WilderShares, LLC

Q2 WilderHill® Quarterly Report: ECO, NEX, H2X, WNX Indexes, June 30, 2024

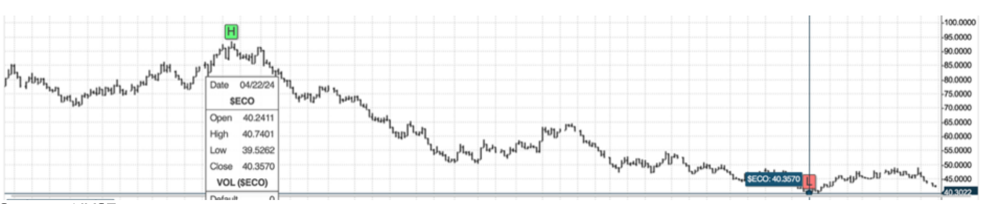
The Clean Energy Index® (ECO) began Q2 at 48, and ended Q2 at 42, down about -12%. Despite hopes last year that inflation might slow and Fed pivot – it hammered this volatile theme all 2023 as ECO ranged from 100 to 70; then in October of '23 it plunged to last year's low of 51. In this capital-intensive interest-rate sensitive story, fears pressed down – vs some eagerness for capital costs to moderate, supply chains loosen. As it grew clear in 2024 rate cuts *weren't* coming early, pessimism again struck; clean energy touched its 1st half low of 40. Year to Date (YTD) 2024, ECO was down in 1H by some -32%. Or last few years, ECO rose +58% in 2019. Remarkably it then rose strongly +203% in 2020 for about the very best performance by any Index or any Fund anywhere. Unsurprising maybe after such gains in 2019 & 2020, ECO fell by -30% in 2021, was off hard -46% in 2022, dropped -22% in 2023 as high rates, supply chaos, perhaps recession - beat out the decarbonization that may favor renewables ahead.

ECO's passive theme is clearly risky & falls hard. From up in the 270's in 2021, down to 40s in 2024, clean energy's story and so ECO plummeted over ~4/5ths. ECO Index®, Global NEX, Hydrogen H2X, Wind WNX can & do at times 'drop like a rock'. Jumps true, yet crashes too. Our mission is to capture and track this highly volatile story hence crashes must be expected. Volatility pervades not only wind, solar, but all renewables, electric vehicles, batteries, hydrogen, energy storage, decarbonization, greening of everything; it's always been thus.

Take say since start of 2023, when ECO was at 80; clean energy benchmark ECO was here down -44% to mid-June 2024. Yet same period an independent tracker for natural gas (it's not ours as we focus on clean themes), and gas is key in generating electricity, fell more: natural gas was *down by* -64%. And while the 1st global clean energy NEX was down here too, -22% since 2023 and up only +7% the last 10 years – so barely above water – that's still far 'better' this latter period than natural gas which was down by -95% the last 10 years!

As clean energy touched a low of 40 in Q2, some asked if this theme might, just possibly, be troughing ahead? *Impossible to say!* And any possible inflection(?) would only be coming *after* 3+ strongly down years. Yet at least new H2X & WNX help show this in more granular ways. And as we saw YTD to end-of-June 2024, wind (WNX) though barely up +1% still stood out on small gains within grid infrastructure; Hydrogen (H2X) was 2nd yet was well down by -12%; the NEX was 3rd down by -15%, while ECO trailed at 4th and was noticeably down a big -32%.

In sum, Hydrogen H2X & Wind WNX join respected ECO & NEX benchmarks for 4 pure plays in facets of new energy. Meanwhile, energy once mainly in fossil fuels taken from deep down underground and then burned – increasingly now comes from renewable sun & breezes, gifted to us all sustainably from up towards Heavens. Here's volatile ECO to late in Q2:



Source: NYSE.com

As noted, 2024 began with strongly downwards moves, pushing past 3 years the big falls seen 2021, 2022, 2023. Charts were thus ugly across clean energy. Indeed first 3 weeks to Jan. 21st, ECO had closed off each day but one. After starting Jan. 1st at 62.05, by Jan. 21, 2024 it was already down to 49.04, fast off -20.9%. As the original to capture & track the clean energy theme, ECO calculating 20+ years now enables one to look far, far back for a January of comparable decline. We thus could see that Jan. of 2008, ECO had opened then at a high of 288.21, and ended that month well down at 226.22: hence the clean energy story and so ECO had similarly gone quite negative some -21.5% in that first month of distant 2008 year.

There remained this 21st day of more recent 2024, another 8 trading days left in that month. Where then, might this Jan. of 2024 end? Near a -21.5% fall like 2008? If so, not too weighty: just 2 roughly similar figures isn't saying much at all. Sparse portent for whatever's next! Plus, there's big differences: early 2008 had come after big gains, then fell back. The opposite of Jan. 2024 that was extending a steep plummet. In other words, a +60% *rise* had happened just before in 2007 – clean energy went from 180 start 2007 – to 288 last day 2007. That prior jump maybe, just possibly, differently, perhaps helped set a stage for a fall more than most, *down hard in* Jan. 2008. And of course, that -21.5% fall first month 2008, neatly heralded too an advent of the Great Recession. That was a time of enormous broader declines.

Or see *intraday* lows for maximal drops. Jan. 2008's intraday nadir was a 203.71 on Jan 22nd – a max fall of -29.3%. By contrast Jan. 2024 had hit its lowest low, so nadir 47.35 on Jan. 19th for a quite lesser fall of -23.6%. 2024's dive differed too by extending falls of a past 3 years – and fell further all Q1 & then Q2 2024 – so if any coiling of spring, was still ongoing in 2024! But again, 2 mere cases of only rough-like plummets in 2 January's years apart, after opposite moves – are of little weight! Jan. 2022, clean energy so ECO also fell from some 150 - to 118, for a 3rd January down too, by similar sounding near -21%. (Parenthetically Jan. of 2023, ECO went from 80 to 96 – so a move also near +20% … but then up!). Yet all is just musing, playing with numbers. Finding patterns by looking backwards only, owing to joys of ample data here. Even if there's a reversal ahead in a regression to mean, at some point, it's just supposing. There's no way to surmise from just that, what may yet happen ahead. One could only look at such thin gruel past and then guess (and be typically wrong!) about the future.

Confounding all is a pace by which new renewables have been going in, setting records for wind, solar, grid, batteries, hydrogen, etc. Global low-carbon investing had hit a record $1.77 Trillion in 2023 – up a big 17% from 2022. How then, can this theme's stocks be plummeting, down for years, again in 2024 – even as clean energy itself grows globally?! We'll look at that curious fact in pages ahead. Just a brief mention here is as margins compress, with green energy pricing in decline – so too are profits hit hard. Meanwhile as China aims for ever-more market share, ever-lower prices + full employment - it has moved past overcapacity fears. Unlike in the West where profitability is a prerequisite. As US & Europe projects get pushed out, delays do persist on interconnection/transmission (IX/TX) chokepoints. Other issues are extant too. Like a scarcity of high voltage transformers, breakers, smart grid, of proper pricing by offtakers throttling back gains. We'll discuss ahead many thorny factors, perhaps diverse reasons why green energy stocks fell back hard over a recent 2021 to 2024.

Anyway a few days later ECO closed the 1st month 2024 at 49 (49.43 close) for 1st month's loss of -20.3%. Dropping so hard in Jan. 2024 after opening at 62, let's look at what components were down the most 1st month 2024. In all 4 Indexes: ECO since 2004 for US listed stocks; NEX since 2006 in *global* clean energy thus with components mainly outside the US; and in 2 newer themes, the global H2X for the hydrogen economy, and the global WNX for wind energy.

First up then, is ECO. By late Jan. 2024 its components most *down* Year to Date had included: a Lithium producer (off -45% as lithium rose then plummeted on spot prices -80% from year prior); a Chinese EV maker (-42% on cutthroat competition); another China EV maker (-38% on same price wars); a solar PV manufacturer (-36% suffering like the rest from overcapacity), again lithium (-36% on lithium bubble bust). ECO's downers had common threads; repeatedly seeing *lithium* was no surprise as a boom & bust commodity. Both US listed & global names were hit 2023/24 as this battery element fell, nickel too in its 'lesser' crash -50%. *Solar manufacturers with some US listed names yet based in Asia where production's cheap, faced over-capacity, fast-falling prices. Only a few names in ECO were up in Jan. 2024. One up the most (+11%) was in speculative solid-state batteries – up on hopes for production. In sum ECO was down all January: it declined the most of these four WilderHill themes, off -20.3%

At NEX, components most down in January included a Swiss/German name (off -42%, it may make PV instead in US on IRA incentives, so compete with China); an EV Charging firm (-36% on difficulties achieving wider profit margins); an EV maker (-34% like many struggling on costs of needed capital); biodiesel & bioethanol maker in Europe (-31% on its product still too costly vs. fossils); and a US residential solar PV installer (-31%, sub-theme decimated of late). Most up here included in graphite in wind, SiC, FCs (+30%); and one in transformers (+14%). Here, year to date to end of Jan. 2024 the NEX was down rather less than ECO, at -13.4%.

At global hydrogen H2X names most down Jan. included an 'OG'/old-school US fuel cell maker (-25%, its high temps FCs can use various fuels yet profitability still elusive); another FC maker (-23% in solid oxide FCs and producing hydrogen; a Norwegian producer & distributor of H2 (-22% making electrolyzers, fuel stations); a German maker of electrolyzers/ converters (-21% on green hydrogen/renewables); a Korean name in advanced composites (-18% and works on H2 storage tanks, since H2 would embrittle steel tanks). Most up here included a maker of graphite used in H2 FC systems (+30%), and related transformers/chargers (+14%). Jan. 2024 this H2X theme was down -7.9%, and so it did rather 'better' than both NEX or ECO.

At the wind WNX theme, components most down were a German name in wind converters (-21%); a Spanish renewables provider (-18% operating wind farms); a S. Korean maker of wind towers (-18%); a German wind operator (-16%); a Spanish firm in construction of wind farms (-14%). Many names were Up Year to Date/YTD in WNX: a Japanese maker of electric cables (+10%), transformers maker in Japan (+9%), French firm in electric services (+8%), and Japan-based name in renewable wind. For all January 2024, wind WNX was down the least of these 4 WilderHill themes, off 'just' by -5.9%. Hence, WNX along with H2X Index did 'better' in first month 2024, than did NEX or ECO. Yes, globally a record amount, at 117 GW new wind power was installed 2023, 50% better than 2022. Cumulative global wind capacity reached then 1,021 GW, about like a thousand nuclear reactors (although wind, being intermittent, is not always on – unlike nukes). And yet, it was far from enough to meet climate goals of 'just' 2.7 degrees F; that would require wind to rise much faster, by a new 320 GW/every year.

Early 2024 clean energy/ECO had 1st hugged near 50 – then dropped to a resistance near 47 on Feb. 5, Feb 23, March 6, & 12. After, fell to low 40s on March 19, near -30% YTD. Could go lower in 2024 of course; was little surprise as it fell to a then 2024 nadir bottom of 40 (40.24 close) on April 19th. In May, it rose a bit part on US tariffs on China-made renewables & EVs as may mean better margins, though no solution long term. Part up maybe too on renewables as a play on AI & need for more energy; also on meme mania in this deeply-shorted sector. Rest of Q2 it bounced in mid/low 40s, first up +20% over that low point, then drifted back late June to a close at 42.19 – barely above its 40 nadir to end first half of the year.

One reason for struggles here, was sub-themes like solar inverters were going through tough times. For example, a US inverter maker saw Q4 23 sales down 65% - vs. a better Q4 in 2022. Gross profit margins went from a positive 20% - to negative 18%; it *lost* $2.85/ share vs. had *earned* $0.36/ share in a prior Q4 2022. On destocking headwinds in 2023, it had cut excess inventory, less sales, meant no joy, its optimizer/string microinverter faced microinverters at a competitor. Hopes were, perhaps, of some troughing say in latter 2024 or in 2025, top line EPS returning to growth; but were just hopes; 2024 did not start out as auspicious.

Grid infrastructure saw a small gain in **wind WNX**, top, not amplified so in ECO, NEX, H2X. Here's a chart for 1H (first half) 2024 for our 4 WH themes to end of June; this also includes 5th an excellent (not ours) solar-only tracker. As noted **wind** was barely up at +1%; **hydrogen** was down about -12%; **NEX** was down -15%; an independent **solar-only** tracker was off -24%; ever-volatile **ECO** was sizably down about -32%. Solar in short continued seeing headwinds, as clean energy broadly including EVs, lithium, cleaner fuels, solar etc - saw overcapacity, impactful declines. Those overshadowed much narrower gains within grid infrastructure:

Source: Yahoo!Finance

Thus, the pessimism of early 2024 was formidable. Interest rates held higher for longer, had been painful as noted. Not long ago, longer renewables' project-cycles had meant they'd enjoyed interest rates *falling*. But as rates rose, high-discount setting, renewables' values fell. Oil shale with its value derived upfront grew more valuable. Drill a shale well & one may see money back quickly; maybe a year, or <5 years. So higher rates had lesser impact on oil & gas. Meanwhile, renewables were hit by heavy, longer carrying costs, vexing green stocks. Longer permitting times in wind, PV, interconnection IX/TX delays etc - were all bigger headwinds than when 'money was free'. The world had added 445 GW new solar in 2023 – yes most of it by & in China – an immense figure, more than all other energy sources combined - any year in history! Yet on overcapacity, was hard to make profits in solar. And ECO/NEX that had risen so very much in 2019 & in 2020 – afterwards saw very big falls in 2021 to 2024.

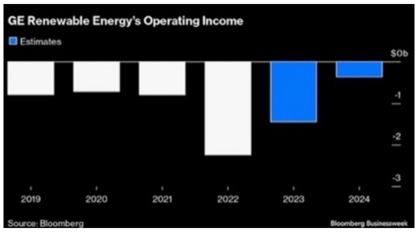
Federal Reserve Economic Data (FRED) for Fed Funds Effective Rates 2020-24, shines a light, as level & direction of Interest Rates can have a heavy influence on clean energy's theme. From a low rate of 1.55% seen Jan. 2020, the Fed had dropped rates yet further (free money!!) to just 0.09% Dec. 2020. Low & falling rates had boosted long-cycle renewables: thank you, Central Banks + little inflation! But rates afterwards leapt - from 0.08% in Jan. 2022, to a once-normal and yet now far-higher 5%+ in latter 2023. Hence big falls in renewables stocks 2021-2024 were perhaps not so surprising on spikes. Central Banks had to head off inflation; just was that they'd responded very late to fast-gathering inflation. That had resulted in those years in some of the fastest interest rate increases seen in, well, nearly-ever.

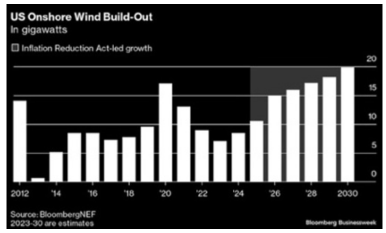
Broadly, at least 15 factors were perhaps at play in clean energy's bearishness 2021-2024. *Debt was sharply up in US/Europe - & in China (eg Evergrande); *Big Inflation too in the West; thus as *Interest rates & credit costs went higher, *Hopes for margin expansion/profit in solar, wind, EVs were dashed. *Funding & New Rules needed 'yesterday'(!) were too slow to come from US Federal agencies. As in *2023, 100+ US residential solar installers went bankrupt, 6-fold a number of prior 3 years, US residential solar installs were down ~15% in 2024, California maybe down 40%-50%. *Overcapacity in China in solar, wind, EV manufacturing seemed to be sticky short + medium term, thus bubble fears. *Some supply chains remained clogged, despite *Less Demand for EVs, wind, solar, with spate of higher costs. While *Large-cap stocks did do better than the mid/small-caps - conversely *Speculative disruptive firms as here faced poorer sentiments, and *100+ SPACs since 2020 that diluted investments. *Ongoing China/vs. Western Tensions threatened to decouple strategic green trade. *A New House Speaker's 1st bill had sought to cut the IRA funding; as a brief *stock jump here late 2023 re-raised over-exuberance worries. Finally, some *Exhaustion on fears raised repeatedly by scientists and given their alarm-bells as to what climate crisis irretrievably may/or will surely mean.

A brief November 2023 low had given way to brief inflection up: ECO in that month was up +8%. NEX up +10%. Hydrogen H2X up +10%. Wind WNX up +13%. In Dec. 2023, the 4 green stories (but not Nat. gas) jumped on a Fed note of maybe declining Rates in 2024. Nov+Dec, NEX was up +23%, H2X +20%, WNX +28%. Yet, October had dropped so hard, 4th Quarter 2023 ECO still *fell* -5.8%. Of course, not just ECO declined 3 years in row. Other competing themes here too had dropped then as well: ECO just presents the longest record, most data.

Raised a Why. Why perhaps had clean energy themes briefly(?) hit then-lows? Why hit brief(!?) bottom? Look at wind, as one facet in this story. On Oct. 31, 2023, US offshore wind made headlines when Orsted abandoned contracts to develop 2 wind farms off New Jersey. Why might such 'failure' be a 'positive'? Well, big wind manufacturers like GE, Siemens – were *losing* money on each enormous offshore turbine/tower delivered. GE had contracted to supply turbines, but that deal for 1st New Jersey wind farm was negotiated 3 years prior. GE was then stuck delivering units even after wind prices jumped 40%. Thus, a $1.5 billion deal obligating GE for new turbines/towers, was putting it ever-deeper in a hole. Ending that contract, ironically, might notably help to reduce its huge $6 billion backlog.

As GE was splitting up for profitability. GE's renewables lost $5.6 billion in 2019 to Q3 2023 – but onshore wind was becoming profitable tail end. Like grid unit's late 2023 small profit in distribution, first in years. Sour headline of a project cancelled, maybe helping mitigate US wind issues. First step if digging oneself into a hole is: stop digging! As GE's renewables narrowed losses, a bottoming(?) ahead seemed, maybe, just a bit possible. Q3 2023 losses slowed to -7.6%, off scarier -26% year before. Some certainty rest of decade came with new incentives in 2022's IRA law (discussed ahead). Seen in wind stocks captured & tracked too by say, WilderHill Wind Energy Index (WNX). As GE concentrated focus after a $500 million charge to repair & maintain its turbine fleet, a new focus at spinoff GE Vernova was on fewer, proven 'workhorse' designs, turbines, towers. A prior too-many tower designs at 40+ in 2021, was being brought down to 9 by 2025. Rotor options cut from 15 to 4. In hopes profit margins might, *possibly,* begin to emerge in years ahead. So, 2023/24 saw, just maybe some maturing in the *onshore* US wind segment. Rather optimistically there were some new hopes that perhaps later even this decade, one might finally start to see an idea of profits ahead:

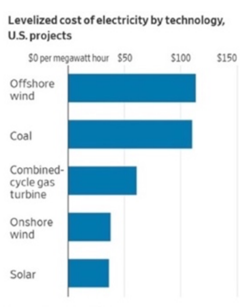


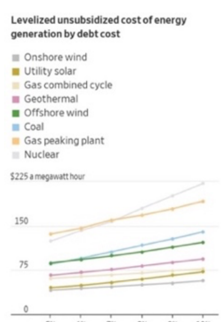


Source: Bloomberg Source: Bloomberg

Many green themed-baskets, like ours – had shown brief bounce Nov./Dec. 2023 - then fell again 2024 – elongating 3+ years of declines. Partly on wind: Orsted in 2024 had pulled out of 2 offshore wind contracts in Maryland USA – on insufficient prices offered USD $131/MWh, $71/MWh. Still, it kept on building – hoping for more $$ ahead. Or consider offshore wind leader UK, with 4 big offshore wind farms. Wind made 13.8% of its electric power 2022 so UK knows a thing or two about successful wind! Vs. a US just-starting offshore, baby steps from scratch, immature supply chains, no installation vessels, vexed! Yet UK had its own issues. It had offered government support of £44 per megawatt-hour (MWh) for offshore wind in 2023 – got No takers, so auction flopped. Though was an unsurprising level just a few years prior. Only after it raised it 66% to £73 late 2023 – may it see bids. And a lot of bids needed if UK is to raise offshore wind capacity 4-fold. From a 13 GW - to 50 GW targeted capacity 2030, it would need to fast attract 6-8 GW new offshore wind bids, each year for next 5 years!

EU put in a new 17 GW wind – yet was also far from 2030 targeted new 30 GW, annually. Cash-strapped Germany stepped up late 2023 even as it pared back on belt-tightening. Gave billions of Euros to support Siemens Energy – that didn't expect to return to profitability 'til 2027 - yet improved clarity ahead. GE in US figured to lose $1 billion on offshore wind 2023, 2024 – yet new clarity. As China's wind makers grew to be among biggest: Xinjiang Goldwind (16 GW commissioned in 2023) and Envision (15 GW); Vestas 13 GW, Windey, Mingyang, and GE in US – as China increasingly grows overseas. German support led to 124 solar projects, 1,600 GW new capacity helping push down solar prices 2024 to just EUR 0.051 (USD 0.056) each kWh – better/lower than prior 2 rounds at 7 USD cents, 6 ½ USD cents. In a US where offshore supply chains are immature, things were sanguine. Its offshore wind costs had risen 40% as wind grew pricier than gas in 2023, near coal. Onshore wind & PV stayed best, cheapest-options if one considers costs of energy vs. debt costs. Clearly better vs. the two costliest: nuclear & gas peakers at other end. Coal, and offshore wind sat then in middle, hit somewhat on costs. And the 3 relative winners were *Baseload natural gas combined cycle, *Utility-scale solar, and *Onshore wind farms – the 3 lowest on costs vs debt:





Source: FactSet, Wall Street J. Source: Wall Street J./ Bloomberg NEF Source: Lazard, Roland Berger, WSJ.

As to why perhaps solar stocks dropped 2021-24, one issue no doubt was China's tremendous & growing solar manufacturing capacity. Shorn of market guardrails, of profit/loss signals dominant in the West – had meant solar's profitability was being decimated worldwide.

From start to end of 2023, PV poly prices fell -50%, panel prices were down -40%. Such super-cheap PV was a tough hurdle for a Europe, US trying to compete. China's solar glut even was thorny to its own solar-firmament, its state-guided economy seeks employment, ever-lower prices, market share. By 2022 China was 90% of world spending on clean energy manufacture, $80 billion. As a bewildering array of firms sought to come in and sell more PV, a dozen China PV names had to put their own expansion plans on hold. 70 listed firms there moved into solar - from dairy farming, fish feed, jewelry, fashion, real estate, chemicals etc. (Bit of a story seen before; Toyota of Japan had begun with weaving looms). A Chinese poly leader defied oversupply fears; it aimed to *add* 575,000 tons more capacity 2024, more than a 200,000 tons needed on market growth. After China's poly oversupply shakeout 2010-13, again 2018-20, fears were of 3rd wave; China poly prices falling to record lows, say <USD $6.75 per kg. Chinese poly rising to near 90%. Yes, non-Chinese poly commands *somewhat* higher prices on domestic-made product. But this big and ever-widening gap was getting 'ridiculous'...

As PV profits collapsed, margins contracted, many problems challenged solar. Finished China PV was *sold* in Europe at near ½ the cost of *producing* panels in Europe. Winners few. China looked 2024 at lifting its 5% cap on curtailments – more green energy. In side-point, solar *may in theory* grow huge: just a square 100 miles x 100 miles of solar in southwest US deserts, in theory could make all America's electricity. Just 0.06% US continental land, for 4 million GWH. Of course, it's intermittent as solar - so add 1x1 miles of batteries. Add another 1x1 square miles for storage via green hydrogen, or ammonia, methanol. Powerlines to move power, IX/TX will take more space of course. But it's viable in theory and moves past thermal coal, gas, nuclear. China can do it + far more PV/wind, many-fold over. Nothing is technically prohibitive: China could sop up its excess capacity too on PV made + used in its vast interiors. Its Gobi and western deserts. Consider: in 2024 power made there equaled ½ of all US generating capacity. Was 500 GW in northwest China (5 inland provinces including Xinjiang) plus 100 GW more made in Gobi = 600 GW and growing fast. Most new energy in northwest China is now solar/wind with ultra-recent voltage DC transmission lines. And over 500 GW solar/wind is planned in China, perhaps hundreds of renewables (mega-) bases. Kubuqi desert energy base 16 GW when done. In India, too. Dwarfing anything in the US! There's immense renewables mega-base potential in China and its desert regions. And for India too.

Solar's outlook 2024 dimmed on overcapacity. China domestic production targeted ~750 GW, while demand might be ~550 GW. As a US faced 100+ bankruptcies/shut-downs in downturn. According to one firm, potentially it may get worse: 500-750 US residential solar install firms may go away. A firm estimated 2024 that of a total of 5,000 US solar installers, some 10% to 15% may disappear. As California by its own hand, faced much worse scenario due to NEM 3.0, as ½ its residential solar installers may not make it. New California NEM 3.0 rules discussed ahead meant the Golden State was looking at maybe a huge 50% plummet in residential PV installations! New rules there made home rooftop solar alone - without battery storage - very unattractive as an economic proposition. Once a proud leader, prognosis near-term 2024 was only for shallow recovery there. So sad a fate, for solar PV at once-proud California.

A longstanding US solar name issued a going concern letter. Debt, uncertainty abounded early 2024: was not auspicious, may shed some light on why solar stocks were so down for years. All while solar installations were, in a real sense, growing. In Europe too, a near-last PV maker looked to leave as local PV-making there neared extinction. So hard to compete vs cheaper Chinese PV imports sold at (below cost?) bargain-basement prices. A Swiss/German name looked to leave Freiberg, Germany - for next Arizona/Colorado - on IRA domestic-content incentives for those willing to start manufacturing new solar PV modules within America.

