UK |
| China Datang Renewables | Wind & hydro in China, that's developing H2 projects. | HG | CHINA |
| Chung-Hsin Electric | Fuel cells. Hydrogen, methanol reformers. | HG | TAIWAN |
| Corp. Acciona Energias Renov. | Green H2, new GreenH2Chain to ensure green H2 origins. | HI | SPAIN |
| Delta Electronics | Solid oxide fuel cells development, also electrolyzers. | FC | TAIWAN |
| DEME Group NV | Offshore energy infrastructure, green hydrogen. | HT | BELGIUM |
| Doosan Fuel Cell | Fuel cells, high temperature for a variety of fuels. | FC | S. KOREA |
| Evonik Industries AG | Chemicals, H2 carriers, membranes for eletrolysis, FCs. | HG | GERMANY |
| Fluence Energy | Energy storage software, hardware for green H2 on grid. | HI | USA |
| Fuelcell Energy Inc | Fuel cells, high temperature so over range of fuel sources. | FC | USA |
| Furuya Metal | Electrolysis, green H2, iridium coating for electrodes. | HG | JAPAN |
| Gevo | Renewable hydrogen, and hydrocarbons development. | HI | USA |
| Hanwha Solutions | H2 storage, refueling vehicles, drones, aerospace. | HS | S. KOREA |
| Hexagon Composites | Hydrogen storage, also RNG, composite tanks. | HS | NORWAY |
| Hyosung Advanced Materials | Advanced composite materials for hydrogen tanks. | HS | S. KOREA |
| Hyster-Yale | Lift trucks, powered cleanly by hydrogen fuel cells. | HT | USA |
| Industrie De Nora SpA | Green hydrogen, by alkaline water electrolysis. | GH | ITALY |
| Infineon Technologies | Power electronics, in green hydrogen, wind, solar. | GH | GERMANY |
| ITM Power PLC | Fuel cells, PEM; electrolyzer manufacturing green H2. | GH | UK |
| Johnson Matthey | Catalyst-coated membranes, in fuel cells, electrolyzers. | FC | UK |
| Kaori Heat | Hydrogen (H2) generators, methanol fuel cells (FCs). | FC | TAIWAN |
| Kolon Industries | Membranes, fuel cell PEMs, MEA commercialization. | HI | S. KOREA |
| LEM Holding | Power measurements, better fuel cell efficiencies. | FC | CHINA |
| Littelfuse | Hydrogen & fuel cell sensors, temperature probes. | HS | USA |
| Lotte Fine Chemical | Green hydrogen, production launch, ammonia. | GH | S. KOREA |
| Nel ASA | Electrolysis for H2 from water, using alkaline and PEM. | GH | NORWAY |
| Nexans SA | Cables, can carry both H2 + electricity, H2 pipelines. | HT | FRANCE |
| NFI Group | Hydrogen fuel cell electric power in buses, | HT | CANADA |
| Nippon Sanso Holdings | Hydrogen fuel, carried via ammonia for fuel cells. | HS | JAPAN |
| OCI N.V. | Green Ammonia, building up from biogas, hydrogen. | HG | NETHER. |
| Opmobility SE | H2 and fuel cell technologies in automobiles, trains. | HT | FRANCE |
| Orsted A/S | Green hydrogen directly from wind power, early stage. | GH | DENMARK |
| Plug Power Inc | Green hydrogen, and fuel cell systems in development. | HI | USA |
| Renesas Electronics | Hydrogen gas sensors, power controller systems. | HG | JAPAN |
| Renew Energy Global | Green hydrogen activity, India, Egypt, elsewhere. | GH | INDIA |
| Resonac Holdings Corp | Lower-CO2 hydrogen from used plastics; graphite uses. | HI | JAPAN |