Picture what Europe's PV makers faced, as some China PV was sold maybe *below* production costs. Europe doesn't impose Tariffs (unlike US), so Chinese PV appeared in Europe oft at *half* or less US prices. Downstream, European installers opposed Tariffs, wanting cheap panels! As India added 20.8 GW solar module manufacturing capacity in 2023, which by 2024 reached 65 GW. All that new capacity dimmed prospects to grow PV manufacturing in the EU, or in US. Solar price wars 2024 (like seen in EVs, as China eyed building cheap EVs in Mexico) – chilled industry. China was growing its capacity & efficiency fast. We note that in 2023 alone, China installed an immense 216 GW of solar – which was more than the US which had invented PV, and installed a record 19.6 GW utility-scale PV in 2023, *had ever installed to date!*

For a scale & pace of solar pricing declines, consider 2 compelling paragraphs from Raymond James dated February 7, 2024, marking 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 a ly of $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 makes clear how relentless & ruthless solar PV manufacturing in, or outside of Asia – has become! Yes, steeply falling prices conducive to growing installations. Yet PV module pricing mid-2024, was about 1/2 of March 2023. Wind too, faced other pricing issues. There, inflation in materials & labor, in warranty claims, inadequate off-take prices – hurt. Yet some hope was for maybe some troughing; eg France's successful wind tender 2024 oversubscribed at 1,800 MW saw >1,000 MW awarded, 577 projects at weighted avg. EUR 87 (USD 93)/ MWh – up from before. Higher off-taker prices, improved profit expectations could be a salve for wind. Consider too renewables pricing going to or below zero if sunny/windy – can/ does vex fossil+nuclear competitors: less-nimble fossils/nukes must contend with ever-high fuel costs, need to dispose of pollution, wastes. Yet it can vex also investments in renewables, too! The future, just perhaps, just maybe, possibly is pro-renewables-biased. Still, getting past a tumultuous near-term early/mid-2020s, to reach perhaps a real profitability later, has been & remains a huge obstacle. A thorny gulf to navigate! Would be no easy feat (if done ahead?) to see better margins, sustainable spreadsheets not only in solar/wind/storage – but also in EVs etc. Hence a question mid-2020s is how long must-loss-making sub-themes endure dismal results before renewables, EVs, and better grid, might become profitable ….

Here there's recent tailwinds: *Old Utility-brown-power is getting costlier; *45X credits will help US to make solar, inverters, wind, batteries; *US electricity demand rising 2024, 2025 at 4,099 billion kWh, 4,128 billion kWh beats a record 4,003 billion kWh of 2018; as *US heating & transport gets increasingly electrified, so new *Demand is Certainly There. Consider too competing natural gas & nuclear are hobbled; gas is core to US power generation a steady 42% in 2023 & 2024. Like oil – gas has bit of price floor say $1.50/mn Btu, under which it gets chaotic (for oil is <$20/barrel – though neither stays there long!). Gas supply did rise fast on war but prices then fell in 2024. Meanwhile, nuclear is very costly in the West; US nuclear made a static 19% of America's electricity in '23, '24, '25. Coal's share is falling - from 20% in 2022, to 17% in 2023, 15% in 2024, 14% 2025. Coal in 2023 was just ½ its role in US electricity vs. a decade prior - mostly replaced by natural gas. While electricity from new energy like wind, hydro, and solar *rose* from 21% in 2023, to 23% in 2024, on to 25% in 2025.

Yet for US makers of PV, inverters, wiring, trackers etc, products get commoditized. Harder to differentiate premium brands. In 2024 the very biggest PV maker in China so world, asked its government to bar competitors from selling PV at below cost; those sub-par failing panels were giving solar a bad name. While a US premium solar brand with IP protection had guided Up in 2024, revenues expected to be up 36%, 2/3rds thanks to new Sec. 45X credits. In this arena one analyst firm felt a leading PV name competing against commodity panels, could trade in range 8-12x EBITDA - Earnings Before Interest, Taxes, Depreciation, Amortization. They expected long term revenue growth to be 8-12%, EBITDA growth 1.5x; that stock then was trading at multiples of just 5.5x of 2025E EBITDA, so was hardly a high or very risky estimate. Hence late 2024/early 2025 might be an interesting time, one to look around and see if overcapacity, lost margins are being better-addressed. Equities, ever forward-looking, will seek to anticipate such moves - well ahead of when they *may* in fact arrive.

In other news, 2023 had separately brought news of 7 new US 'clean' hydrogen hubs to get $7 billion federal funds ahead. An Appalachia hub to get $925 million but using natural gas – so-called 'blue' H_2 which isn't truly clean. California to get $1.2 billion for its renewable H_2. Gulf Coast gets $1.2 billion – that's partly natural gas to H_2 so not truly clean – but also renewables too to H_2. America's Heartland gets $925 million partly to decarbonize agricultural fertilizer-use. Mid-Atlantic gets $750 million for H_2 from renewables, but also from nuclear. Midwest will apply H_2 ahead in steel, glass, power production, also sustainable aviation fuels and gets $1 billion. Pacific Northwest will use electrolysis for clean H_2 and gets $1 billion. Of course green, local, clean-H_2 on 'additionality' from new renewables is always best. Thus, on adding new clean power+H_2 that's matched to hours when sun shines, the wind blows.

A COP28 Climate Conference concluded late 2023 choreographing a shiny (oily) veneer of success. It highlighted an Agreement to reach 3x global renewables capacity by end of decade: nothing wrong there! The petrostate heading it was very smart to put 3x in front. But what they did Not highlight, is also worth considering. Fossil employees/ reps dominated that COP28 like never before: ~4 times that in Egypt a year before; 2,400 people – was greater than any Country Delegation (except Brazil). Quietly too they'd made *Petro-states' interests centerpiece there – eg citing 'carbon capture' (that can allow oil/gas and coal to go on decades to come) – while *Removing teeth from final language. COP Drafts went from perhaps 'phase out" of fossils – to a softer "transition away from". Some silliness too like "responsible yachting". Worse was wording that sought mainly to 'accelerate' so-called 'carbon capture and storage'. This COP's end-product was deemed 'devastating', 'dangerous' by many climate scientists, but in saltier language. Fossil-fuels-focused nations viewed that COP28's final result a significant success, indeed they Voted for its outcome.

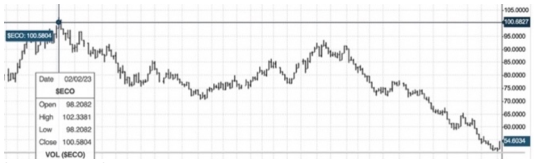
Next for data-lovers, are math parlor-tricks, coincidences discoverable in clean energy's story thanks to so much data. Of just mild interest, found in ECO calculating live 20+ years. Take say 3 volatile down-years, 2021, 2022, 2023. Clean energy's story so passive ECO plummeted in 2021 as we've noted to a year low, going down by a nearly-exact, non-imprecise -50%. Was down -½ (-49.6%) falling from 286.89 intraday peak Feb. 10, 2021 - to a nadir low that year of 142.39. That intraday low off ½ was reached near end of that year, Dec. 29, 2021.

Then, next, 2022, green energy's story fell a 2nd time, again by quite-close -½ to a nadir for that year. From closing 1st day 2022 at year's high 152.87 – lowest close for that year would be again a bit interestingly, -50% (-49.7%) to 76.02 on 3rd to last day 2022. Such a -50% fall in this passive story was again just by chance, only seen looking *backwards* on rich data sets. Still two oddly non-imprecise consecutive declines near -50%. Or looking for coincidences say Q1 2022, it fell to near a say, 100-resistance level 4 times (103): 28 Jan.; 24 Feb.; 28 April, 2 May. Or, early 2023, it initially fell repeatedly to a rounded 70; of course, later that year obliterated a random 70, falling hard through down to 51. Down more to 40 in 2024.

The 2 falls in 2 years of -50% in clean energy's story/ECO, coincidences in the data-rich past. Meaningless, looking forward. Sometimes infra-year only; other times only start of year – sometimes intraday, other times, closing values. But does show *how volatile this theme is,* falling -50% even in a 2020 big up year! Or take a non-calendar 12 months say, end Q1 2021 – to end Q1 2022. Meaningless as a non-calendar period, yet went roughly 200-100, April 2021 at 205.65 close - followed by 2 lows Jan. 27th & Feb 23rd both near 107 close (102 intraday). Come to think of it, funny how 2 lows, again were not far off -50% going from rounded 205 - to 102. War sparked a brief +40% rally in better solutions here, before falling back. But to so cherry-pick from these data, especially infra-year, is NOT predictive. It's only a bit of fun given so many data points. As Mark Twain once humorously put it, "Lies, Damn Lies, and Statistics". Just playing with ample data, parlor tricks on thousands of data points available. More importantly this brief bit of fun is of no real help when looking forward.

Thus, one mustn't read too much into that, other than to confirm a great volatility, oft down! Like Jan. 2022 this passive theme fell near neat -30% in a blow-out; down hard Jan. of 2024. Never predictive, it's ephemeral. Maybe points a bit to 'enter on dips – sell on rips'! One thing noticeable in 2022 unlike a prior year, was clean energy fell throughout that year – so 2022's high/start of year, were about same; 2022's low/end of year also near same. Just for giggles, conjecture, 2022's high close was a 152.8730 seen on Jan. 3rd (154.4136 intraday Jan 4th). So a hypothetical calendar year low, if another 'exact' -½ down, just playing, might be a 76.4365 nadir close in 2022. A nadir low any day was possible of course – yet all the maths were, it's very, very unlikely to be this – and end of year! So was interesting to see when/where 2022's nadir did fall. Not surprisingly, *not* exactly 76.4365! Interestingly, though, on Dec. 28, 2022 this theme did hit its 2022 low of 76.0202. As noted not far off a 'neat' -50% nadir of 76.4365. Just conjecture, yet rounding off to whole numbers, both were near 76.

Hence 'for fun' we'd looked again 3rd year at 2023's high in clean energy's story: that was to be a high of 102.3381 (intraday) early-ish in year: Feb. 2, 2023. So, of mild (but bit growing) interest, a symmetrical fall again in clean energy's story of -50% might guess this theme would hit a nadir – ½ low late-ish in 2023, near a rounded figure of 51 (or intraday low of 51.1690). A head-scratcher was how close to what was born-out, this actually was! Next at left is theme's high Feb. 2nd – as ECO hit a rounded 102(.3381) intraday. At far right, bottom, one sees a rounded 51 low touched on November 1st – so near the roughly -50% conjecture:

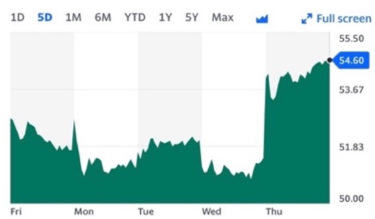


Source: NYSE.com

In October this theme was falling hard & fast towards past a ‘conjectured’ 51 low: it had hit a 53 low on Oct 23rd; again 25th/26th. Then hit 51(.62) hard 27th. Plummeting, it really felt like a rounded 51 low idea was about to be decidedly breached – and thus proven well-wrong.

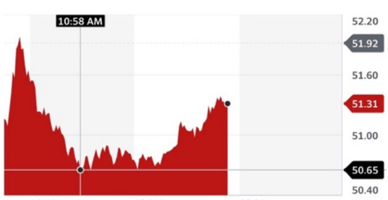
And yet. End October, clean energy’s theme suddenly bottomed, by a conjectured 51 (-50% from high) – touched again Oct. 30th. Then November 1st notably touched (only) a tad lower, 3rd low so far in that year: still rounded 51. If this low were to hold as nadir in all 2023 – then a -50% conjecture might be born out just curiously a 3rd year! This is a passive theme yet curious coincidences may be discerned from sea of data! Next at left, this theme did hit that low on Nov. 1st, for a 3rd time in 2023 at intraday low of a rounded 51 (50.6194).
At right, we see same 51 bottom on Nov. 1st – in a more conventional 5-day chart:

Source: NYSE.com

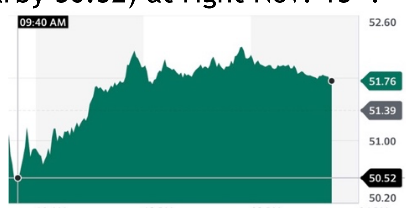


Source: YahooFinance.com

Nov. 2nd this theme rose somewhat, laid in 51 as something of a resistance-level. Maybe raised a modest chance this low could possibly stand as nadir for year… a rounded 51 (50.61) near ‘as surmised/conjectured’. But other hand, shorts were then attacking solar, wind, EVs, fuel cells, hydrogen hard; led one to guess 51 is to be re-tested, soon going lower into 40s. Indeed again 10 days later it touched rounded 51 a 4th time; a fuel cell maker then raised doubts as a going concern, solar trackers crashing, EVs hammered. In this environment, was no surprise to see this theme again touch a rounded 51 low (50.65 intraday) on Friday, Nov. 10th at left. Then, it touched a 5th time about 51 (nearby 50.52) at right Nov. 13th:



Source: YahooFinance.com



Source: YahooFinance.com

After a brief jump to 59 in Nov., theme leveled then fell and 51 again lurched into view as ECO touched 52 intraday on 28th. Would it hold, not break below a conjectured 51 floor all December, last month of year? Or go lower into 40s, bust this ‘just-for-fun’ parlor trick of clean energy’s story down -½? On Dec. 13th the Fed indicated there might yet be Interest Rate *Declines* 2024 – reducing concerns weighing heavily on ECO. On that, this theme leapt +14% on Dec 13th/14th (too much?!) to low 60s in Dec. A big jump, perhaps premature as on merely the hope of rate cuts - against regression to mean that could take ECO back into 40s. Was poised to go down to (low?) 40s in 1st half 2024 - as indeed soon happened when hoped-for cuts took longer to materialize. On lingering inflation, hopes went from 5 or even 6 rate cuts – to maybe 2 or 3 – then maybe 1 … or none in 2024! Lastly, importantly, having fallen so far past 3 years to end of 2023, going forward from 2024, such -50% conjecture no longer applies. For past data, see, https://www.nyse.com/quote/index/ECO

For 20+ years we've looked at how green innovations, *may* be superior vis-à-vis old energy. Ways disruptive solar, wind, EVs, storage, hydrogen (H_2) – *may* potentially make sense in their own right. And as clean technologies arise we've emphasized too that stocks here shall be very volatile, they can & will 'drop like a rock'. We're proud as the Originals, creators of Benchmarks ECO since 2004 – and global NEX since 2006, to have noted zero-carbon energy can help *avoid climate risk in first place,* while solutions *may* appeal regardless of climate. Yet climate risk has risen to fore of late. Our hotter planet seems to be yelling, along with a robust new scientific consensus, that tipping point threats *may* be already at hand.

It's so significant, we'll take some precious early pages to discuss science and issues raised. Consider, carbon dioxide (CO_2) at levels over 400 ppm and rising fast hasn't been this high, since the Pliocene 2.6 million to 5.3 million years ago when Earth was very different. July like all 2023, set planetary heat records, blew away prior 16.63 degrees C (Celsius). Much more than cranking up the AC may be needed in response. From 18,000 to 6,000 years ago, Earth had warmed rapidly on natural causes, discussed ahead. At times then sea levels jumped dramatically. By a huge 10 ft and more, per century. Ponder that 'delta' for a moment.

Sea levels recent, recorded human history were weirdly stable in geologic-terms – rising only 2 millimeters (mm)/year. Given 25 mm to an inch, was 'near-nothing' rise of <1 inch per decade. But rises are now gaining fast. Lately a US Gulf of Mexico rose 10 mm+/per year(!), so near ½ inch/year – or 5 inches/decade. True local issues of soil compaction + subsidence, gravity are at play there too. But seas are rising worldwide, in non-linear ways. An implication is 10 ft+ per century *may* be seen again. Especially as we push CO_2 up at rates 100-times that which once-unfolded over thousands of years. Leaving last Ice age, it took only 6,000 years for CO_2 to swiftly rise 80 ppm. Now, in just one brief human lifetime, CO_2 was pushed up - already by more! Sea levels in this century and the next, may soon be a top-level concern.

Or, as late-night ads shout, 'but wait, there's more!'. Melting ice in Greenland & Arctic may spill a freshwater lens atop North Atlantic, changing salinity. Pausing thermohaline circulation – deep ocean currents like blood coursing through our bodies. If 'AMOC' slows, even shuts, that can end the Gulf Stream. 2023 models raised concerns this potentially may happen this century, or next. Such would be catastrophic; temperatures may immediately swing by some 18-30 degrees F or more. Given data indicating: a) It's already slowing; b) Shut-downs of the Gulf Stream have happened in the past; and c) Greenland & much of the Arctic Ocean are projected to be 'ice-free' in this millennium – severe impacts seem fairly plausible.

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

A bitter freeze that hit Texas in Feb. 2021 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 loss of wind power - when in fact, natural gas' freezing off was the lion's share of fault). But let's turn first, to a more recent baking Summer in 2023 as Texas saw record high temps. This time clearly, zero-carbon renewables solar & wind were heroes (plus nuclear); these 3 kept electricity on June 2023 – then in July – power flowing, firm, without huge prices spikes.

Fortunate for it, Texas had begun better positioning itself earlier, a few years prior. So, it then had a big 16 GW (gigawatts) of solar power deployable by June 2023 – was a bit like 16 nuclear plants though not-firm. That 16 GW was 8x vs. a puny 2 GW solar it'd had in 2019. As a baking heat arrived June '23, temps soared: what helped save its grid? Operate no anomaly, prices fairly-low instead of spiking as thermal plants went offline, unable to handle heat/less maintenance? Notably in an intense heat June 28th & 29th, renewable solar/wind (plus nuclear) made up 55% of power generation. At peak demand early evenings – renewables (plus nukes) met near 50% of electricity demand. Solar worked well as intended daytimes. Wind performed well, oft best nighttime hours. But, needed now is far more energy *Storage,* only begun to grow there, to help further smooth out intermittency. Of 700 MW of new energy storage that went in across all the US in the 1st Quarter 2023, 70% of that went into just Texas.

Despite love for oil/gas felt by some of its politicians, Texas blew away other states lately in its gains in solar & wind capacity. Free markets work in its favor, when heat - or cold, settles over a Southern US. Indeed in 2023 it installed *another* 7 GW utility-scale solar; no other US state was close. It aimed for 25 GW utility-scale solar capacity online by end 2025. Enough to energize 10 million Texas homes. For comparison, when peak demand had hit in July of 2022, a then 59% of demand was met by gas, 15% by coal, 10% solar, 9% wind, 6% solar. Yet the next year, in July 2023 on a record 83,414 megawatts demand, that was met by 57% natural gas; meanwhile solar was better 2nd at 14% - edging out coal's 14%, while wind was 9% (calm day; would have been more if windier day), 6% nukes. Thus, a coming-fast bigger 25+ GW new solar + plus much more wind power, much more storage, can't come soon enough!

In Texas' Summer 2023, all its thermal plants suffered from intense heat. Fossil fuels /nukes were forced down for planned – and unplanned maintenance. All power on offer was impacted by this sort of intermittency. Not what fossils/nukes pin on solar ('won't work if cloudy or night') or pin on wind ('only works in breezes') – *thermal plants instead couldn't handle new weather extremes*. Thermals are at whims too of global fuel costs. Contrasts with solar, wind that worked more stable ways 2023 – enjoying 'free fuel'. It's estimated Texas' renewables saved its consumers over a billion $ dollars during that heatwave. Money that its citizens didn't need to send senselessly (like they did in 2021) towards spiking energy costs.

Summer 2023's extreme heat was too much. Aug. 6th power prices skyrocketed 800% from $275 - to $2,500/MWh. Just 1.6 GW spare capacity left 6 pm sun setting, as demand peaked 84.4 GW – new State record. Emergency cooling centers set up. Renewables propped up its fossils-grid, kept prices lower thanks to sun/wind – but can only do so much. Sept. emergency saw just 500 MW left! And Derecho winds in Spring can bring 90+ MPH winds that hit the grid. So 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 cruel irony, we all may be doing something about it unalterably. Normally a rise of ocean temps of a few 10ths of degree is notable: seas require far more heat to rise, than air. Yet in North Atlantic off Newfoundland in Summer 2023, sea surface temps had reached 9-18 degrees Fahrenheit (5–10 degrees C) over normal: that's beyond even many extreme climate models.

In Florida Keys, sea temps in 2023 went over 100 degrees Fahrenheit, hot tub temps. Yes, it was in shallow waters with less open ocean flushing, seagrass dark bottom absorbing heat … but still. Antarctic sea ice lately isn't rebuilding like normal in winters – worrying scientists who fear maybe collapse in sea ice extent. There's a fear of slowing in Antarctic overturning current which keeps stable the 'normal' global temps upon which we all depend.

Bloomberg New Energy Finance (and NEF partnered with us early on in creating the NEX) has noted that to end of 2020s so just a few years, the US may build 600 gigawatts (GW) new *solar, *wind, *energy storage capacity. BNEF points to as 1 impetus Inflation Reduction Act (IRA) discussed ahead: may go over $1 trillion, plus other support. Yet there's big hurdles to 600 GW too, *costs of capital, *inflation, *supply chains, *slow permitting, *antiquated grid: all impediments to seeing such 'leaps' in this decade. Still, 'leaps' compared to past. It had forecast 358 GW US solar capacity 2023-30, near 3-fold total US solar capacity of 2022. They foresee 137 GW new wind capacity to 2030, near 2x total wind capacity of 2022. 111 GW battery storage capacity to 2030 – 9x gain over 2022; starts from a low base yes, but growth. And the fact is, US in 2023 had badly lacked grid capacity for such growth. They thus expect $83 billion in grid investments; yet even that, would be $172 billion short of spending needed for US is to reach 50% emission cuts by 2030. IRA is most a package of tax incentives; it's NOT a strategy to decarbonize. In sum, green growth over 2020s. Still, even *600 GW falls well short of achieving US targeted 50% cuts in its CO_2 emissions, by the end of this decade.*

Looked at another way, thanks to 3 big Federal laws since 2022, US may 2x its recent pace of decarbonizing – to 4%/per year *fewer* emissions by 2030. A 4%/year of cuts brings down emissions by 40% to 2030 - But that rate still falls short of 50% emission cut called for by the White House. As a 50% cut is what's needed to stay <2 degrees C global heating. 50% goal by 2030 could take US to net-zero 2050. But 50% by 2030 means doubling, 2x our fastest rates 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 by just 4%/year - but rather 6%/year to 2030. Then, speed up cuts by even more. While not now in the cards, it's technically, very do-able. Thus, no surprise clean energy spilled into American politics in 2023. Criticisms rife. Some critiques quite accurate. Such as far *more* US minerals were/are needed, quickly, to decarbonize US & to electrify all - vs. a fossil-economy. Too few minerals were domestic-sourced. True too: electrifying heat is costly: heat pumps vs. furnaces: but then costs fast equalize on efficiency. Yet many other much harsher criticisms aimed at clean energy 2023, were less accurate.

For example, contrary to politically-driven claims – clean energy can *reduce* costs of energy. As seen in Texas, *renewables can be Deflationary.* Or Australia that had once clung to coal, resisted new energy until recently. On a new government, its renewables have surged; green energy in 2023 met 2/3rds electricity demand. Solar output there went up +23% year on year. With less need for costly gas, wholesale power prices went to zero, or negative, 12% of time. 9 am-5 pm in populous Victoria & S. Australia, wholesale prices negative 55% of time. Yet, negative prices can also disrupt monetary incentives for more renewables. Power prices can be set in 'day ahead' auction markets, as generators all bid to supply power next 24 hours, so when generators expect an excess, they have to bid 'negative' prices, harming themselves (and say, nuclear and coal power plants too, who cannot easily shut down). Wrong too have been critics who bemoaned EVs as forever-costly: China has an <$10,000 (equivalent) Dolphin EV on 200+ mile range. Other criticisms perplex, such as by a few who still claim since climate has always changed over Earth's history, curiously, any pro-renewables policy must be bad: perhaps that's on mis-understanding of what it means if science is right. Such arguments have perhaps retreated just a bit – but certainly climate skeptics and deniers remain vocal.

Europe, where climate science is more a given, has big, hairy, ambitious aims. Bloomberg NEF notes Europe may invest $32 *Trillion* - if net zero targets by 2050 are to be met. That can mean spending growing by *more than 3-fold a higher pace over rest of 2020s*. Then, *4-fold rate over 2030s* vs 2022 if to be on track. More €€ to be invested in renewables, in EVs, heat pumps, etc. Like nothing seen before in old-world Europe, and 2/3rds of spending may be on upgrades on Demand Side. Heat pumps (costly!) replacing old furnaces: $1.4 Trillion. EVs: a massive $21 Trillion 2023-2050. Generating side, $3.8+ Trillion in wind & solar by 2050. Some 40% of that at first quickly to 2030. Put differently, European spending rest of decade *may* accelerate. Onshore & offshore wind for example, maybe jumping big, from 234 GW wind in 2022 – to maybe seeing 675 GW of wind by 2030. In forenotice Europe solar power summer 2023 did out-generate coal, 1st-time ever. Yet on lack of grid capacity, that pushed prices at times below <zero (bad, for suppliers incusing renewables). For Europe's grid to accept huge renewables generation, grid spending may need $3.8 Trillion. Solar rising from 226 GW in 2022 – to 774 GW by 2030. Some there aim for solar to be #1 energy source 2030, tripling swiftly. For solar & wind together by 2050, to meet 84% of Europe electricity demand, with change in manufacturing too. Germany in 2012 had (we recall this!) been key in PV-making. But by 2022, China made 97% of silicon wafers in panels, 2/3rds+ of world's PV modules. So, for Germany to again be a key PV is very ambitious. Like everywhere, there's strong opposition to to such massive change. And must work against the tides of negative pricing: in 1st 6 months of 2024, Great Britain saw a 3.5x jump in times of negative pricing (thank you, wind!) vs. all 2023.

Yet on clean energy's efficiencies, on electrifying heat, transport etc = that *could* cut energy-use by 30% to 2050 - vs had heat, transport, still been by fossil fuels. By 2050, electricity *may* be The Single-Biggest component in new energy-applications, going from 20% in 2023 – to 46%. COP27 Conference indeed highlighted $4 Trillion: it called for that renewable energy investing by 2030. In hopes of helping to achieve net zero by 2050. All huge numbers!

We are not on track for that. Figures imply big shifts have begun: 2023 global solar investments greater than in oil, first time ever. $1.7 Trillion went to renewables, storage, non-fossil energies (even to 'low-carbon' nuclear) - while 'only' $1 Trillion went to older coal, oil & gas. Perhaps start of a shift ahead. Separately, spectre of possible US Debt Default cast a shadow. A handful in Congress bitter over slim passage of IRA in 2022 – maybe saw threat of a 1st-ever US Debt Default, as an opportune 2nd bite at apple, unprecedented 2nd chance to hobble US renewables. But the Oval Office fast made clear undoing any of then prior-year's IRA was a red line not to be crossed. Thus IRA survived at least Summer 2023 intact. And a brief May-June 2023 jump was seen then in the 4 WilderHill themes: ECO rose by +21% from a 70 on May 4th to an 86 on June 15th. H2X rose from a 60 on May 31st to 68 on June 14th. WNX rose from 80 on May 31st to 87 on June 14th. NEX rose from 281 on May 31st to 305 June 14th. Still, a 'final Debt Deal' is never done: expect recurring fights over 11 annual spending Bills, maybe crossing into shutdown too at times in the battles over appropriations.

Utterly different, also of note, had been a shift 2022/23 from La Nina weather pattern that held temperatures down – to an El Nino so hotter oceans. Heatwaves on land impacting us humans. We simply don't see stunning ocean heat happening now as being as consequential, foreboding as it really deeply is. Hot oceans & Mediterranean Sea may have far greater impacts for we air-breathing, bipedal, land-based humans – than turning up AC in response. Potentially new ocean regimes may mean existential threats we can't yet conceive of. Like say slowing of a key Antarctic overturning current which drives so much. All that, right now, right in front of us. Big, near-term risks, yet that we humans seem unable to fathom.

Progress is happening, in say Texas where fast-growth in solar/wind ruffles many politicians' feathers, even as it saved Texas' grid in 2023. A deeply-conservative place, yet Texas' private sector is growing renewables-generation at a European pace, akin to Portugal. Portuguese new solar 2023 had met 7% of demand (same as Texas) - and its wind power met 25% of electricity demand - both near-identical to Texas. Differently though, Portugal has far more hydropower, met 23% of its demand 2023; & on biomass it aims for renewables to meet 85% of demand by 2030. So, Portugal & Texas are both near 7% solar/25% wind – growing fast. As some in Texas fear green growth puts gas/nukes under threat, perhaps so! But other key ways they differ. In Europe natural gas is pricier, not-secure, not domestic, less used - than Texas. In 2023 renewables met 61% of Portugal's demand – up from 50% in 2022; Portugal benefits from so much hydropower - unlike flat arid Texas. Yet both cases, the renewables are proving both cheaper(!), and far better on climate & human health. Portugal was very proud in 2023 as just its renewables alone briefly met 100% of its electricity demand 6 days in a row.

Still, via a climate lens it's scary as nowhere is clean energy moving fast enough. Everywhere, decarbonizing is set back. On our unending CO_2 one can't hope for 'just' 1.5 C hotter ahead; that's non-realistic. In 2023, China & Saudi refused to discuss 2025 targets at a G-20 ministers meeting. China was 196% of increased emissions 2019-2022; 1/3rd of all emissions. Even per-capita, China was 3/4ths of *increased* emissions; it ok'd 50 GW coal, 41 GW new announced; 8 GW of 'shelved' coal was revived. On coal alone, any optimism for our Earth is unfounded.

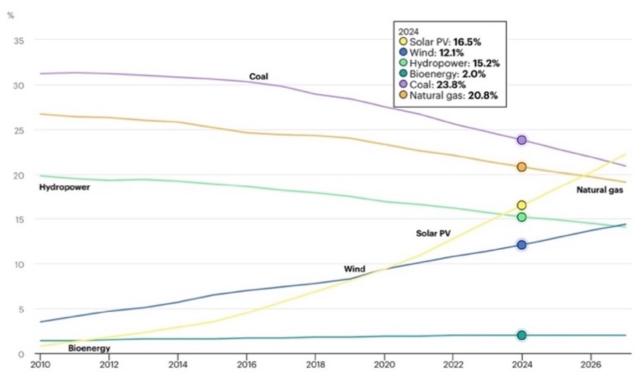
Or take a rich UK that had led on wind but decided 2023 on more oil & gas. To grant hundreds of new drilling licenses. It even expects once at 'net-zero' 2050, to get 25% of energy from oil & gas. As hoped-for UK offshore wind deals were cancelled 2023, did Not pencil out on capital costs. As it grows more-likely U.K. won't realize 2050 aims, its plans only get part-way there. Underlying all, a belief that putting off stronger action was 'pragmatic' – but, *that's plain wrong;* renewables *can be tangibly cheaper*. Spain's new solar in July 2023 met 24% of demand - up from 16% in 2022. Greece's solar hit 30% of demand in July 2023. In Sicily, half of its excessive demand coming a very hot summer day was being met by solar.

And there were many bad surprises 2021-2024. Offshore wind was hit hard. A German/Spanish wind giant had giant losses – due to inflation, repairs; it announced a €2.2 billion charge on quality troubles in onshore/offshore wind turbines, net fiscal year Loss 3x what was expected. Earlier on markets valued its wind unit at €5.5 billion; they after gave it near-zero value then. Wind was pared back worldwide; fell 20% 2022 from prior year's levels; 32% less growth than a record 2020. Oil & gas were different (although nat. gas stocks plummeted too 2024). In 2023, 20% of oil & gas projects set to start 2023-28, were at Final Investment Decision stage (FID), far better than 8% of offshore wind projects, a meagre 3% of H_2 projects were so far along. Things did improve: 12.3 GW offshore wind, a new record reached FID in 2023. In 2022, was just 0.80 GW. Later on, eight European projects making 9.3 GW hit FID in 2023.

Texas in a US mirrored global tensions. Its gas-fired plants struggled to meet demands in cold & heat extremes – fuel costs at times soared. Cheap solar/wind much helped. And 'firm' fossil plants Do Fail: as Texas' gas froze off 2021, some there tried to blame renewables. PR efforts were scrambled to call only the fossils 'reliable' – despite facts. 2023 again showed gas strain in hot/cold beyond what was expected when plants were built. As weather extremes grow in frequency, it's now challenging thermals that'll grow intermittent, struggling in newly-typical temps. Better are solar, wind, storage to lift teetering grids from failure, plus keep power prices from skyrocketing. Yet without much-needed huge new storage, transmission, robust grid resiliency to make renewables firm & dispatchable, it's not near enough.

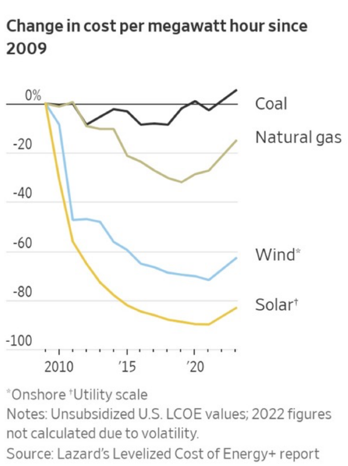
There's bits of good news. US solar installs in 2023 had rebounded some in places (not California) – growing +50% to reach 32 GW as supply chain bottlenecks began easing & on IRA. However seen via a lens of what's required for climate 'solutions', on physics & chemistry, this decade will soon be ending scarily Bust. Sunny Arizona may make home solar uneconomic! California, once a leader, is now not far 'behind' - beating up on its solar. As June 2023 was a hottest then on record, so was each month rest of 2023. Sept. 2023 then hottest on record - not by a usual tenth of a degree – but by 0.83 F! Yet late 2020s natural gas is slated to still be making huge gobs of power – despite CO_2 & it spilling methane. Globally, coal too seen as abundant 2029. Wind power up, yet 2020s tough for it. Green's growing. But solar/wind are projected as still nowhere near say >90%. Instead they're overshadowed by the inertia of big, dirty energy at 45% still in 2024; coal 23%, natural gas 21%. So fossils are still to be elevated in 2029. Thus on science, the CO_2/and greenhouse gases, the 2020s end a Bust for all.

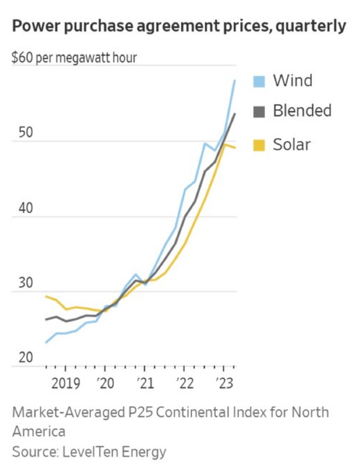
<u>Share of Cumulative Power Capacity By Technology, 2010 - 2027</u>



Source: IEA, *Share of cumulative power capacity by technology, 2010-2027*, IEA, Paris https://www.iea.org/data-and-statistics/charts/share-of-cumulative-power-capacity-by-technology-2010-2027, IEA. Licence: CC BY 4.0

In many ways 2021 to 2024 were tough on clean energy equities. Partly because after a prior decade's usual annual *Declines in* green power prices – green power costs instead *rose*. Sure, prices rose too over at coal, nuclear power. While they rather crashed in natural gas. For clean energy's theme – this was all an inauspicious time. Hit clean energy stocks hard. (A side note is that it's difficult to capture natural gas prices though a very important commodity, in an ETF or a Fund normally made of equities. Gas futures trade for instance on Henry Hub (gas more localized than oil – so location was key) – yet contracts roll over, so there'd be constant drag down on an ETF/Fund, and drift as they renew or in contango; for comparative theme purposes in these Report charts, we typically use a major natural gas tracker ETF for it).





Green shoots like in a windy North Sea 2020s could offer hope for what *may* be ahead. Perhaps just a bit like how once, hydroelectric power 19th century led to 2,500 mills that made ½ the world's cotton in Lancashire, 1860s. Or cheap hydroelectric led to aluminum smelters, then airplanes in Seattle last century. After all industry follows cheap energy. True, Ruhr Valley German coal did lead to steel-makers and (dirty) industries. But this time, far better, can be *clean* economies that *may* grow ahead: like for zero CO_2 steel. Or green hydrogen (H_2), green ammonia (NH_3), or other derivatives for possibly instead clean renewables-based energy.

In Europe offshore wind *might be* starting to scale. Turbines at sea can be near 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, or like 5x world wind capacity that was seen 2022. A bit like 24,000 biggish turbines. Enough to make electricity for say 200 million Europe households. Some firms that once kitted offshore oil/gas, may shift to offshore wind like near Esbjerg Denmark. This town of 72,000 souls could boast 2023 of having helped assemble 2/3 of region's offshore turbines, enough to run 40 million homes. It aims to grow capacity even farther ahead, by another 3x to 2026, maybe a European wind hub. (Or, how about new geothermal ahead?!).

Harnessing resources akin to North European wind, may be duplicated say in a Spain blessed with bounteous solar; its PV met only <8% of demand 2021. North African sun + PV can be moved by undersea cable – or green H_2 by ship/pipelines to voracious Europe. War ended an affinity for cheap Russian fuel; newer aims: security+climate. Fossil fuels yes got us to today, but in future bold new opportunities may belong instead to sustainable energy.

In the US, Inflation Reduction Act (IRA) of 2022 was spurring investments. For fresh US battery manufacturing, minerals mining, refining. Car builders onshoring battery-making – to take advantage of US Tax Credits. No surprise many seek to build US supply from scratch. Georgia saw 1/4th of new US projects just since 2022, 30 plants announced. US Treasury then drafting rules on what counts as US battery minerals, domestic EV content, maybe a big loophole if say, EVs are leased. Meanwhile all looked to get minerals in greener ways. A big US-based solar maker enjoyed near 4 cents/watt premium on supply of tellurium, cadmium; it bought a Europe pervovskite specialist in 2023. So, was on some brief optimism equities first rose January 2023 – but also on hopes inflation peaks, Fed pivots to lower rates. When that didn't happen all 2023, was hard for riskier equities to compete with 5%+ returns in far safer bonds and Treasuries. Stocks fell on inflation, bank scares amid debt bomb, possible US Default. All moved more towards risk-off, some collapse globally in risk-assets confidence early 2024.

And yet there's also green progress. 2023 for first time-ever, it was cheaper to *build a* new US solar/wind farm from scratch – than to get electricity from *built, existing US* coal plants - at all but 1 US coal plant! On IRA + new Rules, coal grew costlier at 99% of US power plants. Of 210 US coal plants, just a Dry Fork Plant in Wyoming was cost-competitive. Marginal costs for many US coal plants were nearer $36 per megawatt-hour – vs. $24 per megawatt-hour for well-sited solar. US coal, like US nukes & gas plants, were pricey to run on frequent servicing, plus big labor costs. Take Texas' huge Samson Solar Energy Center, a new 1.3 GW solar farm: required just 12 full-time staff plus some goats to keep grass down. By contrast a South Texas Nuclear Project also 1.3 GW in size, was needing its 1,300 expensive trained full-time staff! Solar's/wind's fuel is free + no pollutants. Fuel for coal, gas is costly. Coal's many pollutants are costly too, beyond climate risks, besides its carbon dioxide. Coal's awful mercury causes brain damage. Its sulphur dioxide making acid rain, NOx vexes as do huge wastes. And nukes very costly toxic wastes must be safeguarded for centuries, even longer!

Green energy can grow. 3 decades ago, 11 (now-tiny) turbines made the world's 1st offshore wind farm: all was all of 5 megawatts total size in Vindeby, Denmark. 1 offshore turbine now reaches 15+ MW – *each turbine!* 18+ MW models have been unveiled. Just imagine 100 say, of the 15 MW turbine behemoths – or why not say, 1,000, or even thousands(!?). Wind in future can make GWs, so more than nuclear. Indeed, China has huge ambitions for onshore/ offshore wind ahead – and that nation has sheer ability to make thousands of GWs happen.

Coal once was big in US, still is in China. Yet 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 and 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 now inauspicious. Interestingly however, some conservatives who normally venerate free markets – look towards Rules *Requiring* coal be kept going(!!) – even if coal plant owners want to shut it down! In W. Virginia, Kentucky, Montana, Utah, Wyoming, they've lately claimed this is now a fight about 'culture'.

A transition to clean energy *may* be starting. In 2022 the world invested $1.1 Trillion into low-carbon technologies, a 31% gain over 2021, 1st time over $1 Trillion/fossil-investing levels. What saw biggest % gains in green tech – vs. not-so-big % gains in 2022? One big gain was electrifying transport: it jumped 54% year over year, to $466 billion. To near totals for solar & wind at $495 billion, latter only up 17% vs 2021. Other than a nuclear that was flatlined – new investments in green storage, heat, electrifying transport, rose. Even speculative hydrogen (H_2) drew interest though 'only' $1 billion 2022, still that was up 3x over 2021.

So much driving demand the International Energy Agency (IEA) in 2023 opined even on war, so efforts to rein in demand, it still *grew* by 2% in 2022. IEA forecast 3 years to 2025, demand could grow 3%/year. Maybe all that met by renewables + nuclear. Renewables might rise from meeting 29% of power needs in 2022 - to say 35% by 2025. The US (on pre-IRA data) might lag by making up only 6% of that renewables' growth; the EU may be better at 15%. Meanwhile China could meet an incredible 45% of the renewables' growth. Or not. Collapse of China Evergrande Group in 2021; then of Country Garden in 2023 was inauspicious – 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, ahead of UK. For China's factories making clean tech, investing rose from $52.6 billion in 2021 – to $78.7 billion in 2022. Unsurprisingly China got remarkably 91% of investments, and China was moving farthest & the fastest, along with having the most supply chain diversification.

Green hydrogen, is a new area China is targeting too for massive fresh investments from 2024. Its national government aims for 50,000 hydrogen fuel cell powered vehicles on roads – to be powered by 100,000-200,000 tonnes annually of green H_2 (from electrolysis on renewable power). Getting sufficient demand here will be key; so note local/municipal entities aim high. Inner Mongolia, Qinghai, Gansu, together seek 740,000 tonnes annual green H_2 production. 13 cities/provinces aim for 110,000 fuel cells vehicles in 2025! One might think this means surely green H_2 *over*-production – so too many electrolyzers chasing little demand: green H_2 needs may be only 10 GW in 2025 … as >70 GW electrolyzer capacity comes online 2025. But, other side of coin is China is the biggest producer of grey H2 (from dirty fossil fuels) – and that H_2 for industries in steel, cement etc could switch from bad grey – to renewable green.

And yet on climate, to reach net zero global spending figures are still NO-where near enough. Bloomberg New Energy Finance (NEF, early partner on NEX) estimated the world must invest on average, *USD $4.55 Trillion per year – each year, rest of decade(!) on Net Zero Scenario.* IEA says *$35 Trillion more* must still be invested just to 2030. Global deployment of GW going from 3,000 GW to 10,000 GW – if we're to stay under <1.5 degrees C heating.

China's the 800-pound gorilla in making renewables cheap/er. And while we may think of Oil as overly-dominated by OPEC – China's control of green manufacturing is even *far greater*. In so many ways, its control is (much too!) huge. Take cobalt used in many batteries, 95% of world cobalt is refined in China. New battery designs ahead may no longer need any cobalt; so, 1 stranglehold can be broken. But what of nickel, or graphite?! In key areas of silicon-solar cell manufacturing, or PV modules, or global capacity for EV battery production, China leads at near 70%-75%. By comparison with oil, just 14 OPEC nations control fully 40% of global oil supply; viewed as OPEC+ with Russia it jumps to 60%. Compare that 60% of oil in 2020s - with just one China, whose hold on green tech is greater than is OPEC's over oil. This conundrum got entrenched in a last decade. China intentionally became THE global leader in wind, solar etc as it took ~70% market share. It aims similarly high/more leadership in EVs too.

Was only 'ok' in a sense exporting that cheap PV was a win in the climate crisis; 2010 to 2021, solar-electricity costs fell 90%. Building a China solar factory 1/5th the costs of in US, Europe. Conversely electrolyzers cost 5x+ more in US, Europe 2023 – than China - so catching up isn't easy! But there's issues aplenty with China. Some PV from there intercepted at US border on big forced-labor concerns discussed ahead. In 2023, US Customs released meaningful numbers of panels for a bounce in China solar; also maybe dark clouds on accounting (non)transparency & so delisting off US exchanges, dissipated. Yet new tensions and issues do keep appearing. On energy security, decarbonizing, onshoring green jobs, Taiwan: all argue for more overseas production – outside China. Even if costlier in short-term. And 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 2021-24, made some equities perhaps more akin to value, than high P/E growth. *If* inflation is tamed some, *if* capital gets cheaper, *if* supply chains loosen, if risk appetite is back, perhaps animal spirits *may* return. But other side, are concerns over high US interest rates, tensions with China, recession, dire shadows too. Watch how supply chains evolve in vital minerals, or for a 'nickel pickle', or for domestic refining going forward.

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 its EV scaling – as 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 chargers installed each year in China, 1.8 million to end 2022; on low-utilization rates yet dwarfs China's 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 – contrasted with once-lingering US CCS or sad US J1772 designs – themselves bad vs. a far-better 250 kW v3 NACS plug by America's leading EV maker. In 2023 thankfully this US leader opened its NACS to all: Ford, GM etc which all trailed badly. Morally better than a walled garden of this 1 EV leader alone with NACS – and means better EV experiences overall. On 3rd party 350+ kW chargers, NACS v4 installed and it soon may pass 500 kW+. Still US lags in EV sales; to keep up with fast-China meant US EV charger installs must grow 4-fold 2023 to 2025. The EU too is growing its EV sales faster than in America, yet it must raise its rate of EU charging points from 2,000/ week seen in 2023 – to near a 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 may go into US solar/wind/EVs soon thanks to an *uncapped* IRA. But many renewable projects recently were slowed, or even killed. Supply chains in solar, in wind, EVs are full of pitfalls. For instance, US approvals to connect to grid still take far too many years, sometimes a decade+! Local regulations, protests all vex. US big wind farm starts fell by a dramatic 77.5% in Q3 2022 – vs a 3rd Quarter 2021. New utility-scale solar projects fell by 40% in 2022 – vs 2021 - despite the big demand for green electrons and for green projects.

Investors in early 2020s *wanted* to pour $ billions into renewable energy. But PV panels mainly come from China - and those panels were held back by US tariff battles. The US President temporarily halted tariffs on 4 Asian nations finishing China-panels, but that pause ends. Also, some Chinese PV was withheld on need for proof NO forced labor was used in manufacture. Plus, further troubles brewed over non-transparency in China Accounting firms. Perhaps some China solar/wind stocks might even be delisted off US exchanges, depriving them of capital; that issue was maybe avoided 2023, but a threat lingers. Still, Q1 2023 saw a record 6 GW of US solar installations – thanks in part to cheap Chinese PV cleared/ and its re-availability.

Then came troubling self-goals. California once led solar, but it cut back on home solar value in 2023. Its 3 public Utilities seriously pushed to end incentives for home solar – to charge fees based on users' income, rather than electricity use. In Q1 2023, Florida installed 70% more new solar capacity than California. Forced labor was found in 2023 in Malaysia in its PV. In other matters, wind turbines grew fast in size, as unreliability made some wind maker's warranty costs double: industry needs to improve reliability of huge turbines – before turbines grow further. US Treasury was slow to proffer details implementing tax credits. A US Senator key in the IRA was surprised by criticisms at Davos 2023 on incentives to build in US. Europeans more accustomed to sticks – than carrots – (rightly) feared it driving Euro-firms to US. They called for a European Green Deal Industrial Plan, mimicking America's IRA, carrots to draw firms to old-world in race to top. Largely due to IRA of 2022 – America in Q4 2022 saw $40 billion new for US solar, wind, storage; as much as all of 2021. Private companies & public entities contracted for a record 36 GW clean power in 2022, up 18% over 2021. Many firms clamored to invest 2023. Whether wanting to decarbonize – or merely was virtue signaling – either way, demand to contract for clean electrons in early 2020s was enormous.

Yet demand had to contend with long leads for high voltage equipment - gone from 30 weeks – to 70 weeks. Proposed standalone-battery projects suffocated too by wait times for grid connections stretched places to 2030s. Far more interconnection requests were made, fossil fuel plants too - than built. As only 23% of requests were built. 19 GW of wind farm proposals were later withdrawn (only 20% completed). 60 GW solar was requested – just 16% completed. In 2020 there'd been 5,600 connection requests. 2021 saw a grand 8,100 requests: clearly grid operators who didn't up staffing capacity were overwhelmed. Back in 1st decade of 2000s, wait times averaged 2.1 years/per project. But by 2011-2021 it rose to 3.7 years, then to near 5 years. Things improved some latter 2023, when US FERC gave new rules to speed approvals. Still, with 2,000 GW proposed *new* clean energy awaiting approvals – about as much as then-extant generating capacity – that change was most welcome and sorely needed!

As local opposition (some manufactured) to wind, solar, grid projects grew in Europe & US. In 2021, 19 big solar proposals were vetoed; that jumped to 75 vetoed in 2022. In England/ Wales/Scotland, only 4 proposals were rejected 2017 to 2020. That jumped to 23 proposals rejected in 2021 to July 2022. Other side of coin, France looked for example 2023 at requiring all its big parking lots over 80 spaces in size be covered with solar panels.

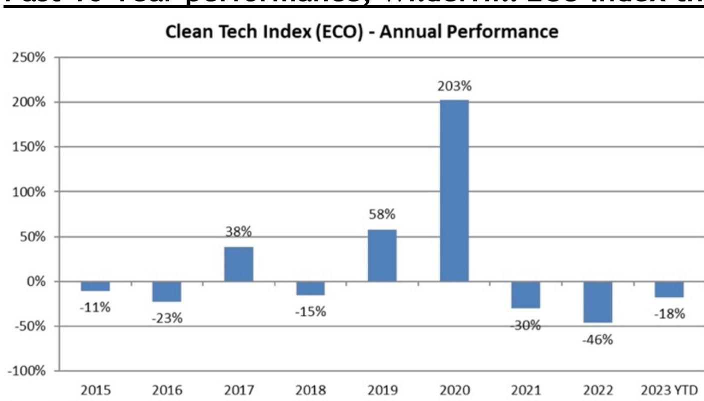
At times local anti-renewables sentiment, opposition went hard against renewables in 2023. For example, Poland looked to potentially revise earlier 10H requirement that wind turbines must be >10-fold height of turbines from houses - to instead maybe bigger 700-meters buffer. Clearly the fossil interests in coal-reliant Poland were not going gently into that good night.