| | | | |
|---|---|---|---|
| Scatec ASA | Green Hydrogen produced by solar power. | GH | NORWAY |
| Schneider Electric SE | Gas analysis, automation for advanced H2 storage. | HS | FRANCE |
| SK IE Technology | Large plants for liquification of blue hydrogen. | HG | S. KOREA |
| SKF AB | Advanced bearings, for H2 by compressed transmission. | HS | SWEDEN |
| SMA Solar Technology | Electrolyzer converters, green H2 from renewables. | GH | GERMANY |
| Solvay SA | Advanced materials, membranes & polymers for H2. | HI | BELGIUM |
| SungEel HiTech | Recycling platinum from fuel cell spent catalysts. | HI | S. KOREA |
| Spie SA | Hydrogen in mobility, H2 production, distribution. | HT | FRANCE |
| Thyssenkrupp Nucera | Electrolyzers, a purer play in hydrogen generation. | GH | GERMANY |
| Tianneng Power | Hydrogen, fuel cells, Li-ion and other batteries. | FC | CHINA |
| Toray Industries | Membranes for H2 purification, generation, fuel cells. | HI | JAPAN |
| Toyo Tanso | Graphite, nanotubes H2 storage, brushes in wind. | HS | JAPAN |
| Verbio Vereinigte Bioenergie AG | H2 from biomethane, biofuels, agriculture. | HG | GERMANY |
| W-Scope | Water electrolysis, by anion exchange membranes. | GH | S. KOREA |
| Wacker Chemie AG | Green H2 from water using renewables, into methanol. | GH | GERMANY |
| Weichai Power | Hydrogen uses in forklifts, fuel cell buses, Asia. | GT | CHINA |
| Wolfspeed | High power fuel cell systems, SiC, GaN. | HT | USA |
| Yara International | Green ammonia, H2 catapult aims for H2 <$2/kg. | GH | NORWAY |

For Rebalance in Latter Q1 2025:
Additions: Aker Carbon Capture, SK IE
Deletions: Brookfield, Dae Myoung, Neoen, TE Connectivity, Voltalia

% Equal Weight each component: 1.63934
61 Components % each = 1.63934

| Hydrogen Index H2X Sector | # |
|---|---|
| FUEL CELLS (FC) | 10 |
| GREEN HYDROGEN (GH) | 14 |
| HYDROGEN GENERATION (HG) | 9 |
| HYDROGEN INNOVATION (HI) | 10 |
| HYDROGEN STORAGE (HS) | 9 |
| HYDROGEN in TRANSPORT. (HT) | 9 |
| | 61 |

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## Appendix VII: WilderHill Wind Energy Index (WNX) for Latter Q1 2025 (66 components):

| Name | Description | Sector | Activity |
|---|---|---|---|
| Acciona | Sustainability infrastructure, engineering. | SG | SPAIN |
| Alfen NV | Smart power grid, energy storage systems. | SG | NETHER. |
| Allis Electric | Transformers in grid, switchgear, inverters. | SG | TAIWAN |
| Arcadis NV | Engineering, EPC, develops wind projects. | WI | NETHER. |
| Atkore | Conduit, cables, electrification assemblies. | SG | USA |
| Belden | Wind cables, turbine data communications. | WM | USA |
| Boralex Inc | Development and operation of wind farms. | WF | CANADA |
| Cadeler A/S | Offshore wind construction, maintenance. | WF | DENMARK |
| China Datang Corp Renewable | Among largest listed wind operators in China. | WF | CHINA |
| Corporacion Acciona Energias | Wind, global energy exclusively renewables. | WI | SPAIN |
| CS Wind | Wind power, both onshore, and also offshore. | WF | S. KOREA |
| DEME Group NV | Offshore wind infrastructure, undersea cable. | WI | BELGIUM |
| Daihen | Transformers, power distribution, inverters. | SG | JAPAN |
| EDP Renovaveis SA | Wind, among the world's largest generators. | WI | PORTUGAL |
| Elia Group SA | High voltage power transmission, Europe/UK. | SG | BELGIUM |
| Energix Renewable | Wind, solar, independent power producer. | WF | ISRAEL |
| Enlight Renewable Energy Ltd | Builds and operates wind, also solar sites. | WF | ISRAEL |
| Eos Energy | Zinc batteries, safer alternative to Li-ion. | SG | USA |
| ERG SpA | Wind, going from fossils to clean renewables. | WF | ITALY |
| Fluence | Energy storage, using intermittent wind in grid. | SG | USA |
| Fortune Electric | Wind power transmission, grid transformers. | WI | TAIWAN |
| Fujikura | Power cables, overhead transmission lines. | WM | JAPAN |
| Furukawa Electric | Cable connectors, electrical conductors. | WM | JAPAN |
| Grenergy Renovables | Wind, development, construction, operation. | WF | SPAIN |
| HD Hyundai Electric | Power transformers, circuit breakers for grid. | WM | S. KOREA |
| Hubbell | Electrical gear, modernizes grid, utilities. | SG | USA |
| Hydro One | Electricity transmission, distribution, Ontario. | SG | CANADA |
| IMCD NV | Wind lubricants, 100% recycled blade foam. | WM | NETHER. |
| Infineon Tech AG | Converters and inverters, wind power systems. | WM | GERMANY |
| Innergex Renewable Energy | Independent renewable producer, wind. | WF | CANADA |
| Landis&Gyr | Smart Grid management, advanced meters. | WM | SWITZER. |
| LEM Holding | Power measurement, transducers, wind, grid. | WI | CHINA |
| LG Energy Solution | Batteries, ESS for strenghtening the grid. | SG | S. KOREA |
| Littelfuse | Wind controls, sensors, circuit protection. | WM | USA |
| LS Electric | Offshore wind power, transformers & grid. | WI | S. KOREA |
| Mersen SA | Carbon brushes in wind power, & graphite. | WM | FRANCE |
| Nexans SA | Subsea cables for offshore wind farms. | SG | FRANCE |
| NKT A/S | High voltage DC offshore wind, cables. | SG | DENMARK |
| Nordex SE | One of world's largest wind turbine makers. | WI | GERMANY |
| Orsted A/S | Renewable energy - transitioned from fossils. | WI | DENMARK |
| Prysmian SpA | Cables for new offshore wind and grid. | SG | ITALY |
| Quantumscape | Solid state batteries, lithium, grid storage. | SG | USA |
| Renew Energy Global | Utility scale wind in India, also green H2. | WF | INDIA |
| Renova Inc | Independent renewable power producer. | WF | JAPAN |