Fights brewed too on what's clean, 'green hydrogen'. In US some fossil-tinged players claimed they could generate 'green' H_2 on electricity mains/grid typically run from fossil gas and/or non-renewables like nuclear – via a 'trick' of buying RECs (renewable energy credits) from wind & solar even if generated at distant places and times. They'd still call this 'green H_2'. By combining not-really green RECs - with electrolyzing H_2 – call offspring green H_2 no matter the power source. They might market that H_2 as 'clean' – as if made from wind or solar. US tax incentives in new Sec. 45V may be $3/kg, but electrolyzers must be put in service within 3 years of the new clean power plants, 'additionality'. In same region, match wind/sun hours. Indeed, hourly energy matching means honesty clean energy is being used. Would be more truthful in aligning H_2 production with renewables, but also harder to implement.

Europe in 2023 drafted rules-to ensure green H_2 well & truly had nexus to added renewables, locally sourced. Guarantee green H_2 is generated same time sun is shining, or wind blowing. That H_2 is made from 'additional' true-green-electrons. Rules too for renewable fuels of non-biological origin (RFNBOs) drafted. Unsurprisingly France pushed as expected to add nuclear to what is deemed 'low-carbon H_2'. Some championed biomethane too, to capture 'renewable natural gas' from landfills or ag wastes; this makes sense since avoiding methane releases is a good and fast way to limit greenhouse gases. Yet whether in Europe, or US, a big issue 2020s has been that gray H_2 from fossil (dirty) natural gas - was still much cheaper @ €1.50/kilogram - than a green H_2 costing some 2x-3x more. So yes, by end of the 2020s it's very possible *Green* H_2 will then be cheapest, helping make grey H_2 obsolete. But mid-2020s, green H_2/methane/ammonia were pricier; so the costs/Incentives were a huge issue.

Speaking of incentives, US Treasury partly decides what may grow fastest. Note then that a new 45X MPTC (Manufacturing Production Tax Credit) in IRA *can make US-built solar/wind for first-time cheapest in world!* A 75% credit per full unit to 2030 (50 critical materials beyond 2030) means that with PTC, a solar panel @7 cents Wdc, might get 5.25 cents Wdc tax credit! On prevailing wages & on apprentices, but wow, 60% cost reductions! May mean 4 million new solar/wind jobs! In short, uncertainty reigns in clean energy, so is no surprise to see such great volatility in clean energy stocks. Hence, big falls in equities, yes – at times gains too. This 10 Year chart captures the theme that's first & best defined by ECO live since 2004.

<u>Past 10 Year performance, WilderHill ECO Index thru end of Q3 2023. Volatility is clear:</u>



Source: Raymond James Research; Factsheet.

In Europe early-2020s, wind & solar met record 24% of EU electricity demand in 1st 6 months of that awful war, March to Sept. In doing so a 27-nation EU avoided spending €99 billion for natural gas. (In late 2022, €1 Euro had nearly equaled $1 Dollar, so was USD $99 billion). The EU then generated €11 billion more clean new energy in that period, than it had all 2021 – thanks again to green growth. Imported piped Russia gas-use dropped fast on war, from meeting 40% of demand 2021, to just 7% early 2023. Solar output near doubled. In 2022, % of electricity demand met by wind/solar – exceeded that from gas – first-time ever. Might have been even better, were not large, hydroelectric dam output then so far down by -21% on the drought & heat. (Which had hit France especially hard). Let's look just a bit closer.

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

Yet rarely is news 100% good; no exception here. 2010s, wind & solar got ever-cheaper nearly-every year – vs. year before. But that ended in 2020s. Instead, 2022 saw *rising* costs to buy green energy. Wind power prices 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 etc. Still, was no looking away from higher-prices in renewables too. Higher wind/solar costs in 2022 didn't kill green demand. Rather on cost, tight supply chains, coal demand rose 1.2% in 2022, which set a sad new world record of 8 Billion metric tonnes.

Inflation had meant higher costs for everything: solar panels start of 2022 had cost 35 cents /watt. But mid 2022, nearer 45 cents, then 50+ cents. European power purchase agreements (PPAs) for blended wind & solar generation 3rd Quarter of 2022, jumped 11.3% to €73.54 per megawatt-hour (MWh), 51% higher than Q3 2021! Europe beleaguered by over-relying on (Russian) gas, saw fossil-electricity prices some cases @ €500 per MWh(!). Among renewables, prices rose 2x faster for solar - than wind in Q3 2022; solar rose 15% to €68 MWh, wind rose 8% to €78 MWh. Still, these prices were much 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, as some energy auctions failed. Highly volatile gas prices would soon fall hard globally in early 2023 – even more so in a gas-abundant US, than Europe.

Where it gets interesting is what soon plays out in this decade. Europe now views big imports of Russian gas/oil as unacceptable. Natural gas, once-cheap-in-Europe, spiked in 2020/2021, fell in 2022. So Yes, Europe gas prices were back down in 2023. Crazy-high €300s gas, even €135 per MWh as was seen 2021 can re-stabilize lower - but once super-lower, stabler prices of past (oil too) may perhaps not be seen again soon. Hard to say. Disruptive blue-sky technologies, say, room-temperature superconductors may appear. If China grows again, if global demand returns, on costlier gas – that again may make renewables more desirable. OPEC leaders like Saudis may cut oil supply on fears of weaker demand. A 2022 Report from one energy analysis firm laid out a few possibilities ahead. One, was French nuclear comes back, corrosion problems fixed. Despite recent drought, it sees 30 GW firm power back – this was *not* on track in 2023, but it saw wind & solar as at 50 GW, though intermittent. And if Europe kicks in renewables, on security/inflation/and climate risk concerns, that could mean a new 100 GW of renewable generating capacity online by around 2025.

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3 years on, so late-2020s, they saw Europe at 333 GW green generating capacity. Enough to replace roughly the entire gas-fired electricity fleet seen in 2022. Thank you, green energy storage. Europe, continuing to invest, installs more renewables, also has by late in decade pushed down capital costs for green energy capacity to just $1.30/watt. Even if Europe's natural gas as a fuel has re-stabilized at low costs <€30/MWh, plummeting to €20s as was seen 2023/and low prices early 2024 after record €300 peak August 2022 - that still means levelized cost of energy (LCOE) for *gas-fired* electric power is too high. *At that point, electricity from solar late 2020s can be just one-third the cost of using gas as fuel in Europe!* Gas thus becomes non-sensical, except as Firm backup. Gas futures would need to be €17 / MWh (less than Dutch TTF Futures at €17.35 seen say in Jan. 2021) - to compete with solar, a level that report regarded (*then) as being unthinkable. Back to a stable under €20? No sure thing at all! If once-cheap Russian gas no longer powers EU electricity, renewables supply domestically, much changes. Poland, Estonia, Czech, Netherlands, UK etc may re-up their nuclear; yet the renewables solar & wind win too on Security & Climate concerns. Remaining natural gas plants do linger, yes, maybe more for backup power, such as during weather extremes.

Compare that to a US in 2022 when gas-fired electricity had met 39% of US demand. Gas prices at first some on war, export demand – then fell on storage, abundant US shale+fracking+LNG exports that kept prices cheap/ish, even Europe gas. Overall, US renewables in 2022 had met 24% of total US electricity demand, a then record. Had jumped from 20.6% in 2021 for all US renewables wind, hydro, solar + bits of biomass, geothermal. First 8 months 2022, US wind energy grew 22% YoY to a new high, met 10% of US electricity demand. Solar grew 27% & it met 5% of US electricity demand. US natural gas far cheaper than in Europe – renewables in US can become the best choice given lower cost – but by not by so great a distance.

Yet all energy had suffered in 2022 from inflation. Blended US wind/solar power costs rose 2022 to $45.93 MWh, up 34% from 2021. Costs of wind/solar *may, should* slacken ahead – especially if steel, labor, shipping stabilize, fall. Or even fall a bit, plateau for a while, not fall yearly as before. Needed is loosening of supply chains, lower Rates /capital costs, better predictability & more policy support mid-2020s; all much-desired in clean energy.

Europe gas storage at 1,129 TWh then only met 21% of its demand, at some 5,000 TWh. Which EU nations moderated electricity cost increases in 2022 *relatively*-more-successfully? All Europe struggled at first. Gas jumped continent-wide 2021, so it did in Spain: Europe's biggest LNG plant is based in Barcelona. Note then Spain & Portugal stood out for relatively-modest electricity price gains. How? All nations here looked 'first' to their cheapest power - oft wind & solar yes, but mainly gas, coal, hydro. They rely, most crucially of all, on natural gas to meet a key part of demand. Natural gas is firm & dispatchable. It ensures overall grid stability. Gas fundamentally therefore, is what determines overall 'price for electricity'.

That energy-pricing system birthed in 1990s, is a bit absurd today. Means (at times costly) natural gas is The Key Fuel determining what all power plants are paid, per megawatt made. For nuclear & renewables (latter on free fuel) being fixed-cost generators – it meant in 2022 they got financial 'windfalls'. These 2 zero-CO_2 sources benefitted in 'unforeseen' ways from gas costs spiking in 2022. As for Spain, & Portugal, they'd cleverly asked the EU earlier that year to allow them a different pricing mechanism. As they have relatively much solar/wind, had fewer connections to pan-European grid, needed relatively less (piped) Russian gas, they were granted unusual Exceptions. Spain was already importing much of its gas via LNG vessels, so not by pipelines. That was coming more conveniently from Algeria, the US, elsewhere.

That change separated the top €s paid for gas by others in 2021 at €50, €100, even €200+ per megawatt – from a set €40 'fixed cost' for zero-carbon hydro, wind, solar, and nuclear. In effect kept 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 these 2 Iberian sisters Spain & Portugal. But there were other interesting consequences.

Spain, first 4 months 2022 nicely reduced 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* of that cheap Spanish power, so Spain 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. As gas in EU was costly, renewables/storage not yet big enough, the troubles in fossils prevented truer solutions. Then EU 2022 proposed a twist: a windfall profits tax on 'inframarginal' generators: renewables & nukes could see revenues capped @€180 per MWh - on grounds they saw more profits than expected. Revenues "never dreamt of". But then windfall profits taxes also *Discourage* investments – the 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 UK).

Gas prices that spiked everywhere 2021 – before falling 2024 - hit nations in diverse ways. China pulled back off promises to move off coal, soonish. Yet some locales planned enormous renewables. Chaozhou, Guangdong China began to plan for 43 GW offshore wind from 2025. 50 to 115 miles off China, in windy seas that could run turbines 43% to 49% of the time, 4,000 hours/year. Notably China alone 2021 had added more new offshore wind capacity, 17 GW as 80% of world's new 21 GW – than rest of world past 5 years, together! Of global 54 GW offshore wind 2021, China was half. 43 GW wind could make more electricity, than all Norway's power plants made 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 of new offshore wind by 2029.

After decades warning clean energy is too costly, too intermittent - that only fossils gas, oil & coal can save us, and they alone be economic - turns out we needed to think in new ways! And what of energy demand-side, & efficiency: can't a great deal be done too 2023 on? Absolutely! Take Helsinki Finland. It's long burned coal & gas to make low-grade heat in winters for people. But it was in 2024 constructing a new heating system using near-unlimited cold water piped from offshore – via heat pumps – for warmth in homes, offices etc. The trick is that water at a constant 2 degrees C sure sounds cold, there's enough embedded heat even in such low temps, to provide needed (clean) warmth. Enough to transfer far more heat, than by combustion! Heat pump 'efficiencies' in a heat-transfer sense can be like hundreds of percent! Very unlike old furnaces, or boilers that burn. And that electricity used to run the heat pumps in Helsinki is from sustainable zero-carbon clean renewables (plus nuclear).

War, and initial fears about insufficient gas helped trigger "unprecedented momentum"; the 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 an end of a 'Great Moderation': long-term declining inflation + with growth last 40 years … left in shambles by spiking fossil prices. Renewables, not yet big enough to fill that hole. Far more impactful though, may be nearing end to a Greater Moderation last 7 millennia - in Climate. That allowed civilizations to flourish. If that's lost to hothouse Earth, it may existentially challenge an ability of cultures, even our human species, to flourish.

Green themes equities were down hard 2022 and 2023 - but not in July 2022. That July rise was on a 1 Senator's Yes, begetting the Inflation Reduction Act (IRA) of 2022. Its formal spending was $369 Billion - yet uncapped aspects may lead to $1.2+ Trillion in federal outlays, $3 Trillion investments by business. War, energy insecurity spiked prices at first, then glut led to drop in oil/gas late 2023. Fossils spewing CO_2 tied to weather whiplash lost bit of lustre - vs. intermittent, yet in-many ways better renewables. But look closer and there's many wrinkles. For instance, gas/oil prices dropped in US latter 2023. While vessels carrying US liquified petroleum gas, propane exports to Asia - were hit by drought at Panama Canal. That reduced transits from 40 per day, to 30 in Oct. 2023, then 25 in Dec. 2023. Long alternate LPG sailing routes to Asia on climate crisis/drought, raised propane prices in Asia – as LPG fell elsewhere. Then Suez Canal/Red Sea transits were hit by threat of attacks in early 2024.

In an energy transition begun badly, both gas & weather weaponized, weather mimicking extremes felt decades out, it seemed the 'center might not hold'. Especially society used to stabler climes, may be rent asunder. Climate collapse *possible*, shortages of power, food, water. Attacks on grid. Climate ironies of both droughts, & floods, of bigger hot & cold snaps – all help cast sustainable energy in new light. India may see heat in extremis. As global rich & poor alike are forced some places to blackouts, sometimes to burning coal & wood.

That July 2022-jump was on 1 Senator getting their demands: far less $ spending 1/5th what the President had initially wanted, all carrots, no sticks. Fossils got new incentives too. A gas pipeline promised in a debt default showdown 2023. More tries, even by some liberals to streamline (fossils too) Permitting. Revenues-side, big US corporations see a 15% tax. Some Deficit Reduction. Some is deflationary; the Senator thus so named the Act. And Senate majority leader got a desired Chips Bill the minority leader had before held hostage. Smaller items too like a top White House Aide apologized for heated words half a year prior. Thus, a much-slimmed, mostly defanged IRA was birthed mid-2022. After a tough, long, draining 18 months-long labor. Delivered hot weather in extremis. Kept alive after attacks in 2023.

Green stocks jumped briefly, in that July 2022. Seen too in competing Indexes born after ECO Index® like one say for global 'clean-ish' energy big-caps; and one smartly for solar-alone; another for EVs, Batteries – those capture narrower bits & pieces. ECO Index live since 2004 is the 1st, most comprehensive Clean Energy Index® - and it jumped. 1 day before Senator's change of heart (a bit foreseen discussed ahead) ECO had closed at 100 (99.95). Just 8 trading days later after that Yes, it would be at 125, up +25%. Then unsurprisingly, it fell back.

The carrots-only IRA was far short of climate needs for CO_2 is rising fast. Its $360 billion only felt big, as it barely got 1 last vote. But note: given greenhouse gases, $100 *Trillion in Climate investments* may be needed, globally! Yes, uncapped IRA *is* a tailwind. Compared to last decade when just a 1 renewable hydro had once met 10% of demand, big dams can't grow – so with IRA we turn to wind & solar. Wind & solar are growing vastly faster. End of last decade wind had met just 7% of US demand but growing; solar was 3% but growing. So, that 10% from wind + solar, plus 10% from hydro – then had met 20% of US demand end of last decade. Another 20% was met by nuclear – thus 40% was zero-carbon sources. But, other side of ledger, gas & coal met all other US electricity demand. Natural gas & coal firm & dispatchable, took care of ~60% of US needs end of last decade. Transportation & heat too met by oil, diesel, gas, coal last decade: thus, electrifying all of that will take years. Long-ways to go! Hence a somewhat toothless IRA maybe felt like progress, but truth is we're early innings. We'll discuss ahead and throughout this report, where clean new energy may be heading.

Look at say, US electric generating capacity 1st six-months 2022 as that helps show where US electricity may be heading mid-2020s. My, that's changed! 2/3rds new US power capacity built 1H 2022, was then solar/wind. Wind had led at near 6 gigawatts (5,722 megawatts) new-installed utility-sized wind (>1 megawatt). New solar was 4 GW (3,896 MW): they together made 67.01% of all power built 1H 2022. But, bigger picture alarms, for they aren't anywhere near 100%. Of 14 gigawatts (14,352 MW) US generating capacity built 1H 2022, near 5 gigawatts (4,695 MW) or 1/3rd, was still in natural gas. For new generating capacity placed in service a year later, in 1st half 2023, 34% was solar, and 16% was wind - but 47% was gas.

Geothermal should now be a big, dispatchable renewable. Its steam today running even relic thermal plants. But for now, it's too costly, puny 26 MW capacity built. Biomass can be dirty, albeit renewable; just 2 MW. In the US, just 2 MWs hydro built. Unsurprising, no 2nd generation costly risky new US nuclear fission was being built. Nor any new US coal, unlike some other nations 2022 when India, China, even rich Europe went back to burning coal & wood.

While we're still burning gas until plants are retired, a flip side is a fast-coming new solar & wind pipeline. US Federal Energy Regulatory Commission had estimated in early 2022 that some ~200 GW of new US solar was in pipeline to be built in 3 years to June 2025. 66 gigawatts were 'high-probability' to be done. Solar's not yet hit by retirements, unlike coal, oil, gas, nuclear that are hit too by fuel costs, breakdowns, maintenance, shorter lives. Just on solar's most-likely projects, that can double 2022's US utility-scale solar capacity, taking that to 74 GW (74,530 MW). And, if all solar pipeline in 1H 2022 gets completed, it might raise solar capacity near 4x. Plus those figures were compiled just before IRA was signed in 2022. This IRA law will no doubt stimulate more new US solar building ahead, even faster.

The new US wind capacity to be built to June 2025 may be 70 GW (70,393 MW). 2025 high-probability new US wind & solar capacity together may pass 2.3 GW built/month, not including distributed solar on homes, or geothermal. Watch geothermal later in this decade: for years geothermal most anywhere was stuck at just 0.4% of total electricity mix: but new, deeper wells could expand that. Hence much US solar/onshore wind is expected in this decade. Much new offshore wind, geothermal later ahead too. All pretty good. Yet not nearly enough.

Sadly, far from enough. New US clean energy capacity in 1st half 2022 brought total wind/ solar/ hydro energy to meet 26.74% of US electricity demand. Better, true, than 5 years prior in 2017 when US solar, wind, hydro then together had met just 19.7%. Or 10 years prior, as those 3 had met only 14.76% of US electricity demand in 2012. That was mainly big hydro – only a small few percent was from wind, just a single digit 1-2 percent came from solar.

As natural gas costs spiked 2021, before falling hard <$2.00 by March 2024 (boom and bust), nations turned to burn more coal, devastatingly. Moved beyond-burst global carbon budgets. No chance to see a max of 'just' 1.5 C degrees heat. The physics & chemistry are well known, CO_2 well-understood by science. Look ahead: on present trends we're rushing past 2, and 3+ degrees C of heating. Hotter still, busting past unprecedented gigatons of CO_2. With global blazing temps near-certain, we all may flee to cooler climes in a new 'Cold Rush'. Nearer-term may be vanishingly-short Winters - hot/long Summers = despair. We'd written years ago about the Thwaites, and Pine Island Glaciers, melting ice sheets, sea-level rises in eg, https://blogs.scientificamerican.com/guest-blog/exposed-the-climate-fallacy-of-2100 One can look back at the geological record for clues of what's maybe ahead. Drilling 2 miles below Antarctic ice, science may look back in time. To past climates, as air bubbles reveal CO_2 had generally hovered within a rather narrow range, over a past 'just' 1 million years.

A bit of geology helps looking back at eras far longer than Financial Reports! CO_2 once dropped hard in a past Ice Age, to 160 ppm (parts per million). Naturally bitter cold then. Also was hot then at other times long before we humans. Explained by the fact Earth moves in predictable ways around the sun, in non-round elliptical orbit. Over tens of thousands of years, the Planet moves too 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 too changes Earth’s surface, impacting big ocean currents. How much land is in Northern, vs. in Southern hemisphere affects how much heat is absorbed by – or reflects sun’s heat. Ice sheets near poles reflect sun (cooler) – as dark oceans at poles face the sun, absorbing heat. Net result of a variable 26,000 years in precession, 41,000 years of cycles in axial-tilt, plus continents drifting for cooling, warming. 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 CO_2 released naturally by volcanism, or by CO_2 from decomposing vegetation, or methane under permafrost etc, they can ’kick-start’ rapid-heating via water vapor naturally in air. Water vapor is an even more potent greenhouse gas near-term.

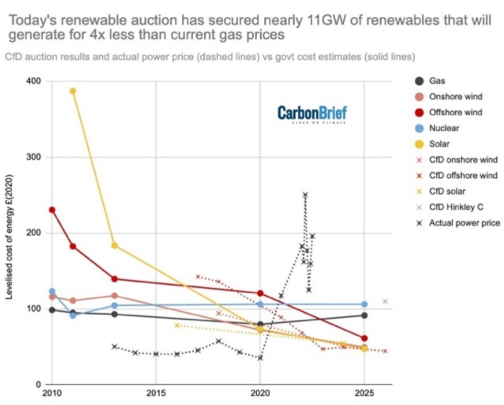
It’s significant that Earth’s CO_2 levels have varied little last 1 million years. From 160 ppm in Ice Ages - to about 2x that or 280 ppm at start of Industrial Revolution. To find higher ppms – one must go back 3-4 million years to hot Earth >420 ppm CO_2 like today. And CO_2 rising hard generally took thousands of years. Instead, vast CO_2 spewed 2 or 3 centuries has meant huge heating is already baked in. Much, much more heat & so lonnggg sea level rises unfolding over tens of millennia+ ahead, are on inertia. May become normal to see lethal 50+ degrees C (122+ F), or normalized Arctic Circle temps 30+ C (86+ F). First, hellish hothouse *conditions* (masked at times say by La Nina) – then after a long-hothouse *state*. We don’t see how oceans already, terrifyingly, are absorbing heat. In 2023 the data showed 396 zeta joules of heat were absorbed 1971 to 2018, in just 1 lifetime. That’s equivalent to 25 *Billion* Hiroshima atom bombs and growing. 2022 oceans added 10 ZJ more heat than 2021, enough to boil 700 million kettles – every second! In 2023, new data indicated this much CO2 was last seen not 4 million years ago – but 14 million years ago; we may reach 600-800 ppm by year 2100.

Hence our problem: by massively burning fossil fuels we’ve put in 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/and least carbon fossil fuel, 4:1 CH_4 so industry calls itself ‘clean’ (it is Not!). Burning each molecule, is only a bit less-horrid than is burning oil or the worst, coal. Take black coal, anthracite (please!). It’s nearly all carbon, very dense. Burning 1 ton of that poison for power makes 4 tons CO_2 – so worse than gas(!). Coal spews 67% more CO_2, plus toxic mercury, particulates, sulphur dioxide, awful ways to make power! Yet young, wet brown coal with impurities, is incredibly worse. For future wet-bulb global temps that may kill.

Hence, remarkable when war spiked gas prices, more coal was used. June 2020, US natural gas had cost $1.48/million BTUs; by Aug. 2022 it was $9.00+ up +500%+! Before falling back hard by 2023. A Europe that 2020 was nearer off coal, returned to it. Short-term, coal = warmth & power. But a price paid in burning carbon gathered over millions of years, releasing it all at once. Yes, EVs & renewables may help keep CO_2 emissions nearer steady (despite coal), or even drop a bit mid-decade. But *reductions in* CO_2/GHG concentrations in air are needed. Necessary: electricity made more sanely than burning fossils - or a Zaporizhzhia nuclear plant Ukraine near shelled in war, explosives stored, safety threatened daily(!). Tsk tsk, silly ways to boil water. Ukraine’s Kakhovka dam under threat. So too, cables on sea floor carrying information globally, a backbone of internet that could be severed.

Two UK power generation auctions, one in 2022, another in 2023 point to how fast things can change. So much electricity still is gas-fired that the infrastructure means not much changes fast. Yet auction results in 2022 showed wind (& solar) can displace much UK gas-power – then a record 11 gigawatts/GW green electricity won bidding – @1/4th the cost of gas! That can power 12 million UK homes. Put another way wind handily beat gas in 2021, 2022. Yes, a 4th UK Contract for Difference (CfD) offshore wind bidding saw prices nicely come in 70% lower than was seen in a 1st wind Round in 2015. Offshore wind got far cheaper ~6 years to 2021. But, then, things rose fast. In 2023 a near-de facto UK onshore wind ban, poor offshore wind support, & inflation in wind was stifling. Before, wind/solar had seen years of cost *decreases*. Then, green energy/wind costs rose 2022/23, like at fossils, nukes. Good Bids for offshore wind in 2022 had once come in nicely low in £GBP/MWh at just £37.35; onshore wind £42.47; solar £45.99. Frankly those were much lower costs than what would be seen in offshore wind a year later, in 2023. Hence when the UK government in 2023 first kept CfD about same £44 for offshore wind – it wasn't good enough, killed 2023's wind auction. Inflation, supply chains all meant higher wind costs were 40%+ higher. Thus 2023's 1st auction was a flop! Late 2023, they raised it to £73. But to make up for lost time, given aims to raise its wind by 4x from 13 GW to 50 GW by 20250, it will need 6-8 GW of bids every year for next 5 years!

All indicative of what was happening globally in green energy. Of UK projects bidding in 2022, the largest share or 7 GW with 93 winners had been offshore wind. UK can grow offshore wind capacity to 50 GW+ by 2030. With a notably low-bid once seen at €37.35/MWh, offshore wind was nicely, 2022 near the cheapest electricity of all then in UK. But 2023 needed a higher CfD floor and still could have been lowish-priced power (vs. gas, nukes). As nearby European Ports like Danish City of Esbjerg, were also ready to ramp wind EU-side too. Increase offshore wind to targeted 150 GW by 2050. On say, 2 Nov. 2022 UK sent a record 20 GW (20,896 MW) wind energy to grid: met 53% of UK electricity demand. Wind/solar/nukes/hydro/storage together met 70% on that day. Despite war, costly power, here was a spot of happy news. UK consumers could pay less, get abundant secure domestic electricity, new jobs too. All thanks to welcome growth early on this decade in *deflationary* wind & green energy:



Source: CarbonBrief

Startling to see above, how swiftly wind & solar costs had plunged 12 years. Natural gas' story went from relatively 'lowish' costs 2010, nukes too – to growing ghastly costly 2022. Gas just after this Chart dropped back sizably in cost 2022/23/24 – as solar, especially offshore wind lost some near-term attraction due to inflation hitting clean energy hard 2021-2024. That's a tale told in pages ahead. Was not so much about volatility in fossil fuels, and nuclear – as about lovely cost-reductions yet potholes too, in innovative renewables. Wind & solar have fast become, simply put often the most affordable electricity. Clean, secure, abundant.

Yet it's not been a straight line. Nor same, all places. Europe, for instance in 2022 enjoyed relatively better/lower costs to install solar vs. the US. Why? For starters, Europeans didn't pay solar tariffs like US buyers have had to do for energy kit from China. Didn't have America's state by state added net metering (NEM) costs. Nor, the same restrictions on China. Plus, natural gas is a core competing fuel in Europe - and the natural gas there has been very expensive. Mid-2022 was $40+ per Mcf. So, gas option there was oft 3x 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, 2022.

Per IRENA data of 2021, Europe already had cut its average all-in installed utility-scale solar costs, by a lot. Germany had pushed solar install costs down to just $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, 2 systems of similar sizes even putting aside the costs of PV hardware (lower as well in Europe), America by 2023 was much less efficient.

Step back, and cost *trends* to install renewables 2020 to 2021 worldwide, had as one hoped to see: Declined. More recent inflation of 2022 & 2023, hadn't shown up in those data, yet. We'll see 2022's inflation in later data. So, looking back at just 2020 to 2021, levelized costs of energy (LCOE) for new utility-scale solar, electricity *fell* 13% from 2020-21 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 80 mid-sized current-gen nuclear reactors. Sure, wind is intermittent, yes. Yet to Germany facing electricity fears, that much new power can be stupendous. 10x more energy, than 7.8 GW its operating offshore wind had made in 1H 2022. Put in perspective 139 billion kWhs of clean energy was made by all of Germany's renewables 1H 2022, and that met near 49% its total electricity demand! Its onshore wind energy had made 59 billion (Bn) kWhs; its solar plants 33 Bn kWhs; its biomass 24 Bn kWhs; its hydro Bn 9 kWhs, and its offshore wind energy had made 12 Bn kWhs.

In 2021/2022/2023 renewables costs rose in solar/wind. Still some fossil price inordinately rose, as renewables' changes were rather moderate, And costs oft handily beat fossils in unprecedented ways. Look at average fuel-only costs in nat. gas electricity (with no CO_2 Fees) mid-2022: these rose to $0.23/kWh, so 23 cents per kilowatt hour wholesale ***for just fuel alone***. Built gas plants in Europe were pricier to run - than it was to build new onshore wind, or solar due to free fuel. Gas fuel costs 2022 jumped briefly 540% vs. 2020. Add carbon Fees like Europe, and 'once-cheap' (not-clean) gas-fired power went >27 cents/ kilowatt hour, 4 to 6-fold more than solar & onshore wind were in 2022. No wonder renewables if competing on even-playing field, were obvious choice. Thermals coal, gas, nukes struggled to stay cool, work Summers. That said, big hydropower struggled too given droughts at dams worldwide 2022: it may have already peaked as well at ~15%, to never again be a 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 that 23 cents per kWh for fuel-alone, 27 cents on carbon Fees like Europe. By comparison, best-case onshore wind was down near just 3 cents(!) thanks to free fuel – and its 68% cost drops since 2010! Solar PV best cost down near 5 cents on declines of 88%!). Offshore wind, best case at just 7 cents, on falls of 60%. Renewables enjoy that free fuel, plus often get cheaper over time to boot. Was becoming No Contest.

As for piped (Russian) gas once EU's chosen path, suddenly it was a red letter of shame. Went from cheap & plentiful– to unavailable, new security risk. Any Russian gas suddenly liability, a dire weakness. Energy Security hawks wanted all (non-Russian) gas they can get asap, even if LNG regas vessels meant more fossil fuel infrastructure. On other hand, Climate hawks wanted immediately to get off all of that. Go directly to new, zero-carbon infrastructure exclusively, now. To keep with any gas was seen by the latter as a mutual suicide pact.

Both sides concurred: Germany & Europe could no more use Russian gas. Emphasized new need, agreed on by all, for vastly more electricity *Storage*. (Electricity storage can be measured as power, so watts – or as energy, so watts over time - like megawatt/hours. And 95% of electricity was once stored as pumped hydro: moving water between 2 elevations, power was by turbine size & elevation difference, & globally 165 GW could be stored. Or as energy, how much water in reservoirs; 2021 it was 9,000 GW/hrs or 9 TW/hrs). Anyway pumped hydro storage capacity was capped: dams can't grow, best sites taken. Electricity storage capacity thus once was mainly pumped hydro – that wasn't now near enough given intermittency & diversity of renewables. Electricity must be used immediately as made, or be stored so intermittent sun & wind demand new storage. Maybe green hydrogen, useful in storage too. Storage, & better grid key to unlocking magnitudes of clean energy growth.

Batteries offer short-term storage, to say 4 hours. Long-term storage options hold electricity for days, weeks, or months. Yet achieving huge-enough zero-emissions global Storage by 2040, means grand new capacity, some 2.5 terawatts (TW) of power, 150 TW/hrs of energy. Thus, Herculean efforts are needed, fast. But outside pumped hydro, very little storage capacity existed. Consider: if all non-pumped-hydro base storage then extant in 2020 were grown by 20-fold, from 2020 to 2030, then it would only come to 1 TW/hr. Just 150th the projected energy storage capacity needed of 150 TW/hrs. No doubt, new non-hydro technology will appear, advancing the curve in unexpected ways. But, this new 2.5 TW is quite an ask!

Some rely on hope. Hoping, say, energy crises in 2020s/30s won't be as bad as in 1970s. Yet, those ahead may be worse. Two 1970s crises were both about oil. Now, 2020s/30s, they're partly about oil – vital natural gas too – even nuclear-fuel-cycle. All that demand pushing up prices for ugly coal too. As CO_2 grows much worse. Yes EVs / renewables may help keep year over year rising CO_2 to 'smallish', nearer nil gains – But that needs to Drop Hard, fast.

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

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

All as opposing ideas battle over what's desirable. For the climate-concerned, 2020/21 was about passing a huge omnibus Build Back Better (BBB) draft bill with both carrots – also sticks limiting fossil fuels. After it narrowly failed 2021, and in 1H 2022, was about a narrower path. After it too failed, hopes were for big Executive Action. In words of one 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 reaching suggestions above, were far, far easier said than done. Each certain to be killed IRL/'in real life' early 2020s. Opponents sure to call any/all Inflationary (though renewables *reduce* energy costs, so deflationary). Plus, Europe badly wanted American LNG so many in America called for big ramps up in exporting fossils. As the US Supreme Court tamped down on EPA's abilities on carbon. Plus, sticks in IRA would be bogged down in Courts, no doubt could be reversed in just one day by a new President with mere stroke of a pen.

Thus that 1 Senator's change in 2022 was 'big', to let Reconciliation Bill 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 streamlining permits was in 'normal times' desired by that Party. And it eyed a majority ahead. Still, IRA gave a brief up to green stocks, for July gains. Then all soon drifted back with H2X & WNX showing too a broad selloff latter 2022.

Even with IRA, issues abound vexing clean energy going forward. So much is yet to be done to swiftly ramp renewables & storage, streamline permits, more. For 1 example, new offshore wind turbines are eye-openingly huge. Sensibly so, for wind power output doesn't just double if rotor diameter doubles – it can go up 4x by doubling wind speeds offshore, going huge can give turbines 8x more power. All maths point to enormous scaled-up offshore turbines. An extant ship say in 2023 once could install not very long-ago a 'big' 1.5 MW turbine at sea. But it can't cope with skyscraper-tall blades seen in gigantic turbines putting out 10, or 12 MW+. Soon maybe 18 MW in size, so 10+ times bigger in output than prior sized blades.

Thus nowadays, ships must be purpose-built wind turbine-installation vessels (WTIVs). In a US it gets 'interesting', due to longstanding Jones Act that stops foreign-owned, built, crewed vessels from operating between 2 US ports. So European WTIVs can't be simply brought over. IRA calls for rapid increases (huzzah!) in offshore wind capacity off US, looks to 30 new GW by 2030. Yet costs are eye-watering high to build WTIVs, with Jones-Act ready vessels not online til 2024 soonest. New 'Edison' vessel can have its housing & warehouse built in, unlike oil rig platforms with crew quarters etc. For hoped-for Southfork, Revolution, Sunrise, to install 1.7 GW. Meanwhile a huge early Jones Act-qualified wind installation vessel, Charybdis built in Texas also chartered. Yet 2023 offshore wind projects were being cancelled – so work-arounds needed. Like maybe base European-WTIVs off Canada first, to help install huge turbines off New England. Use US flagged barges to transport turbines to waiting WTIVs sent from Europe, Asia, etc. In 2023 2 mid-sized wind vessel firms building purpose-made offshore installation ships, merged, creating a much larger single-firm; a step in accessing the kind of capital and scale needed to build offshore wind swiftly, including in the US. Big picture, in 2023 Orsted and other were shelving offshore projects. Sorely needed ahead across 2020s, is capital, huge investments in capacity, loosened supply chains - including in renewables generation, energy storage, smarter and more-capable grid, climate technology.

May be best to think of huge scale now needed to 2050, in rough back-of-napkin figures. To focus Not on what 1 Senator was prepared to give – but rather on the CO_2 cuts needed with global carbon budget according to the best available science. These figures are enormous – but that's true scale of this problem that's undeniable. *<u>Very roughly it's estimated that $100 Trillion total needs to be invested worldwide to decarbonize all activity in 3 decades to 2050</u>*. Tremendous sums. But they can also create immense new gains/jobs – unlike *costs* from a Hothouse Earth, sea levels rising to destroy the State of Florida, New York City, many mega-cities 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's $4 Trillion/year worldwide. Annually over the next three decades to 2050.

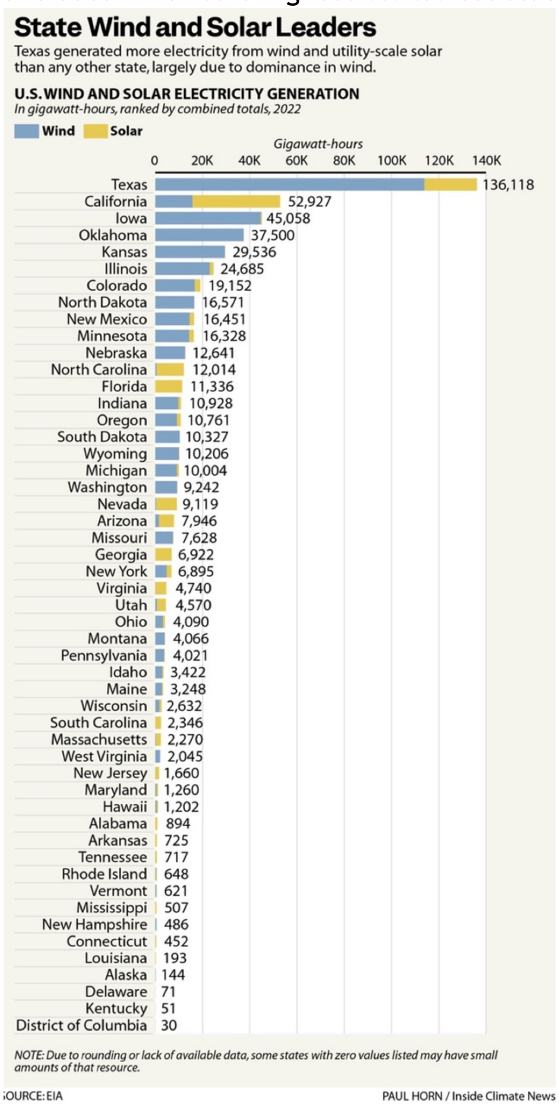
First good news: global investments have hit $1,000 Bn ($1 Trillion) for 2022, a new record. A breakdown from 2021 showed renewables wind/solar investments had grown just modestly in 5 years to $361 billion. What really took off, was electrifying transport: it leapt to $273 billion in 2021 up +77% from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

2026 to 2030, total new spending/investments needs double yet again – to $4,200 billion (or $4.2 Trillion) per year. Thus be 4-fold greater than where we were in 2022! Yes, there's $369 billion a least (uncapped) public spending in IRA – that $$ *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 is 25%, $1,000 billion/yr = $1 Trillion/yr. China similarly 25% but on a more nuclear-heavy path; with much wind/PV manufacturing, strategic minerals, electric vehicle base. Europe say, 20%, $800 billion/yr over 3 decades, also with renewables, transport, green hydrogen for power, heat pumps etc.

On these metrics, uncapped US $369 Billion 2022 IRA goes >$1 Trillion with PTC/ITC lasting decades as discussed ahead as just a start. Think of IRA as one more public sector catalyst for private sector spending on far bigger scales. For example, another place investing needs are great, is building more robust smarter grid. Interestingly, the 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. Wasn't enough to crash regionally wholesale prices. But, meant so much wind & solar was held up, it pushed prices below zero. Wind/solar was curtailed (shut), and offtakers *paid* to take electricity. Waits too long to connect too though addressed some in US in 2023. Grids preventing rapid-build out 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 generation. And January-July 2022, wholesale prices there had went negative a big 17% of time. Versus 7% for grids in heavily-populated California, or Texas. In Q2 2022 close to 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 for 1-way power transmission from big thermal plants. The costs of blackouts are now far-higher too, so $ Trillions to invest in grid improvements may seem even appropriate(!).

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



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

136,118 gigawatt-hours of green power was made in Texas 2022 from wind, and utility-scale solar (above). Yet its electric power needs were so huge, renewables still had only met 34% of Texas' total electricity demand. Adding in nuclear, & hydropower, Texas led the nation by making a big 180,000 gigawatt-hours of zero-carbon electricity. That's all nice, but coal & natural gas still are big there – and 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 whole US, of total demand 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 could grow wind & solar generation faster? A modern grid infrastructure using & sharing power with better resilience. This will mean 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 might have been worse. Fossil & nuclear interests often criticize renewables as intermittent, a 'defect' of no wind or sunshine– 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 big Texas coal plant saw prices briefly fall to -$8,977.46 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. So yes, some $2.5 Trillion in spending by the private sector for stronger grid might indeed happen, and for many reasons.

By end 2022, 31 huge grid outages impacted 1+ million persons globally each past 4 years. In Christmas 2022 a freeze hit much of US. Odesa, Ukraine was hit by Russian drones. 1st Puerto Rico, then Florida were hit by Hurricane Ian 2022. 10 other outages affected over 10 million! If uninterruptable power is mission-critical, outages >8 hours are more than li-ion batteries can bridge. So instead of just storage, think too of fuel cells; they run unlimited long as fuel is supplied. Days, weeks, months. In 2022, fuel was likely natural gas, CH_4. But ahead it may be (green) H_2. Even natural gas to fuel cells 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 more efficient, less polluting. A fuel cell is pollutant-free if using green hydrogen H_2 – no SOx, nor NOx from burning. In this future, H_2 fuel may be made from wind or sun, plus water, so simple if using electrolyzers!

Consider more severe power outages: 3 days impacted 100 million in India on a coal shortage. 7 days out for over 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. Even attacks on grids, or on nukes. Scarier, is blackouts lasting weeks, months; that may mean tens or hundreds of thousands of deaths. Longer could mean millions dead. Attempting risky black starts, bootstraping larger grids back to operation. Doesn't take much to knock out a grid: few bullets, bit of explosives, simple 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 conservatives wanting stronger grid '*now*'! Some may embrace green energy. Conservative-Iowa 2022 got 60% of its power by wind; Kansas got near 50%; Oklahoma close by. Yet their Senators opposed renewables stimulus in IRA, though they increasingly benefit from wind. Conceivably a GOP Senator or few House Members, may tear away from past, partisan GOP opposition to green energy. Maybe on new weather extremes, or quakes from fracking, or unpalatability of Russian fossils. Catalysts may bring back alive elements stricken from IRA, like sticks that can nudge CO_2 heavy plants to retire. Once-heretical ideas like a carbon-tax, be re-considered. Or $ Trillions spent on fossil troubles, climate disasters, or war/s fought again over oil & gas may be rethought - reframing thinking.

We discuss ahead how 1 Senator in 2022 got a defanged IRA passed. We've noted too, Larry Summers who'd forecast Covid stimulus would be inflationary, had some bona fides; Summers told this Senator a narrower IRA – form it took as passed - can be bit *deflationary*. So too had many economists from University of Chicago, Wharton School, etc. Later, early 2024 saw an ongoing, important policy debate – over when/by how much, Interest Rates could be cut. The Summers view was that inflation could not be brought down fast near 2%, without high costs of unemployment. The contrary view expressed by a recent Fed Governor, Christopher Waller – had held that by contrast, *Fed Rate cuts soon do not have to bring high unemployment*. That the classic 'Beveridge Curve' does not now apply; Fed could have raised Rates sooner, and cut faster, too. Since clean energy's stock returns were so hit by inflation those years - a Fed Governor claiming that the Federal Reserve had some latitude to now Cut Rates – without stoking again renewed inflation, was 'kinda a big deal!' But that's another tale.

Here, Bill Gates 2022 had emphasized to that Senator the IRA helps innovation. China after all had nurtured its own nascent battery industry, and by 2022 it had strategic rare Earths, other minerals, processing, refining, production. When Senator & spouse dined with Gates, they discussed how IRA can benefit W. Virginia workers who'd lost coal and power plants jobs. White House reps too, manufacturers, all visited W. Virginia, pointed out to Senator how (smaller) IRA can help a state long in coal. 2 Cabinet members came, praised proposed battery plants. Steel firms too had ideas about solar manufacturing in state. All piled-on at crunch time. AFL-CIO, UMW noted how the IRA can at last funds black lung health benefits, prevailing wages, renewables at closed coal facilities. In the end, all that + the Deficit Reduction = this 1 Senator gave their one key Yes – to a defanged, slimmed-down IRA as carrots-only.

Private sector green *investing*, just before IRA passed 2022 – also informs. First half (1H, Jan.-June) 2022, saw more total investments go to renewable energy, than any prior 6 months period. But, not as much investments $$ went to public stock markets; that investing was off globally 65% in 1H 2022. Instead, private/public funds together reached USD $226 billion (EUR 220 billion), 11% gain over 1H prior year, thanks to newly massive private side. Solar saw USD $120 billion, 33% increase over 1H 2021; wind USD $84 billion, 16% gain. Much USD/RMB/CNY - was China-focused, China-centric: it put an equivalent of USD $58 billion into new wind in 1H 2022 and it put an equivalent to USD $41 billion into big-solar projects!

China was aiming remarkably for 1,200 GW wind & solar capacity by 2030! Worldwide, offshore wind was set to grow in many nations. 1H 2022 investments rose year-over-year by 52%. From total global offshore installed wind 2021 of 53 GW, it might grow 10x to 2035. Yet China-alone was putting investments by rest of world to shame. And, outside China moves rose to avoid rare Earths: Neodymium, Dysprosium, Terbium - given China's dominance.

Also points to our two WilderHill Indexes that launched 2022, for Hydrogen Economy (H2X) - and for Wind Energy (WNX). These H2X & WNX Indexes are green, cognizant of European SFDR for 'deep green' in Europe; average daily trading value (ADTV) floors past 90 days are at >$750k for existing, and >$1m for new components. Like NEX these give each component a voice by being helpfully equal-weighted. Independent trackers for H2X & WNX are in Europe; NEX has an independent tracker in Europe & US too. We were first, had started indexing for deep green themes Hydrogen, Fuel Cells, and Batteries back in late 1990s; so we have deep bench of experience. The website for Hydrogen Economy Index is at, https://h2xindex.com & for Wind Energy is https://wnxindex.com An antecedent from 1999-2007 predecessor, the Wilder-hill Hydrogen Fuel Cell Index is found at, http://h2fuelcells.org

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As a consequential 2022 drew to an end, much had changed. One option some had hoped to see shine – nuclear (Not in our Indexes) - was hard hit by problems. One may have thought France's current-generation nuclear tech could 'ride to rescue' 2022 on Ukraine war. That a French nuclear fleet know-how, would grow its output full tilt. Send added electrons to Europe, sit pretty, unvexed by slowed or a near-cessation of Russian piped natural gas.

Instead, France in 2022 was badly handicapped with 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 the 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, a 27% year over year output drop, to power levels of 30 years ago. Taxpayer subsidized, yet its high electricity costs seemed to vex in perpetuity. Power cuts in 2022 took La Belle France to under <300 terawatt/hours. All with consequences for Europe, that had 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 had 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 was also biggest modern nuclear plant going up 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 then of spiffy nukes being built speedily, elsewhere? Don't they going up fast, on budget, having learned from colossal mistakes like Hinkley? After all nuclear-proponents talk often of lessons learned. Yes, but not in the West. Take America's attempt to do 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 a big $14 Billion & to be done by 2017. But, instead, it drove Westinghouse bankrupt. By 2018 costs re-estimated $25 Billion. Then 2021 costs re, re-estimated $28 Billion; operations only began 2023/2024, @$35 billion – a crazy *$17 billion over-budget!* France's 'new' Flamanville from 2007 was decade+ behind schedule, hundreds of workers re-welding in 2022 costing € billions. Germany may close its nukes. Olkiluoto nuke in Finland was to open in 2009, yet had only begun a regular output 18 years late, in 2023.

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

So 3 factors in equity declines 2021-2023 were *Inflation, green energy costs rather than drop as usual year after year had *rises* not oft seen here; *War, so turmoil; and *Supply chain chaos that hit all renewables. Fossil & nuclear costs rose yes - too, oft by more. Inflation though, was tormenting a green energy long used to price *Declines*, cost *drops* – instead it found No safe port. Green stocks got hammered 2021 to 2023 as costs surged for all: labor, capital, materials, shipping etc. Usually-falling wind & solar prices – then rose. And green equities fell hard, many stocks here were down by -50% in 2022, fell down again hard in 2023, 2024.

Turmoil wasn't confined. April 2022 Russia's Rosneft put up 37 million barrels of its flagship Urals crude for May delivery, at 'fire-sale' (yet high) prices, on fears Europe may halt buying: 'cheap' price if 100% pre-paid. Rosneft pivoted to China, India. A Western major pulled out of Sakhalin-1 mega-project; a trading firm abandoned 10% stake in Vostok-1 mega-project. In 2022 Rosneft signed in prescient fashion a huge $80 billion, 10-year supply deal with big China counterpart CNPC. India's refiners signed for heavy crude. Europe looked instead for alternate supplies fast, for oil & critical diesel, natural gas, mindful of cold winters, hot summers. China thus halted re-selling, exporting gas given domestic needs. Some coal, some nuclear plants slated to close – were kept open or restarted. Despite, and here's looking at you coal, oil, natural gas – that climate crisis will likely be much worse than people yet recognize.

Destructive warfare wasn't just kinetic, some attacks were not covered in the media. Like late February 2022 literally at start of invasion, an attack on satellite data took down remote monitoring of 5,800 wind turbines by Enercon GmbH. On March 31st big wind turbine maker Nordex was hit by a cyberattack. In April 2022 a big ransomware group claimed responsibility for that; then another attack caused yet more significant disruptions to Nordex.

Also some own-goals. 4 countries: Vietnam, Thailand, Malaysia, Cambodia assembled some 80% of solar panels imported to US. After a tiny US solar maker asked US Commerce Dept to investigate see if they were 'China-panels' so circumventing China tariffs, a 200% *retroactive* penalty grew possible - halting solar imports. Projects ground to halt 2021. Slowed hundreds of US projects, a huge 24 gigawatts! One big US solar developer paused 2-3 GW planned projects on lack of solar panels. Quasi-judicial investigation early 2022 proved lugubrious, so solar panels in US grew scarce. Solar developers needed both clarity, and more panels, so in 2022 the US President gave a 2-year reprieve on tariffs. Skirted the issue. Re-opened spigot on all Asia-sourced panels, whether Chinese or not. But it also somewhat just kicked this ball down the road only, something of unneeded US own-goal. Re-raised too in latter 2024.

Clarity had been needed 2021 & 2022 on many green-energy fronts. Would Congress extend US tax credits 10 years for wind, solar, stand-alone storage? Once 1 US Senator got less IRA, a mountain valley pipeline in 2023, some questions went away. But not all. Sorely needed too given ever-rising CO_2, was renewables capacity growth, green incentives, loose supply chains, better energy efficiency, more EVs, carbon pricing. In Europe too. Plans had indeed arisen in 2022 for a 5-fold increase in UK solar capacity from 14 GW - to 70 GW 2035. Germany began planning for solar to grow from 22 GW – to 215 GW by 2030. Europe, US, China, and more were pushing renewables. Sensibly so as these are a great foil against dependency on fossils. For certain too, some previous political naysayers were now attentive to new climate risks. But certainly not all – as opposition remaining rigid in the conservative party in the US. Clean energy went from growth, a spurt of margin expansion and jumping stock prices in 2019 & 2020 – to instead margin compression and drops in 2021, 2022, 2023 and again 2024.