| | | | |
|---|---|---|---|
| Rexel SA | Smart electrical systems, energy efficiency. | WM | FRANCE |
| Scatec ASA | Wind farm, new 5 GW, green H2, ammonia. | WF | NORWAY |
| Schneider Electric | Advanced grid, wind energy management. | SG | FRANCE |
| Shihlin Electric | Heavy transformers for grid, EV charging. | WI | TAIWAN |
| SKF AB | Wind gear rolling bearing, seals, mechatronics. | WM | SWEDEN |
| SMA Solar Technology | Wind power conversion; green H2 from wind. | SG | GERMANY |
| Spie SA | Energy infrastructure sustainability, Europe. | SG | FRANCE |
| Sumitomo Electric | Power cables for offshore wind, grid, SiC. | WM | JAPAN |
| Ta Ya Electric Wire | Power cables, wires, magnetic wires, grid. | SG | TAIWAN |
| Taihan Electric Wire | Submarine cables wind, solar; high voltage. | WI | S. KOREA |
| TECO Electric & Machinery | Turbines for wind energy, and EV motors. | WM | TAIWAN |
| Terna Rete | Europe's largest independent grid operator. | SG | ITALY |
| Timken | Engineered bearings, friction management. | WI | USA |
| Tocalo Co. Ltd. | Advanced surface coatings in wind, lubricity. | WI | JAPAN |
| Toray Industries | Carbon fiber for wind turbine blades. | WI | JAPAN |
| Toyo Tanso | Graphite, nanotubes, in wind, H2 storage. | WM | JAPAN |
| Valmont | Strenthening grid, for more wind & solar. | SG | USA |
| Vestas Wind Systems A/S | One of first, largest, wind turbine makers. | WI | DENMARK |
| Voltronic Power | Power converters, inverters, energy storage. | WM | TAIWAN |
| Wasion Holdings | Advanced metering, energy distribution. | SG | CHINA |
| WESCO International | Utility electric for grid, assists renewables. | WM | USA |
| Wolfspeed | Silicon Carbide SiC in wind, better efficiency. | WI | USA |

For Rebalance Latter Q1 2025
Additions: Cadeler, LG Energy Solutions, Tocalo Co ltd
Deletions: Brookfield, Covestro, JL, Neoen, Shinfox, TE, Voltalia

66 components = 1.51515% Equal Weight each 1.5151515

| 4 WilderHill Wind (WNX) Sectors | # |
|---|---|
| SMARTER GRID (SG) | 21 |
| WIND FARMS (WF) | 12 |
| WIND INNOVATION (WI) | 17 |
| WIND MATERIALS (WM) | 16 |
| Total = | 66 |

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*Covestro was bought out was removed from the WNX in late Q4, effective 5 December 2024.*

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Disclosure: from the 1990s the co-founder and manager of the ECO Index began to sell personal holdings pertinent to any polluting fossil fuels - and to buy/hold instead equities in this clean energy space due to personal convictions and over strong concerns about climate change crisis; some of these may be in the ECO Index and they are all held very-long-term only.

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ECO rebalances quarterly at the end of each March, June, September, December.
NEX/H2X/WNX rebalance quarterly at the end of each February, May, August, November.
For more on all 4 WilderHill Indexes, see: https://wildershares.com – or https://cleanenergyindex.com
For the 1990s antecedents in an original Wilder-hill Hydrogen Fuel Cell Index, see http://h2fuelcells.org

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