Europe weaning off Russian fossils wasn't easy – but came fast. Still, take German car making so core to its economy. Germany is yes exiting diesel fuel – it's moving fast towards EVs that may be renewably-powered. But, what of its auto factories? Can they too go past natural gas in its vehicle *manufacturing?!* For the heat needed say, in its paint shops? How ready was it to shake addiction to cheap natural gas, for necessary heat, from 2025/2026/2027 etc …?

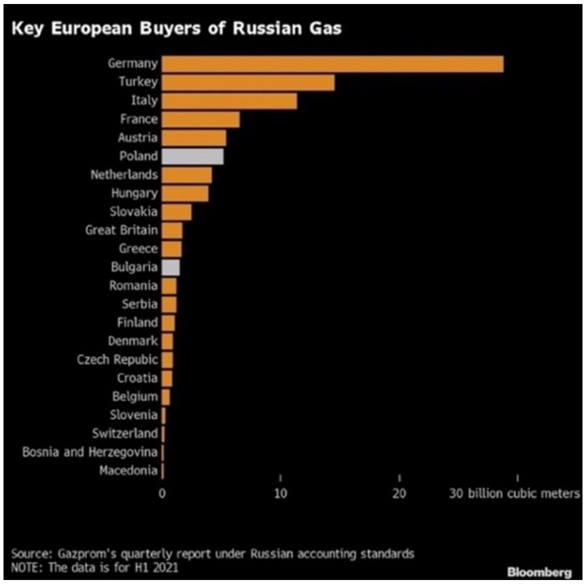
Shell-games like 'carbon offsets', or 'renewable energy certificates' had let firms pretend to use little natural gas. Claim say trees left on slopes so steep they can't be cut, 'reduced' fossil-use via carbon credits. Surplus, non-transparent, European hydro certificates somehow incentivized renewables. But that was oft virtue signaling. Once Russian gas supply tapered – then was mainly shut, it 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 in 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 real high industrial heat – to go from fossils to decarbonizing via green hydrogen, or its derivatives ammonia, methanol, takes in light of our climate crisis, too much time. Time-scale decades, may mean hothouse world very different from our habitable one. In short, green electricity & green *energy heat* are needed ***Now***. Given climate – plus a seeming-always energy security crisis. 1st half of 2020s, 'solutions' were Not happening swiftly enough. Not one bit. Meanwhile that much needed high-grade industrial heat cannot *directly* come from sustainable wind, hydro, or solar electricity.



Source: Gazprom's Quarterly Reports; Bloomberg.

As seen above, Germany, Italy, France etc were in a bind at first over Russia. A worry early 2022 was over natural gas rationing in Europe. Fast moves off Russian oil, especially off gas needed. Spring 2022 Europe first looked at a 210 billion euros (USD $221 billion) REPowerEU plan to up its renewables (some) from 40%, to 45% in 2030. EU renewable energy generation targets rose to 1,236 GW. To cut 6 years red tape for wind permits, 4 years for solar, new 'go to areas' for permits in 'just' 1 year. Aimed to grow EU solar capacity near 2x to 320 GW by 2025; then to 600 GW solar by 2030. New 113 billion euros for renewables, energy efficiency, hydrogen infrastructure, heating for industry. But - still wasn't enough. There was (from a climate perspective) too much spending still on fossils/gas infrastructure – quite like in US and China. Replacing in 1-2 years, Russian piped gas - with LNG could be/ and was done – especially with US LNG. Climate clearly took a back seat behind new energy security.

Despite spending on & attention to clean energy, seems counter-intuitive – yet that did not - & it does not, equate to persistent equity gains for clean energy. Not in ECO, NEX, H2X, WNX. Some months, eg April 2022, ECO dropped hard by say, -22%. By May 2022, Year to Date (YTD) it was down -40%. ECO swooned again June 2022 once more on fast-rising headline inflation. To be fair ECO jumped some in July 2022. Famous tech-heavy NASDAQ was down -13% in April, was -30% YTD June; from its own peak 'Naz' was far off highs; S&P500, Dow down hard YTD, bear markets each. Not as volatile as ECO, to be sure, but as 3 of the world's best-watched themes, NASDAQ/Dow/S&P500 big drops were no small-potatoes. As noted, ECO then briefly jumped in July 2022, far more than major Indexes – but fell back -50% at times in 2022.

Curiously, a well-known active fund manager criticized passive Indexes/ETFs in Spring 2022, claiming 1) passive indexes underperform active-managed funds, & 2) Indexes prevent having growth stories like a notable Tesla early on. Yet both claims were/are demonstrably wrong. First 'point' shown repeatedly false for years: in fact passive Indexes can *Outperform active-managed Funds some 80% of the time!* No wonder passive indexes are 'eating active Funds lunch', growing at latter's expense. We've seen ECO beat an active-Fund in this space most periods. 2nd, ECO added a Tesla, so notable to this theme, at its start/IPO. Indeed that Tesla cited by the fund manager was in fact added here, was put into the ECO Index in the first Quarter that was possible after its own IPO, which was at the start Q3 in 2010, https://wildershares.com/pdf/2010%20Q3%20ECO%20Quarterly%20Report.pdf Prior to that, we'd written about this rather important EV company too – and 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 their ARKK - ECO & NEX Indexes 5 years to late 2023 presented then a rather comparable finish. That ARKK which is younger, is also innovation heavy; it began a decade *after* our own ECO – also in disruptive (but different) themes. Below chart begins roughly similarly. ARKK started later, ARKK in 2014 – vs ECO 2004 & in 2005 for ECO independent tracker; our 1st Global clean energy NEX (lighter blue) was born 2006 / and tracker 2007. All 3 themes center on innovation; in 5 years since Sept. 2018 extended in chart here to end of 2023, **ECO** (dark blue), NEX (light blue) and **ARKK** (red) all jumped fast about same time, March 2020 – then fell hard.

As we see ECO jumped higher & went farther up, than did NEX or ARKK: all 3 co-peaked about Feb. 8, 2021. Then all 3 painfully plummeted. This Chart here to end of 2023 shows ECO for 5+ years from Sept. 2018 – to end of 2023. ECO is about nil - vs. the NEX that's then the most up at +15% - both versus ARKK here at the end of 2023 about -8% underwater:

5+ years to end of 2023 **NEX** is the most up +15%; ECO is about nil; vs. ARKK (red) at down -8%:

Source: finance.yahoo.com

For all our warnings of ECO, NEX about their acute risk, those 2 here went up more, down a bit less here than ARKK. Yes, we see periods where ECO/NEX drop more than ARKK; there is nodoubt but that all three themes are highly volatile! As always too, innovation/tech are volatile, hugely risky areas – whether active like ARKK, or passive like here. Clean energy in wind, solar, EVs, H2 etc never havens of calm. And 2020s look to be a time, when all energy may see acute volatility, with shortages, rationing, perhaps calamitous blackouts.

Energy, unavoidably, is complex. Full of 'on the other hands.' Take renewables in applied on ground ways. Facing decrepit old grids; war; fuels scarcity; fuel switching off Russian gas; weather extremes, wildfire, attacks, more. 'On the other hand' a good milestone 2022 was California on one windy day for 1st time briefly got 100% of its power from renewables. A sample less-windy day, May 5, 2022, on 23,000 MW demand - 17,000 MW or 70% was met by solar, wind, geothermal. They may ramp ahead, displacing more (on that day 17%) natural gas. Sunny daytimes, much demand is met by solar, and wind. But the sun always sets, and some times surely are not at all windy: electric power Must be dispatchable all the times - meaning more renewables needed with storage. Figures are far behind where they must be - given CO_2 levels & climate emergency. Grid and supplies long at sixes & sevens – bottlenecks galore. As seen when California was badly short some 1,800 MW much-needed electrical power – not enough to handle what's sure to be-ahead hot Summers & cold Winters. Small wonder its lone nuclear plant though costly, still making 6% of the State's power, saw its life extended by 5 years in 2022, going from a 2025 – to later 2030 Retirement. As shortages threaten, and Blackouts too, not just in this rich US state, but all of Europe, China, and globally.

Clearly, bearish troubles overshadowed clean energy as 2021, 2022, 2023, then 2024 opened. One worry at first was 'only' a bipartisan $1.2 Trillion(!) infrastructure passed in 2021. Little in it relevant to clean energy – or climate. Compared to a BBB reconciliation draft that at first was $3 Trillion, then 'less' at $2 Tn, then $1 Tn focused on clean energy & climate - but stumbled & failed 2021 - that was 'thin gruel'. For example to make an aged US electric grid net-zero, would have to require very big capacity upgrades. Yet that Infrastructure law's text only gave grid facilitation meagre $ amounts. Grid resilience $11 billion, but power failures discussed ahead, vex now. They can cripple; $3 billion in grants not near up to task. A still 'small' $65 billion for grid transmission can be fast eaten by spending on transmission for fossils-made electricity, that's outside of more pressing need for decarbonization.

$66 billion was for transport: electric rail, OK; but not fossils-based transport expansion. $3.5 billion was for low-income community weatherization, a start. Like $7.5 billion helpful for electric vehicle charging infrastructure, $5 billion to replace dirty diesel school buses with electrics and alternatives, discussed below. But $6 billion for batteries was nowhere enough 2022. Not as competing China already spent so many multiples of that last decade to 'own' battery manufacturing. The US unfathomably nearly had 'given up' in a global race for batteries. Tesla was 1 great US outlier 2022 – but Asia, even Europe, were ahead. Europe may install millions of EV chargers, to match the 130 million EVs expected by 2035.

Globally 2021/22/23/24 saw strangely both big energy needs - & big equity declines. China, Europe, US - all saw much demand for solar, wind, batteries, EVs. Ahead say, hydrogen too. Yet interestingly as renewables grew worldwide – these risky high PE green stocks plummeted, dropping hard these years. Clean energy may show promise ahead, this decade – yet this theme and so ECO Index - were hard down hard on inflation & supply chains 2021 – 2024 etc.

Consider declines at one of world's biggest wind turbine makers 2021, Siemens Gamesa. (In China too a big wind maker saw profits decline 5.3% in 2021; revenues up just 3.3% on material costs rising, supply chains chaos). For Spanish/German 'Siemens G.' its stock fell by -45% to end of 2021; market cap down by near half. October-Dec. 2021 it saw revenues fall to €1.83 billion; year on year -20%. Expected revenues then fell more. Blamed vexed supply chains, cost inflation. Pointed to volatility that "impacted some customers investment decisions", project delays. Dire straits yet it was not alone: competitor Vestas noted "supply chains instability caused by pandemic", "cost inflation in raw materials, turbine components, energy costs." All were doubtless at issue in wind energy. Indeed 2022 Vestas posted a 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 would be paused and there was a €2.2 billion charge due to quality issues, €4.5 billion net loss.

Zoom in at 2021. Take onshore & offshore turbine orders at all 4 leaders: Denmark's Vestas, America's GE, Germany's Nordex, and Spanish/German Siemens G. Together, all 4 only saw a 3% decline in new wind business year over year. Orders at all dipped yes, but only by a bit – to 48.5 GW 2020 from 49.8 GW in 2019. They made up most west wind manufacturing. Of them Siemens G's offshore & onshore turbine orders fell the most, by -17%. Vestas saw a +6% *increase* in 2019 as it reorganized - but it was hit too 2022. Orders at GE & Nordex were near steady 2019, then dipped just -1% & -3%. GE's Renewable Energy segment would soon see $2 billion in losses in tough 2022, due to inflation; on greater than expected warranty claims, a tough execution for supply chains; lowered US wind demand on a prior PTC lapse – but back in 2020 it and other 3 had seen better times. So, what might have been involved in Siemens Gamesa's own larger declines in 2021 – harsher than seen at the other three?

Perhaps, partly was on 'Siemens G.' moving from high volumes to more profitable projects; suffered too having been offshore wind leader, who others gunned for. Vestas introduced a huge 15 MW offshore turbine hoping to take market share, so too GE Haliade-X turbine. Vestas & GE hoped to 'eat Siemen's lunch'; Siemens G. went from 60%-70% offshore wind share 2011, to down near 50% 2021. Siemens G. reported in 2022 a €377 loss on less revenues, negative margins. EUR €884 million loss 2022, warranty costs like from wrinkles in blades, faulty gears, component failures in 2023. Only the Servicing of turbines saw much growth.

Onshore wind, ex-China grew modestly. *Offshore* wind *may* grow near annual 23% rate. Yet take famous Vestas: in 2022, it too reported dismal results. Despite big top line revenue up +5.2%, poor net profits EUR €176 million were off -77.2% vs. prior year. At fault: skyrocketing raw materials costs, tough logistics, Covid troubles for all wind manufacturers. Vestas was hit by cyberattacks. Revenues healthy 2022 near €15 billion. But transport costs, logistics, all vexed Vestas' bottom line. Especially steel as is some 2/3rds cost of turbine structure, 66%-79% total turbine mass – yet *doubled(!)* in costs early in pandemic – subsiding later some. Still, from early 2020 to early 2023, costs for 7 metals in wind turbine construction rose by 93%. Molybdenum in steel, key to wind towers and turbines – rose by 285%! Zinc was up 'only' 23% that period, but strong headwinds against profitability. In 2023, Vestas did move towards hoped for profit on better revenues, but with irony in its wind servicing business.

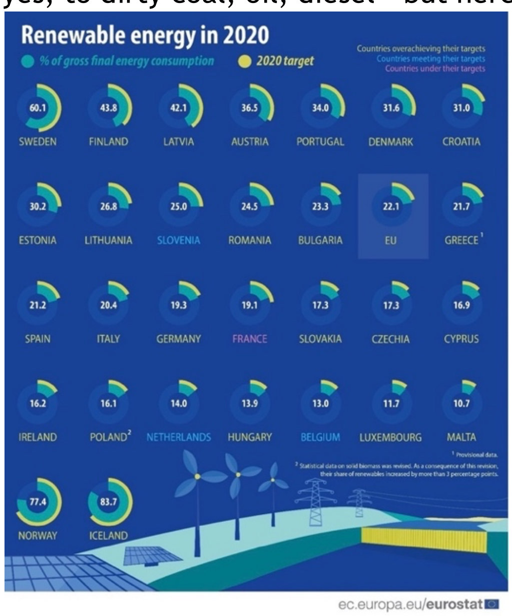
Wind's growth had meant in 2020, 25% of UK power was from wind over a year. And UK wanted wind to account for more, over $1/3^{rd}$+ of its power by 2030. In Europe, wind power made on average 16% of electric power 2020 and growing. Pair that green resource with energy storage, and wind/solar together may be a dispatchable power. Green hydrogen, too, *might* potentially be a more viable idea - but only if wind/solar first get very cheap.

Yet as noted, wind's growth 2021, '22 didn't translate to equity gains. Quite the contrary: in 2023 all big wind developers were in trouble! A parent, Siemens Energy AG in 2022 stepped in to buy last 32.9% stake of Siemens G. it didn't own. A flailing "deteriorating situation" to be "stopped as soon as possible". Ironically, wind (& solar) were leading renewables early 2020s. Onshore wind grew moderately on constraints (China onshore wind grew by leaps & bounds despite high steel costs). Offshore wind was starting from scratch, unconstrained. Orsted grew operating profit by 94% Q1 2022, confirmed EBIDTA guidance 2022 – yet Orsted would plummet latter 2023. Meanwhile, solar too has enormous fantastic potential. Albeit was a tiny slice of overall power generation in 2022, far smaller than wind, look for that to change fast in this and next decade. In places, solar & wind together will be the biggest 2 power sources, not just of renewables – but all electricity. Getting more affordable than all else, maybe hastening energy transition. Since war in Europe hastened a departure from (Russian) gas, from diesel, coal – it may accelerate renewables' growth across this decade. Yet Siemens G. fell hard in 2021, 2022, 2023; Orsted too. Projects shelved.

Once, hydropower, huge dams was the renewable resource, 1970s & 1980s. Some places dams generated 10%+ of energy mix – as near 100% of renewables. But that potential mostly is capped, no new places for big dams to go in. So it's with no regret hugely scalable solar & wind instead are growing fastest. Meanwhile, small run-of-river hydro, geothermal have much potential. They could go in many places while adding desired firm power. Big oil may explore geothermal for is drilling holes, which they're quite 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 similar-output gas fired plant.

Net result is wind & solar were 2 biggest renewables start of decade, as rich Europe led. Europe gross electricity demand met in 2020 by renewables was near 1/4th, close to 25%. The 2020 figures below 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%. Nearby Latvia, Austria were 32%, 36%. But of course, there were EU laggards too. Belgium had then gotten only 13% from its renewables; The Netherlands then just 14%. Both only barely reached then targets (better since!), so were rather 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:



Source: Eurostat.

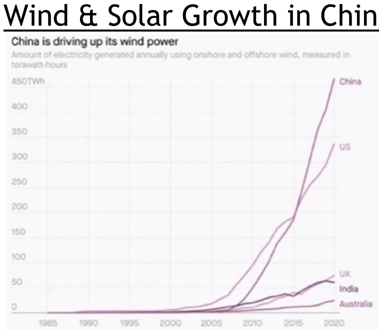
UK famously had left 27 member European Union in 2020, so isn't seen above. But, the UK did in 2020 source 42% of its energy needs from renewables, thanks to a big wind push. Expect offshore wind to fast rise in UK & Europe. Yet curiously if renewable costs in UK, like elsewhere fell – why did UK average home energy bills in 2021 *jump* to GBP £1,200/or USD $1,630? And go *higher* 2022 as UK wind power was made for just 5p per kilowatt hour (kWh) – under ¼ what a homeowner pays?! That, was due to 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 1/3rd 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 – ahead of a 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 2022/23; 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 fast. That vastly beat a US at just 1 EV out of every 20 cars. For a Europe where 1/3rd of oil, more gas had 2021 come from Russia, war served to turbocharge green energy growth. Yet, with also a nightmarish rush to again burn more domestic coal.

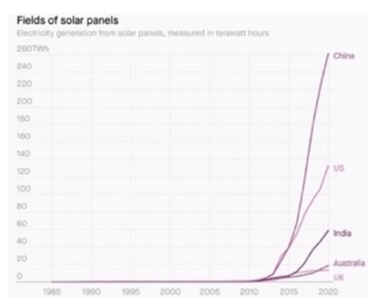
What of China? As arguably the most important bloc for renewables? China in 2020 was world leader in its absolute energy generating capacity. Yet its 342 gigawatts (GW) green capacity still meant (only) 14% of power was from renewables. 14% not far off figures for the US. Still, figures can deceive. 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:

<u>Wind & Solar Growth in China surpassing all:</u>



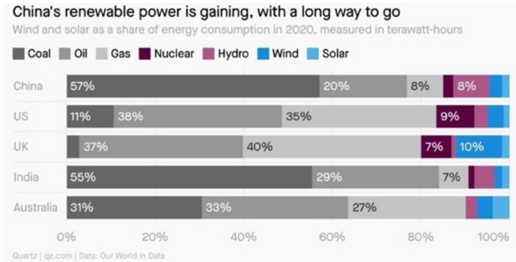
Source: Quartz / Our World in Data.



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 fared 2020 is seen here as fossils in charcoals, browns & grays dominate, left. At right brighter 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

Coal-loving Australia for instance was at bottom here, coal 60% of electric generation in 2021. Though renewables are a better bet; at a Badgingarra Western Australia wind farm, capacity rate (how much 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: the one test in America shut down late 2023. Much preferable would be distributed 'SMR's of another kind, clean & greener too: Small Modular Renewables.

World fossil linchpin China seen at top still burnw so much coal, absolute & relative ways, it ensures we humans release unprecedented CO_2. In 2021 China's coal production leapt to 4.07 billion tonnes/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, 2023. In California a Commission overseeing power had favored centralized utilities, over small rooftop solar. To a consternation of many – in 2022 it *reversed* incentives for home rooftop PV, so only solar+storage makes sense. A draft 'NEM 3.0' even had a $8/kW solar tax that can push solar payback from reasonable 6-9 years for solar – to 20+ years: makes No economic sense. That was changed after uproar; but they imposed a 75% drop in value of solar-alone. Eliminated retail rates, went to 'avoided cost' – so compensation plunged from 30 cents /kWh, to just 7 cents. That made solar-only (with no battery) unaffordable, purely non-sensical to most people. Only PV with batteries for evenings – made sense – but it was unaffordable to great many Californians. That in verdant green California! San Diego's local Utility was charging on average, retail rate of 47 cents/kWh ($470 a megawatt hour) – yet the Utilities were able to hobble or sink home solar.

An expert in Net Energy Metering (NEM) called a 2022 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 near 7 years [born out by our own experience]. That installed PV doesn't cost a low $2.38/watt proffered in PD, but nearer $4/watt. To put huge costs on PV – *retroactively* – can kill distributed home solar. And adding storage – costs much $$$.

Pre-election outcry over draft solar tax, seemed to kill a $10-$20/month 'grid participation' fee. Discriminatory anti-solar charges to be paid only by homes with PV, were rare: seen at just 2 of 172 investor-owned utilities nationwide so <3%. Yes, 27 times in the past various utilities had *proposed to* add charges for solar homes only. But nearly all of those were withdrawn or rejected outright. And none imposed retroactively, like was proposed here!

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

Utilities are accustomed to big, centralized thermal-plants - that they alone own/control. They may support too 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 on California homes could instead 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 gas burner car – to instead have solar power roof & EV. This 1st PD would quash the option, even in progressive California, even in 2022. Pushback was swift & vocal. Notably when California pushed that off to after November Elections – it piled uncertainty atop 2022. Pushed down a solar sector already hit by anti-circumvention, further. Only costliest solar+storage, might then make sense.

Not just in California either: sunny Florida had its factions trying to halt rising roof solar too in 2022. A bill introduced in Florida's State legislature, backed by its huge electric utility, could decimate home rooftop solar. Well, that legislation wasn't just 'backed' by that utility. It was later uncovered 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 at 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 best accept big central PV - if they alone can 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 is 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 from California Operator (CAISO) in charge of 80% of State grid. Drafted 2022 it laid out State power supply for 2040. It looked at adding 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. Greater-than 4 hours of energy storage, another 4 GW.

As vital as what California may *add* next 20 years – is what it might *take away* under this Plan. 2 big targets in crosshairs were to *slash Natural Gas over its greenhouse gases – and *end current-gen II Nuclear as exceptionally risky and costly. Cutting natural gas near-term is a huge ask. Gas has long been at heart of California's power – both in-State and imported electrons. In 2021 natural gas was a key 48.35% of the in-State power generation; and made up 37.06% of the 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. Makes a gaping firm-power hole. Hence, this plan seeks for utility-scale solar, to triple. Energy storage short-term (<4 hours via batteries) jumping 15x from 2.6 GW in 2021. Longer-duration >4 hours energy storage like pumped water, rises 4 GW. Of course, just planned in 2022. How then, near-term, to actually replace GWs of firm natural gas – plus big last nuclear plant soon, this decade – with anything near as energy-rich? In 2020s the answer wasn't 100% certain, and threats of rolling blackouts soon, ahem, are real. In an energy transition that highlighted demand for yet *more* natural gas, and keeping nukes – not one seeking less of either.

That 2022 Plan anticipated 12 GW of renewables brought from out of state. 3 GW wind/sun on a SunZia line from New Mexico/AZ which got its $11 billion in funds and after 17 years of Permits, began construction in 2024 as one of biggest clean energy projects in US history; 4.7 GW transmission of Wyoming wind on TransWest line. GWs can't happen soon enough. CAISO's draft Plan projected going from 7.8 GW California wind power, to 24 GW wind in West 2040. In past a too long 8-10 years was needed for permits; 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 to allow local off-takers to use offshore wind, $11 Billion to bring wind power from out of state. $ Billions – and $2.5 Trillion over a decade are 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 sums on oil & gas, $$ for renewables are relatable. Particularly as resilience for California's $3 Trillion economy. Were the state a nation it'd be 4th or 5th largest in the world. Ahead of India, the UK. Blackouts there – or anywhere, whether due to heat/freezes/attacks must be avoided.

A biting issue 2020s was poor US grid resilience – power lost too frequently. 2021 saw 180 big power disruptions; 20 years earlier, it was fewer than 2 dozen. Not just unprecedented weather extremes at fault, the US grid is aging badly. 70% of transmission & distribution was far in 2nd half of 50-year lifespans, with 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 on, natural gas became king as shale fracking made it cheap. Since then, renewables began to compete, and at times beat all on price. But given an intermittency of renewables & need for storage, problems rife in all fossils, nukes, razor-thin power reserves – plus old grid and power non-resilient, it will stay this way 'til vast new storage comes online. There's no easy answer. But certainly, with more abundant, cheap, clean renewables, both newer storage & better grid have simply got to be grown swiftly too.

Storage & grid will take time to be built. So what of 2 parts to this puzzle: current gas & gen II nuclear near-term? Right now, California needs all its 25 GW of renewables – plus 50+ GW more green generation. 17 GW utility scale solar should be added 'yesterday' - even utilities support that. More offshore wind, fast. Were new gen IV/V nukes safe and affordable, no wastes, that would be wonderful! But the State's one, last gen II nuclear plant extended from 2025 – to 2030 closure, was none of those things. California's grid ahead 2032, may be 70% renewables & be 85% greenhouse-gases free. But next few years in 2020s are scary.

It's easy, thinking of politics, to forget about how CO_2/climate actually will 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. Clouds, especially, have long bedeviled forecasts. Just how clouds, water vapor ahead 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 mean we're on a bit less of a blazing cauldron, than what models so far have predicted.

A National Center for Atmospheric Research (NCAR) Community Earth System Model 2 (CESM2) implied more impactful heating *may* come, sooner than was forecast by 20 prior models. So, scientists in 2022 re-looked at CESM2. More granular, sophisticated than prior models, a bigger amplification is seen as *possible* from clouds, maybe, should be, worrying. Clouds may reduce heating (yay) - or maybe instead supercharge it – so getting clouds' complicated impacts right, is of the essence. Like impacts of shorter-lived methane, other GHGs besides carbon dioxide (CO_2) – consequences can be planetary-scale. Clearly, water vapor is crucial.

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 start of industrial era – from earlier 270 ppm to 550 ppm where we're fast now headed on CO_2 already over 420+ 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 1/3rd higher temperatures, than prior models implied, so getting accurate modeling was no small interest. 9 degrees F would feel in places like a furnace. On accuracy of climate models, then, much depends. It's an entirely different way to forecast what may be, than looking back in geologic time to when CO_2 levels were roughly similar, estimating what temperatures may be like ahead. (Maybe it's back to Pliocene, then Miocene for us)! Either way, the 'merely' transitory extreme heating we may feel a 1st century or two @550 ppm, can pale to far hotter equilibria later unfolded over many millennia. Far Hotter. With long rising seas discussed ahead.

That's why, when review of 39 climate models found 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 those models are partly right? To say nothing of unstoppable permafrost melting, undersea methane, clathrates or hydrates like 125,000 years ago in Eemian interglacial 'hot' era, as global seas were 20+ ft higher.

Let's shift gears back from climate - to finance & equities, and a bit of helpful news. One is there's more breadth across potential candidate clean energy stocks. More public companies are working in clean energy, climate/tech solutions. Markets better advancing global new energy innovation. Firms here, by market capitalization in 2020s, now oft much larger than at turn of millennium ~25 ago, even 10 years ago. In applied side-note related to Indexing here, market consultations in 2022 and 2023 resulted in a few changes to the NEX Guidelines. NEX Index average daily traded value (ADTV) floor became USD $1 million/day past 90 days for new adds, and USD $750k for extant components. Screens for NEX/H2X/WNX are Global Standards Screening (GSS), Controversy Score, 'ESG'/Risk Ratings (ESG RR), & various Product Involvement (PI) fields; so companies missing GSS, Controversy Score, ESG/RR or all PI fields, would be removed from the eligible universe. More is on these Indexes' websites.

Staying with reasons 2021-2023 were rough in equities, one was investment banks already 2021 predicted sparse profits for 2022. Earnings targets at S&P500 firms were for 'lower-highs & lower-lows'. Take newish S&P500 name, Tesla: had a huge market cap, among S&P's biggest as it entered that 500 (funny enough, late on hesitancy over reputational risk). It set a tone as its head aptly expressed concerns for supply chains risks for the whole of coming 2022 year. A high-end estimate for all S&P in 2022 saw only gain of +9.1%. Other forecasts were flat, or negative like the S&P ends 2022 down -7.7%. Average predictions at 9 institutions saw puny +2.8% return for 2022. Causes for pessimism weren't transitory; saw headwinds as sticky. As valuations began 2022 high, late 2021 S&P500 price/earnings (PE) 27, maybe meant likelihood of falls. High 27 PE hadn't been seen since the tech bubble, and we know how that one had ended. To expect earnings to justify as rich PE as 27, was maybe a fool's errand.

Back in 2019, there'd been sound reasons for optimism on earnings & growth in 2020. S&P500 profits then had just hit a record. Government stimulus was about to flow due to Covid. Profits just jumped +25% to new records. Still, operating margins hit plateau. Late 2021, there wasn't room for big rates of growth like years earlier. Pessimism was backed by metrics, like a cyclically-adjusted price earnings (CAPE) of 40. CAPE since 1877 had only hit 40 once-before – in a dot.com frenzy, and again we recall how it ended. When S&P dropped -40% in 3-years in dot.com decline, it took another 13 years until that S&P again reached its prior levels.

A big headwind start of 2022 was rising interest rates hurting equites. Not long-ago, investors got nearly Zero % from bonds. So demand grew for high-risk themes, for better-returns (at times) in volatile themes. But if lower-risk alternatives could soon boast respectable rates - then Treasuries, bonds etc might re-see a flood of capital returning for smart place to call home. Real rates 2014-18 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 more common 21 – to high 27, CAPE went from normal 20s – to (yikes!) 40. On rate hikes a return to mean is bearish for stocks. Especially with rates higher/tightening. All fundamental points in 2022.

If a threat 2023 wasn't 'Unprecedented' inflation (it had been so high 1981) – maybe it was high inflation takes root, growing hard to kill, rates staying higher longer. Inflation is partly a state of mind, psychological. If expectations take root, persist, both higher rates + stagnant / sluggish economy stagflation, slugflation; Fed Rates tools wickedly un-useful in recession. No central bank wishes to hike rates going into a recession, economy cooling. Equity-risk premiums of holding to stocks (vs safer bonds) - makes equities decidedly unhappy place; CD rates over 5% mean a new world. Higher rates are something a younger generation doesn't viscerally remember. Over a decade to 2022, no G7 central bank had put rates above 2.5%. But in 1990, they'd all been over 5%! On rising rates - 2021, 2022 & 2023 were decidedly not great times for riskier, volatile, high PE growth themes in green tech. It's ever-impossible to successfully time markets. To foresee, in advance, a best = lowest clear entry point.

Lightening mood for fun, coincidences may be seen *looking back in time, only*. For example, ECO had hit a high on Dec. 26, 2007 at 297 (297.05 close) – just coincidentally, it would later hit a next big peak Feb. 10, 2021 bit near-ish that at 287 (286.89 intraday). Or it rose by a near-perfect/neat +200%, up 3X in 2020 from 71.47 on Jan. 2nd – to 214.06 close on Dec 31st.

Or, prior to rising hard from March 2020, it had fallen earlier that year 1st by near-neat -50%; it then had plummeted by -48.8% from a 92.53 close Feb. 20, 2020 – to 47.37 close March 18, 2020. Afterwards, it would rise a big 6-fold from March 2020 nadir - to Feb. 2021 top.

Or in 2021, the clean energy theme fell a strangely neat, near-exact, non-imprecise -50% in going down near -½ (down -49.6%). Here it went from 286.89 intraday peak on Feb 10, 2021 - to its 2021 nadir low 142.39 seen intraday near the very end of year on Dec. 29, 2021.

In 2022, a 2nd time, clean energy fell by a near-perfect -½. From close 1st day 2022 at 152.87 – to its nadir close 76.02 near end of year 3rd from last day of 2022, it was down -50% (-49.7%). Again a near exact -50% fall only by chance, found looking *back* over very, very rich data sets. A few oddly non-imprecise declines in clean energy's near perfect -50%. Or look say at Q1 2022: it then hit near a 100 bottom 4 times of 103: on 28 Jan.; 24 Feb; 28 April, 2 May. Or in early 2023, this theme 1st fell to similar resistance level repeatedly about 70, a few times.

Just spotting clean energy coincidences in data-rich past: it's meaningless looking forward. Sometimes looking back infra-year; other times looking from year's start. Does though, point to how volatile clen energy/ECO is, falling -50% even in up years! Or non-calendar 12 months, say from end Q1 2021 – to end Q1 2022; that's meaningless as a non-calendar period. Yet was roughly 200-100, from peak April 1, 2021 at 205.65 - followed by 2 lows Jan. 27th & Feb 23rd both at 107 close (or 102 intraday). Come to think of it, funny how those 2 lows, were both again not far off neat -50% drop going from 205 - to 102! War sparked a brief +40% rally in these clean solutions here Q1 2022, before falling back. But again, to so cherry-pick data, especially infra-year is NOT predictive. Only bit of fun, on so much data, even non-calendar. As Mark Twain so humorously put it, "Lies, Damn Lies, and Statistics". Just playing with such ample clean energy data, merely a parlour trick, no real help when looking forward.

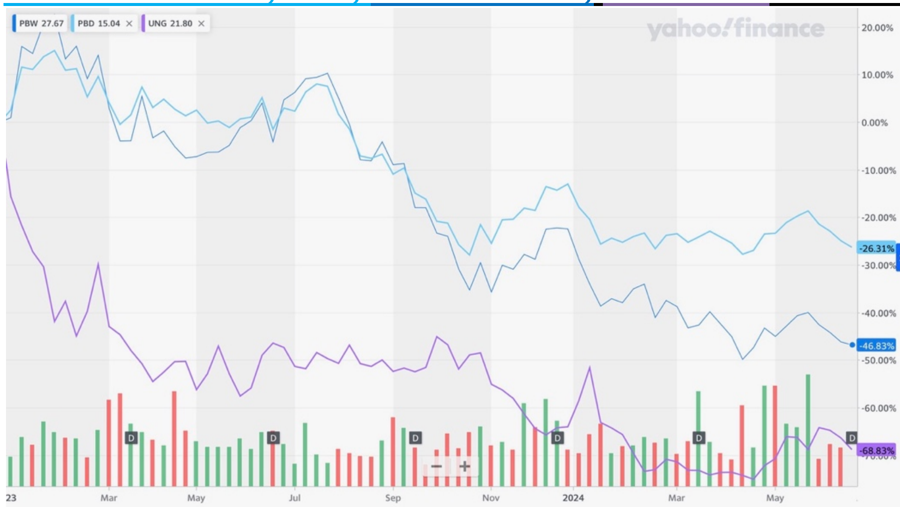
One mustn't read much into it, other than to confirm great volatility, oft down! Jan. 2022 passive ECO fell near a neat -30% in a blow-out month. Again near that, Aug+Sept 2023. Never predictive, it's ephemeral. Maybe bit of attention to 'enter on the dips – sell on rips'! One thing we did noticeably see, unlike a prior year, was in 2022 this clean energy theme fell throughout whole year – so both 2022's high & its start of year, happened around same time. And 2022's low & its end of year – also were nearly same. Just for giggles, let's for conjecture look closer at all 2022: its yearly high hit 152.8730 at close on Jan. 3rd (154.4136 intraday Jan 4th) as high to year's end 2022. So a hypothetical calendar year low, if thinking of another -½ down, just playing here, would be a 76.4365 at nadir close late 2022. Any realistic nadir low was possible of course – yet all maths were - are it's very, very unlikely this! So, was interesting to see when/where 2022's nadir did later fall. Not surprisingly, was *not* exact 76.4365! Just spotting coincidences in ample data. Interestingly though, on Dec. 28, 2022 this theme did hit its 2022 closing low: 76.0202 – so not far off 'neat' -50% theme nadir of 76.4365; near an even 76. Yet the broader tech market themes were rather similarly down here as well.

A head-scratcher was how close this -50% down conjecture seemed to happen again a 3rd year in a row: 2023. More a fluke than expected! Looking at clean energy's theme again 2023, an intraday high was 102.33 at ECO the 2nd month in, on Feb. 2, 2023. Meant just for fun, of mild interest as coincidence only, a fall again in clean energy of -50% could mean ECO hitting an intraday nadir that year near 51.165 – or in whole rounded numbers, about 51. So was an eyebrow arching moment 2023 as a year low put in 4 times … was indeed about a rounded 51! Came in 2nd to last month of year – November, right near rounded 51 (50.45). In December clean energy jumped to low 60s – and so that did win out as the year's low nadir: 51.

Lastly, having now fallen so far now, going forward that -50% down no longer applies.
For ECO past data, see, https://www.nyse.com/quote/index/ECO

Past few Quarters
If volatile WilderHill (WH) Indexes with purer-plays can at times jump up faster & higher, than competing energy themes in Up times – a flip-side is WH themes can surely plummet hard/er & faster/er Down times. Recent Quarters embody this. In Jan. 2023 ECO jumped high/er as 1 CPI Report 1-day showed maybe cooler inflation: ECO jumped +10.1% that day. That jump in ECO was more than other (all younger) alt-energy themes. But as seen in this Chart, especially ECO – also NEX – along with Natural Gas tracker also go Very Hard, Down! Clean energy's story may at times enjoy immense demand. Other times long crashes over years, like 2021 to 2024 eg harshly down period as in particular ECO, NEX plummeted. Volatile ECO fell hard(!) down to touch 40 mid-year 2024, then down some -30% for 2024 year to date. Yet such ECO drops are Not the worst in all energy, Not close! Clean repeatedly has also done 'better' than a natural gas tracker, a major theme as seen below. Even when ECO was in 40s, and NEX was the 'best' here – though natural gas has jumped at times. This Chart 2023 to mid-2024 shows NEX down -30%, ECO down more, -44%. Meanwhile for comparison, a major ETF tracker for natural gas so core in electricity generation - was down by far more, off -68%:

Start of 2023 to end of June 2024 for ECO & NEX, plus Natural Gas tracker (all Far Down!); NEX is 'least down', -30%, ECO down -44%; Natural Gas is remarkably down by -68%:



Source: finance.yahoo.com

Index components early 2024 can be compared Year to Date to Feb. 16th - thanks to NEX/ H2X/ WNX being straight equal-weighted and ECO being modified equal-weighted:
ECO Index® in first half Q1 2024 after starting year at 62.05, ended period down at 52.59. Components in ECO most up to mid-Feb. some 6 weeks before Quarterly rebalance, included one in solar trackers (+28%), wind (+28%), and batteries (+22). Components in ECO Index well Down in those 6 weeks included one in EVs (-58%), lithium (-52%), again lithium (-48%).
Global Clean Energy NEX components well up at mid-Feb. 2024 (so ~2 weeks before Latter Q1 rebalances of the 3, NEX, H2X, WNX) included in graphite (+48%), batteries (+31%), cables (+16%). Those well down here included in solar (-44%), power electronics (-38%), EVs (-34%).
Hydrogen Economy (H2X) components well up 2024 to mid-Feb. included in hydrogen storage (+48%), hydrogen from wastes (+16%), and lift trucks running on hydrogen fuel cells (+13%). Those well down were in fuel cells (-33%), H2 by biomethane (-30%), electrolyzers (-30%).
Wind Energy (WNX) components well up 2024 to mid-Feb. included in power transformers to strengthen grid and expand wind potential (+41%), in power cables and grid (+19%), and power transmission also making a smarter grid (+16%). Those well down were in making composite wind blade materials (-29%), operating wind farms (-23%), again in wind parks (-22%).

Green themes had briefly jumped 1st month 2023 by 20%, on a narrative – or on hopes really, inflation might slow. So Fed might pivot off high rates to a hoped-for soft landing. Yet as 2023 went on, talk fast shifted from soft landing, strong employment – to instead raising rates on strong jobs numbers 'til things break. Amidst threat, fears lingered of maybe bank crisis. Of recession, government shutdown, maybe a debt bomb. Rate hikes needed on inflation, but coming at cost say, of stagflation, slugflation. All 4 themes fell hard 2021-2024 on that picture. ECO in mid-2024 down to a 40 low. To be sure with remarkable volatility here.

Another cause for volatility had been outbreak of war. Big equity valuation changes downside - or up – are oft associated with surprise. A big 'surprise' Feb. 2022 was war, energy used as a weapon. Fossils & food prices spiked as shooting went beyond Crimea & Donbass; all hell broke loose. First weeks of war 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 found here. Need for better energy security: 13 European nations had 2022 relied on Russia for >1/3rd their oil. Yet, ECO soon after fell back hard - first under <90 in May 2022 – then to 40 in 2024. As US fast grew its own natural gas LNG exports 3 fold, from start of war - to 2024! Still, arguably, Russia's invasion shouldn't have been such huge surprise, if one had been watching closely in early-2022. There were then small hints.

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

It seemed early in 2022 an invasion of Ukraine *might* happen – contrary to what many felt was impossible. Russia at first denied plans to invade. Germany's Navy Chief took Russia at its word, stated Crimea was forever lost; Russia only wanted respect, nothing more. Yet invasion began 2022 and was clear from the start that Ukraine was in precarious spot. A Kosmos 2553 rocket launch a bit worrying too for satellites. As was, initially, world oil & gas security.

Yet that narrative soon flipped on its head post-invasion, as Lithuania, Europe etc stopped buying Russian gas. Vilnius used floating regas vessels, to fast import LNG from Qatar, Norway, US, so replaced Russian gas. Germany needed 90 billion cubic meters/year – it aimed to hit >90% storage in 2022, a mission swiftly done. Floating re-gassers became all the rage. War like a 3D chess game, & on LNG, Russia no longer held all power. Lithuania could even then ban trains carrying sanctioned goods, from transiting it, Russia across to Kaliningrad.

Russia did move 3 new MiG-31 warplanes & Kinzhal Dagger hypersonic missiles (bit like China's DF-17 hypersonic 4,000 mph carrier killers) to Kaliningrad. Susceptible to Patriot missile defenses, yet smack in NATO 'twixt Lithuania & Poland - earlier a Kinzhal obliterated Ivano-Frankivsk weapons depot. In far more pathbreaking change, Germany at last began to fast cut overreliance on Russian gas. Russia/Germany once had promised Nord I & II commercial use only – no political leverage. But war, and gas cuts, put paid to that! Germany started planning to bring forward by 15 years aims of 100% renewables to 2035. It started planning 20+ GW/year solar capacity latter decade. Onshore wind 10 GW/year. Offshore wind capacity from scratch to hit 30 GW 2030; 70 GW by 2045. Germany's Greens in 2022 swallowed LNG terminals – to hit 100% renewables sooner. Hopes to shut nuclear, zero-out coal; but if no Russian gas, something fast was needed to fill gaps as renewables got built. Faster-storage was one; new LNG terminals that can be used after instead for green H2 until renewables take over. Still, yes, new gas storage could get past normal winters/summers… but what if, few-reserves left, higher demand returns!? 2022-24, Europe moved fast to non-Russia gas, from more alternate routes than anyone (Russia included) had ever expected. Would that be enough??

Clean energy so ECO rose briefly, mid-2022. In Real-Life, 'IRL', oil & gas jumped like little in recent memory. Oh my, what reversal from what we'd seen in fossil fuels last decade! Especially on new US IRA law, clean energy so ECO briefly jumped, to be seen again Jan 2023, mid-2024. Spiked up. One item that set a stage was a long-ailing, then-failing draft $4 billion+ BBB bill: its repeated failure owed to a staccato NO from 1 US Senator. That fall, arguably helped push down clean energy equities most of 2021, 2022, 2023, 2024. Helped compress a spring, had knocked down equities to then repeated lows, down to 40 mid-2024 at ECO.

How is it solar/wind did so poorly over 2021-24 (rose a bit at times) – as fossil prices spiked??! As noted, overall energy prices tend to reflect the 1 fuel that's the most crucial – the 1 that's key to grid stability. Rather like how income tax rates reflect last marginal rate on highest/ last dollar earned. Given natural gas was key in power generation, it made all the difference. When natural gas prices did spike hard – electric power costs did too. US electricity from coal rose +22% in sympathy (with gas) in 2021. Natural gas spikes shall recur – falls too like 2023 – though oil jumped. As the renewables, are still a minority of power made, they do not determine prices. Meanwhile natural gas prices *rose* 2021, then fell back at times, then spiked again not surprisingly over 2022-24 - on longstanding fossil boom/bust cycles there.

What's Past is Prologue. In 2021 an oil price spike had come only *after* fossils had plunged in 2020. Only *after* US coal production had hit 50-year lows, after 151 mines were closed or idled. Only *after* oil hit historic lows back in 2020 on Demand Collapse, tank top fears of no storage. Meanwhile, much of the oil industry needs oil at least >$60s, 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 after big supply cuts, some output shut + renewed demand after Covid, discussed ahead - did oil roar back to $70s-$100/barrel on supply curtailments, like again 2023, 2024. At any rate, once high-again, dear oil & gas prices 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 low and stay there at times, naturally.* It's a characteristic, indeed a key trait of the 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 2020 when oil had no floor. What changed dramatically in 2021, after demand destruction – was renewed demand. It's aptly said that 'the *cure for cheap oil, is cheap oil'* – and lo & behold, fossils jumped in 2021.

Said another way, were a prior 100m+ barrels/day of oil still being supplied in 2020, it could have prolonged collapse. As for coal, it's no longer tracked by a US ETF, no new coal power plants in US. Yet on big *Global* coal demand, prices jumped +25% in 2021 on overseas demand. (Gas first spiked on war 2022). In US, domestic coal's economics are dismal, hence miners have looked to where it's burned. Asia, Europe, had huge appetite early 2020s. Today, the fact that America's own domestic coal supplies had once been the last century's cheapest, dirtiest and most stable source of US electricity, suddenly is no longer much in its favor.

Discussed ahead too, just touched on here, is greenwashing by fossil interests. Like hyped 'blue hydrogen' – even though methane leaks can make H_2 (hydrogen) 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 2030. On climate crisis that's a huge worry, as is burning coal. Rich Europe *may* 2030 have reduced gas-use sizably – coal more with big stumbles like acute gas shortages discussed ahead. Like late 2021 as China made a coal record, mined 385 million tons of coal; walloped prior record. In a new global record, its coal grew +9% and even more coal was used 2022, as gas costs rocketed due to war. Even in a rich EU, coal made more electricity – grew in 2022 over a year before. Western Europe/Germany *may* go over 50% of its electricity from renewables by 2030. But, scarily, the fact 1, even 2 of world's 3 big blocs may still rely on non-renewable gas (burning coal too!) end of this decade, looms large. As does sneaky inevitable hydrogen leaks: 10% leak rate by this GHG may obviate advantages.

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

Broadly, change is afoot. Some may be helpful. Maybe spiff electric aircraft helping electrify all, challenging past fossils hegemony fueling short-range air transport. Cleaner power for ships, planes. Batteries made perhaps of lower-carbon lithium, or graphite. 'Greening' rare Earths in wind, EVs - or avoiding rare Earths – instead, ferrite, strontium increasingly looked at as substitutes 2024 onwards if low magnetic potential, ok. Likely are recycle batteries, new circular economies. In 2023 a Model S from America's leading EV maker had cost $4.33 average to charge at home; that saved $10.87 over taking a 'gasser' car on fuel costs. Such a delta favored EVs, especially when gasoline prices spike, as they will do at times!

Yet CO_2 levels 2023 were already over 420+ ppm & rising fast, so there's no true possibility of holding global heating to less than <2.0 C, Let alone under <1.5 degrees C. Hence climate-induced weather whiplash seems forbiddingly looming just ahead. Agricultural crises too and so shortages of food, water/drought – as well ironically as flooding too given hotter air holds more moisture. Action is necessary - action that is nowhere fast enough. With other ironies: Russia's war in Ukraine stoked new European energy fears, pushed rich Europe to move faster beyond Russian gas – and yet world is burning *more* coal. Talk about renewables, storage, better grid. Maybe dreams of a 'Marshall Plan'- yet still it's just dreams. Shorter term, LNG is the compromise embraced; one Germany's Greens grimly accepted. Yet on ongoing fossil use too, it's all been and continues to be, simply put huge climate opportunity lost.

Not long ago, 2021 had been wracked by record heat, drought, storms, floods. Yet in just a few decades, maybe sooner, people may look back at that 2021 with its miserable heat, flooding, cold, hurricanes, rapidly disappearing sea ice, and rising seas - as having been part of a far cooler, more stable, far more desirable past. One that can never be recovered.

Data have since made clear, too, that there never was post-Covid hoped-for Green recovery. Clearly, no post-pandemic green moves *away* from fossil fuels; CO_2 emissions first fell, then *exceeded* pre-pandemic by over 5%. Got worse in 2021, worse still 2022, '23, '24. On climate, we're losing badly. Facts so far are no cause for optimism. Not this decade, nor century.

2021 then '22 did flesh out the debate over big proposed US climate spending. Outlines of a Gordian knot well-known: 2 legislative bills were in play. One was of a classic, 'smaller' Infrastructure Bill supported by some conservatives, so Bipartisan. However it did near *nothing* for climate. Less-costly of the 2, yet still $1.2 Trillion(!), had clear 'pay-for' revenue sources - relative to past of big deficit spending/or tax cuts used by both parties.

Second was an omnibus, huge, 'Build Back Better' (BBB) reconciliation bill. One-third or $550 Billion of it for climate/clean energy. It needed No votes from conservative party: but could pass but ONLY if voted-for-unanimously by liberal party. At first, was a $3.5 Trillion wish-list of liberal aims, climate-heavy. Early text in 2021 had Grants (carrots) for utilities to green - those that didn't, would pay Fees (sticks). There were many big $$ green tax credits too. As for incentives, utilities that *grow* clean energy 4%/year in early BBB draft, might get $150 per megawatt/ hour. Draft limits were <0.10 tons CO_2 per mW/hr - so coal spewing 10x that by utilities *not* cleaning up, could be hit by fees. Nuclear might benefit too, as would solar, wind, hydro: each one might win as 'zero-carbon' under this initial proposed legislation.

Politics, were 1 oft self-described moderate Senator from a fossils-state couldn't support a BBB reconciliation bill as conceived. Both on the substance, saying transition from fossils to clean was 'already happening' so why spend taxpayer dollars to speed up – and $3.5 Trillion price stating was far too high, inflationary. That Senator felt all had to be 'additive' (with fossils) - not exclusionary or penalizing them (despite climate risk). Yet that Senator plus many House moderates did want much of the new traditional spending on roads, bridges etc. New $$ for infrastructure of classic kind. Perhaps some so-called 'carbon sequestration' to try to add years more to dirty fossils, by pretending they're cleaner. That might give coal, oil & gas longer-lives on a pretense that their CO_2 somehow might be cheaply avoided.

Progressives weren't as concerned on pay-fors. Nor, $3.5 Trillion reconciliation size. For them taxes on wealthy worked fine, or deficit-spending as done by conservatives to cut taxes. They'd noted blood & treasure spent on wars without benefit. They feared their own party's moderates were too concerned over pay-fors, not enough on climate – so might go for a small $1.2 Trillion bipartisan bill only. Moderates won a vote deadline on smaller bill, so tension late Q3 on BBB bill too. Liberals aimed for $3.5 Trillion top line dollar figure – not wanting a lesser $1.5 - $2 Trillion hinted at by that coal state Senator, who resisted naming a $ figure. US Debt default also grew possible. Late 2021 it grew self-evident any BBB figure would be well under $3.5 Trillion. All got pushed to Q4 - when a deal *might* happen near Christmas - or it might all fall apart. If BBB died, there'd perhaps be still a narrow lane to resurrect parts for a smaller clean energy & tax credits bill in more piecemeal fashion in 2022. Were just the $1 Tn bipartisan fossils-heavy bill all that could pass, that was worse than nothing to many progressives; several wouldn't support it. Progressives' leverage was to link both.

They knew several moderates sought that $1T roads & bridges, maybe ‘carbon sequestration’, ‘advanced nuclear’ too. Many progressives were willing to deny that, to get reconciliation BBB done. One progressive leader felt $6 Trillion BBB was right, given scale of problem, taxes and/or deficits to pay for it, $3.5 Trillion was already a compromise. But such (small) leverage would be challenged late 2021 by a real possibility of perhaps No Deal, on either bill.

Meanwhile, conservatives had no-doubt enjoyed a moderate‘s call to pause on BBB. They also could threaten to Not raise US debt ceiling, for a historic US debt default, shutdown. It came to who would blink? All sides likely to be perhaps getting less than what they’d wanted.

While infrastructure in that moderate Senator’s home state was very poor, their willingness to wait, or move goal posts meant BBB’s window would soon close. Finding a sweet spot soon on $$ size was key. All agreed Infrastructure = jobs. That Senator, a Committee Chair had helped sculpt bipartisan bill, desired it. And goodies make much possible (recall Bob Byrd?) bringing moderates off the fence. But, could a big $1.5T reconciliation, BBB happen? Or, a far smaller bill only? Might internal dissension on liberal side sink both bills/all!?? Progressive members tried to hold to all or nothing – as ‘nothing’ for climate was in that roads and bridges Bill. Yet infra-party dissension could kill both. All came to a juncture just before a G-20 overseas meeting, and then a global COP26 Climate Conference in Scotland.

It boiled down to: could reconciliation with some teeth, some climate action, but ‘just’ $2T – and then ‘just’ $1.5 Trillion – win unanimous support needed? Progressives felt it must be all, or nothing. They saw a $1T Bipartisan bill wedded-to fossil thinking, as baby steps only, no answer. Several would vote No if small bill was all on the plate. Could progressives relent on slimmed-down $1.5 Trillion climate bill? They didn’t want to go down, to $1.5T. But, might be forced to - then maybe return to the well later. To agree on the $1T Bipartisan now with more compromises – or on $1.5T BBB (yet it maybe falling lower or apart) was a nub of it.

Had that $3.5 Trillion compromise progressives wanted won out, analysis showed 7.7 million US jobs might have been created as clean energy grows US economy $1 Trillion to 2031. Jobs in electric grid, solar, wind, EVs, charging, better efficiency, smart buildings heated or cooled by air source heat pumps etc. That could mean good green jobs. As discussed ahead, going big earlier-on, at start of this decade in big clean power way - could both have saved money. And have made clean electricity, *much less-costly, sooner,* than if made by fossil fuels.

Many things changed late 2021 as talks moved zig-zag fashion. The President had hoped to bring a legislative win to G-20, then COP26 Scotland. Yet COP26 failed going in: little was sought, less than needed, some nations didn’t step up, didn’t attend. US President’s party needed to show it could govern: elections were to be held and the conservative party was favored. Seeking resolution, trying to reach a deal over suspenseful days, one potential path came into focus. That smaller $1.2T Bipartisan Infrastructure bill already had passed in Senate and was less controversial. Several progressives in the House wouldn’t support it, for doing so would imperil the BBB giving away leverage before it was taken up - and would grow more old-school fossil emissions without assurances. As a result, Bipartisan Problem Solvers Caucus that had worked for months on bill, was called on to supply dozen or so ‘Aye’ votes needed from the conservative Party. Partly to notch some victory, partly to try to build trust across aisle, the Speaker brought this ‘smaller’ $1.2 Trillion bipartisan bill up for a Vote. Having now the votes needed, before even taking up BBB for vote, so de-linking the two.

Several liberal House members didn't support it, consistent with concerns they'd long voiced on climate. Thus, a dozen or so members from the conservative Party were called on to vote for a $1.2 Trillion Infrastructure Bill – to pass it. This bill was not relevant to climate; just some $ for electric buses, for EV charging. Direct climate action instead was mired, stuck in a BBB bill along with big-social-spending programs. No breakthrough likely there at all.

On BBB, 1-2 Senators at odds with their liberal Party held firm. They demanded ongoing added 'compromise' cuts from other 48 Senators. Well, it wasn't really compromise they sought – so much as one-sided capitulation: those 2 held all the cards. All 50 Senate votes were required for reconciliation so no leeway for alternatives. Thus, a Senator from a coal-state was able to keep moving goal posts, whittle down BBB key ways. Biggest changes deleting any/all sticks from a reconciliation BBB to draw-down fossils; originally BBB envisioned as having both essential carrots, and big sticks. That plus cutting it all dramatically in size.

Shorn of restrictions, no sticks to cut coal, oil, or gas, those dirties could instead go on being burned pretty freely under a much-slimmed BBB, without utilities having to scale back. Gone was a $150 billion in clean energy performance goals & penalties on carbon; removed. Bulk of plans to clean up US emissions were shorn off, a real blow. Efforts to keep in a few sticks, like needing use of 'carbon sequestration' weren't successful: that 1 Senator recognized 'sequestration' was mainly just a marketing fudge. Nowhere was that actually, cheaply reducing carbon from coal, oil or gas – keeping it in wouldn't have actually helped fossils.

On the other hand, opportunities remained for some progress. Much could still be done ***for*** clean energy like via tax credits; incentives to grow clean energy via carrots alone. Still, just 1-2 Senators held back far bigger legislation. That implied if liberal Party gains 2 Senate seats in future, it could be disproportionately impactful ahead. But Not so likely; traditionally the President's Party loses seats in midterms. Still, it's extremely likely climate emergencies are not going away. And public sentiment already favors action here. A few Senator/s may one day, break from other side of aisle, support climate action. In other words, future likely belongs if only eventually, to acting on climate later this decade. But then it's too late - as wilder weather, escalating costs of climate *inaction* – gets made-more bitingly clear.

From one viewpoint, that 1 Senator 'won' as they'd kept the coal, oil & gas fires burning – big loser was our climate future. Given that far stronger action was needed, things may indeed get much worse. That 1 Senator saw themselves as a lone moderate in deeply divided country. As a realist, who'd cared for US energy reliability vs. multiplying crises. But it may reflect a deep misunderstanding. There's no moderate redemption found in science, by pushing off action to later years. Not a good 'compromise' here, like is usually seen in politics.

That 1 Senator watered down a proposed rule that would have tamped down more on methane – a greenhouse gas (GHG) released to air like an open sewer. Methane is a far more potent GHG, than is carbon dioxide/CO_2, so controlling it better prevents many million metric tons equivalent of carbon dioxide. Like pulling millions of gas-cars off roads. Scary that methane concentration increases 2020 and 2021 of 15 and 18 ppb, were largest since monitoring began in 1983. As for CO_2, we refer ahead interchangeably - to 'carbon' - or 'CO_2' - latter atomic weight 12 atomic mass units (AMU) and oxygen 16 AMU, so mass ratio of one CO_2 molecule to one carbon atom is roughly 3.67. (The point here is just 1 person would dicker to dilute, cap, and knock down a proposed methane rule in final 2022 IRA draft. Plus killed off all draft GHG sticks, that had made much scientific sense, and that could have been impactful).

Trying to keep hope alive, new revenue pay-fors were suggested to cover $1.5 Tn BBB cost. Instead of eg raising taxes, or capital gains rates, novel tax scenarios were discussed. One idea was a 15% minimum corporate tax for American companies, as some avoided any taxes. That could help get to the revenue-neutrality moderates demanded. Also raised – and rejected - was unprecedented tax on unrealized gains of very wealthy (could one deduct their unrealized losses?) that might be unconstitutional given a 16th Amendment's requirement of realized income. Instead, that 15% minimum corporate tax idea steered clear of increasing traditional taxes, or cap gains, or taxes on unrealized income. In draft form it was joined with a proposed idea of new surtax on very highest earners, helping to pay down the Debt.

Hence 1-2 Senators had ensured in 2021 there'd be *No new sticks so fossils left unfettered; *No traditional Tax Hikes to pay for climate programs, and *No Big climate moves in that year. Nor were huge bill/s likely on 2022 election calendar. Maybe just a narrow lane for lesser, smaller bits of BBB tax-credits in 2022, just before spotlight goes to the Fall elections. Bigger green omnibus actions – might thus be put off to 2023 or 2024 or after at least.

Fury over how badly a reconciliation BBB had been eviscerated in 2021 was immediate. Hyperbolic-sounding criticisms fast sprung up such as 1 person had forced impacts to Earth so profound, they might be visible in thousands of years hence looking back at geologic record. To suppose a single person could have a visible influence on the geologic record, can normally be laughed at, no chance, just hyperbole. But climate is unique, singularly different. Worryingly, such critique *ought to have had* a zero chance of being right. Terrifyingly there was maybe, perhaps non-negligible non-zero risk that it might turn out true.

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

Back to politics, biggest greenhouse emitter China said it wouldn't show at COP26 in Scotland. After a prior outcry that China's 5-year Plan wouldn't start reducing coal until 2030, they'd upped ambitions aiming to peak coal sooner. But since initial steps away from coal - China was hit 2021 by a severe energy crunch. It grew less certain they could keep peak pre-2030 aims. By 2022, it seemed clear there was no chance. Plus as rich nations failed their own $100 billion commitments to transfer funds & know-how to developing world to help reduce carbon emissions, there was this little reason a developing China, India, Indonesia etc felt to offer more. Besides the leaders of Russia, Brazil, Mexico didn't even show at COP 2021: they likewise were hardly enthused about calls there for more 'cuts' soon in carbon.

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 that self-proclaim virtue like US, Japan, Germany, UK, others. Whose addictions were at odds with prettier promises at G-20 events, Climate Conferences. As HRM the Queen of England so wisely and aptly remarked in a lead up to COP26, it's irritating the way global leaders "talk", but "don't do." Private industry, was more of the same. Like state-owned fossil firms offering vague promises, glossy blue hydrogen ads, talk of distant 'carbon neutrality' in distant 2050 – all conflicted with more pressing CO_2 reality. COP26 only days after G-20 had all failed regardless, and apart from any merely in-draft 2021, fast-dying US BBB legislation.

On 3 reasons, 2021 COP's goals were tougher than vaguer Paris Agreement. 1) Rich nations' big 'commitments' of $100 Billion/year for developing nations were easier to just mouth at Paris – than actually mobilize at Glasgow. 2) Global carbon rules, tougher than talk, like seen in US Congress flailing on disintegrating BBB. 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 at COP26. Commitments on offer were far short of 2 degrees; 1.5 via 45% *fewer* emissions, a bridge much too far. Simply adding up all 2021 commitments COP26, meant emissions, if followed, would drop by oh … umm, ahem, *Nothing!* Instead, they'd go Up +14% *higher* on best commitments of 2021. Say, Canada increased ambitions at COP26, yet its new 'tougher' goals were so lax, that they'd still be in line with 4 degrees C further heating.

Physics & chemistry give us a total carbon budget: how much emissions left if we're to have a 50% chance of not going past 1.5 degrees C. It's 2,890 Bn tonnes of CO_2 – but, we'd emitted 2,390 Bn tonnes by 2019. Left 400 Bn tonnes by 2022, but since we spew 40 Bn tonnes/year – to stay under 1.5 C is now impossible; we're toast. On current trends we'll pass that carbon ceiling very soon. It's laughable to think we'll go for years – then, switch off in 2030 all CO_2 emissions 100% at once. In 1824, Frenchman Joseph Fourier showed how Earth is warmer than a planet without an atmosphere. In 1856, brilliant American scientist Eunice Foote noted how CO_2 warms inside a jar; she predicted CO_2 can cause climate change – a century & a half ago. John Tyndall in 1860s correctly showed how greater CO_2, water vapor, plus methane could all impact & heat the planet's climate. Over a century ago, Svante Arrhenius & Arvid Hogbom of Sweden determined the How, and Why, a then-forecasted 3 degrees+ C rise in global warming results from each 3/2 rise in CO_2. The ratio has since been refined, but principle roughly is same with more heating at poles than at equator. A linear increase first of the CO_2, meant by a power law for the second; temperatures rising up as a logarithm of CO_2.

As for a draft BBB, 2021/2022 had brought it to head: either compromise – or failure. The Senate Parliamentarian needed to see all items as spending-related in a 'Byrd Bath'. But scoring had to be reviewed by 1 Senator – whose vote was necessary. Things didn't look good. To cut spending, some of that in draft was re-written pared back from 10 years – to a 3-years sunset (or 1 year) hoping a future Congress renews. That reduced top-line costs, but those weren't the real cost reductions that 1 Senator demanded. Fears social spends will stoke inflation, the sticks would hurt fossils dear to that 1 Senator's heart, it looked like bipartisan bill only – small already passed, might be all done. To some, an eviscerated $550 billion would go farther than ever on climate – so great. Partly (though arguably not fully) paid for, revenue raisers that needn't rely on raising regular taxes, nor cap gains tax feared by some moderates and conservatives. Yet without doubt, the BBB was also a missed chance 2021 & 2022. A huge loss, given what that Bill might have been. It might have taken seriously at last, overlooked GHGs especially methane, & clathrates etc as sleeping giant risks besides the CO_2.

In sum a 'small' IRA that was signed 2022, was bit of a 'win'. Not an end, for sure. In words of The Economist (5 November 2022), "Given the lasting impact of greenhouse gases already emitted, and the impossibility of stopping emission overnight, there is no way Earth can now avoid a temperature rise of more than 1.5 C." Ahead maybe, electrolyzer makers may invent better catalysts, or low-CO_2 hydrogen tax credits are for carbon avoided; carbon taxes. Because wee IRA of 2022 was negotiated quietly, between just Majority Leader and 1 Senator, a narrow lane probably was all that existed, then. That final puny 2022 IRA was defanged of any/ all text penalizing fossils – become all carrots, aided fossils & nukes. Perhaps the 'best' that was then possible. Still, an earlier BBB text repeatedly killed, may have shown which way the wind was blowing. It should be re-raised if climate is regarded seriously.

Bits of BBB Bill were put in IRA; others parts may be re-raised ahead. Draft text had implied 10% greater ITC if 40% US-manufactured content. More, if US steel in trackers. Residential PV could see a 30% ITC for better periods like 10 years. Inverters aided. In draft, that ITC could grow if projects are near former coal mines, or coal power sites. Maybe a 45Q tax credit for 'carbon capture & utilization', or for direct air capture. And there was $$ for nukes. Proposed too were needed, much stronger Federal methane Rules; any fees on methane are important, although what passed on this matter got diluted in the final IRA of 2022.

That US Senator had repeatedly declared a $2 Trillion+ BBB 'Dead'. Not surprisingly as that Senator long criticized its size, scope, direction; especially social spends not energy/ climate from start. But it wasn't, really "dead". Nor omnibus; a smaller more targeted Bill was possible. Thus, like in 'Princess Bride' movie, hopes lingered it wasn't 'all dead' – just 'mostly dead'. A slimmed bill *could* get 'Yes'. In that movie Inigo Montoya hoped to bring Buttercup's True Love back to life. Miracle Max called him 'mostly dead' - thus slightly alive – here, slimmed down bill was better than 'all dead'. And in Washington DC, the joke was 1 Senator may allow for something that helps fossil fuels too: thus it was no longer BBB – but rather 'Build Back Manchin.' Thus, late in July 2022, the Senator did 'surprise' with a Yes vote.

Thus, the Inflation Reduction Act of 2022 was born. With notables like tighter $7,500 EV tax credits + income limits; that Senator felt giving any tax credits to wealthy would be 'ludicrous' – though in 2023 the Administration looked for work-arounds: eg, $7,500 credit still applies if a vehicle is Leased. New assistance too for fossils & nukes; more oil & gas leasing acreage as Senator wanted this An All-US Energy approach. Incentives for more US domestic batteries, mining/refining domestically US critical minerals. (China had long captured strategic minerals supplies and something needed to be done, though China had built an enormous lead).

Think of carbon linchpin, China. So wedded to coal it didn't talk at COP26 of coal 'phase-out' – but rather of a 'phase-down.' Yet its possibilities for solar power are immense. China, more than anyone, 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 had been called-for in its earlier Plans. It could boast that 1/3rd all global solar capacity was commissioned due to its domestic China demand, with reverberating benefits planet-wide.

Consider what's possible there, high end. In theory if all China's areas that can easily have solar, had it, in mainly sparsely-populated northwest (most people live in southeast), the '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 (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 net-zero emissions. ½ its potential solar-areas were already capable of PV being cheaper there, 2020, than coal. 80% of its solar areas can be cheaper than coal in 2022. As solar improves more by 2030, solar could be cheaper than coal - across all China!

China's solar PV costs had averaged 4.93 cents/kWh in 2020. Costs were projected to drop to 1.3 cents/kWh by 2030. Then, as solar gets even cheaper – 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 it. But coal means jobs, is firm now, dispatchable, uninterruptible vast domestic power it needed. Solar, hobbled by intermittency, dearly needs energy storage so as to be firm. Put together storage + solar can be 100% dispatchable; by 2030 a projected 5.2 petawatt-hours of solar-with-storage might be available in China. All of that could be cheaper than dirty coal, too – and near its 7.5 PW total demand.

By 2060 solar+storage could make 7.2 petawatt-hours, meeting 1/2 of China's electricity demand. Complimented by huge wind, geothermal etc; to meet all needs – alongside maybe nuclear fusion, better than fission! Yet put aside unknown fusion – think instead of challenges in ramping proven renewables. Especially as material costs pinch. Battery designs if need say, cobalt, may hoover 36% of world known cobalt reserves – that's on past battery designs. But on new, better, batteries not needing cobalt, discussed ahead, all gets easier. Even lithium needs might be 'only' 8% of global reserves. Hence green, alternative technologies are crucial – myriad ideas may blossom for fewer raw materials. Material availability, tech maturity, cost, efficiency impact choices. Look back a few years: it may have been propitious to have 'gone into **Photons**' then – into solar as one 'P' (like China did). Look ahead, another P here 'Protons' is risky energy storage & energy conversion, with electrons in H_2, fuel cells etc – it *may be* propitious one day ahead. But unknowable in 2020s, with huge volatility. So what is certain is this 'protons' theme in 2020s *is hugely risky*. More so, than surer-solar.

Solar is steeply cutting costs. On modern manufacturing gets ever cheaper, like semi chips. Energy conversion/ via protons, different. Vexed by uncertainties, many breakthroughs still needed yet to harness protons (eg fuel cells) - unlike photons/solar where PV costs are much down. Unlike battery-making, too, where persistent steadier cost reductions of 6-8%/year were helpful. Instead, Protons in 2020s in fuel cells, green hydrogen, ammonia, methanol, were far more a wild card. As to biofuels and Index (ECO), we prefer to include cellulosic advanced fuels (not compete with food) – over less-advanced corn ethanol. A closer call is when corn ethanol may be paired with carbon capture & storage (CCS) to lower CO_2 impacts; that began to be seen 2024 and CCS is closer question as for ECO inclusion. Can happen, given our mission to capture & track this sector. That said, when indirect land use impacts of biofuels are included – the story is very challenging (if not impossible) to match what clean energy+ storage can do. Thus, main renewables solar/wind with storage pervade ECO.

A wilder step 2020s was a *potential* nuclear fusion. Put aside attention to H_2, fuel cells, PV, batteries, electricity. Instead focus on neutrons: fuse 2 isotopes of hydrogen, deuterium (^{2}H in seawater with 2 Neutrons) - with tritium (^{3}H with 3 neutrons as bred by lithium) – it creates 2 neutrons helium (^{4}HE). Critically leaves a third neutron out; that, on Mr. Einstein's famous $E=MC^2$ is mass imbalance, immense kinetic energy, 17.59 MeV as mass disappears. Immense energy, no wastes! But practical issues like overcoming Coulomb barrier in net positive ways, inertial confinement at temps & pressures mimicking a star's core, mean it's latter half century at soonest - before significant applied fusion is on grid. It was represented as energy-positive – but in fact, 100x that ignition was power used by lasers – so it is yet far from it!! Next century, it *may be* a new addition, but on both climate risk + energy security, much faster growth is needed in renewables solar/wind and storage now: 2020s, 2030s, 2040s.

All as input costs to grow clean energy 2022/23/24 had soared. Supply chains were stretched. Inflation more than 'transitory' curiously first noted by Fed. Steeply rising input costs were / are thorny for clean energy. Went from efficient '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 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 in ^{2}H/^{3}H DT fusion ignition – but price rises like of 2021 as Europe wholesale PV prices inflated +19%. Back to a price of 2018. Panel prices in 2021 were up 50% euro cents/kW, from 2020. Polysilicon prices spiked 4x, from 2020 to 2021. Rose again 2022, 23. If US is to grow its solar from meeting a meager 3% of its demand in 2021 - to meeting 50%+ by 2050, hurdles loom large. Poly is discussed ahead. But there's other key materials in manufacturing solar PV.

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

For comparison's 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 is able to 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 PV.

Take buses, likely to move towards electrifying. A typical dirty, smelly diesel school bus 2021 cost $150,000. A quiet, electric school bus, by contrast 2021 had cost dearer $350,000. So only 1,000 buses, pilot projects or on grants were electric in US fleet of 480,000 school buses. Think then of the passed 'small' bipartisan infrastructure bill: $5 Billion, ½ for electric, ½ for low-emission (CNG) buses. It could mean schools maybe even buying thousands of electric buses ahead. Driving costs down too for future EV buses with use of vehicle to grid to boot.

One big school bus manufacturer is Blue Bird, and half its 11,000/year buses back in 2021 had been dirty diesel. Other half burned alternatives, eg propane or compressed gas, still polluting & awful for kids and climate. It only sold a tiny number of clean electric buses: 775 in 3 years to 2021. Understandable given high upfront purchase costs. Yet low-maintenance electric school buses *may* be afoot. Moreover, with greater battery storage, fleets of EV buses could be excellent backup to grid. Made cheaper by mass production. Used some days in Vehicle to Grid (V2G) selling back power, earning schools' money. Or as emergency community backup power. And $7 Billion for EV chargers. $ for H_2 demonstration buses (electric too in a way) that passed back in 2021 in an Infrastructure Bill means they'll improve faster as well.

There'll be many obstacles to clean. Arrows shot, rocks doubtless thrown at green energy. Some claims, contrived by renewables' opponents blamed clean (wrongly) for power outages. Like Texas in 2021, blackouts first blamed on wind energy (wrongly!!) - described ahead. There'll be times renewables rightly may be criticized in this decade – but mainly because they aren't big enough yet! As gas/oil/coal falter – solar/wind aren't to blame. Instead, it's because there *isn't yet enough* renewables+storage to make up the difference. Wind/ solar/ storage are just starting to displace dirty; there's just not enough clean early 2020s - yet.

Wind, yes is highly intermittent. So much so, lack of wind in some months ('wind drought') can be rough. That was so at times early 2020 especially as there was not near enough clean energy storage, but this is changing fast. 2016 the world had passed an early storage marker: its first puny 1 gigawatt of energy storage capacity. Just 5 years later, 2021, the world had 12 GW new storage capacity – as much was built in a month, as was installed all 2016 year. New storage capacity quickened rapidly. So much that it's estimated that by 2030 there may be 70 GW of new storage capacity being installed, in each and every year. Maybe a 14-fold increase in installation rates over what we'd seen early 2020's. Much of that now is batteries, but new other technologies could bring far more. And so then-large 400 MW battery installed early 2022, while then world's biggest, should soon be regarded as just 'meh'.

For why natural gas storage meantime has a big role, consider cold Europe Winters. An issue began mid-2021 as Russia suddenly began exporting far less gas to Europe, than typical 80 million cubic meters (mcm)/day. Russia lowered its gas exports to Europe in July '21 to 49 mcm/day. Then August 2021 to 20 mcm/day. Gas levels were already very low in Europe/ UK & globally. Why? Covid-driven supply cuts + weather volatility had cut gas supply worldwide. US hurricanes compounded it. Net/net on sharp loss of gas supply & less storage - natural gas prices jumped. Europe doesn't frack, lacks big domestic gas supplies, so long (over)relied on cheap Russian pipelined gas. As natural gas costs spiked, so electricity prices too skyrocketed latter 2021, Asia grew hungry for scarcer gas as well; in no time, all gave way to bedeviling gas shortages. Eye-watering high electricity costs late 2021/2022 for a prostate Europe. Bitter cold - or heat, or some other event (soon: War) could create crisis. Action was needed.

It's been suggested gas export tightening 2021 by Russia was to help it win a needed OK for its Nord Stream 2 pipeline to Germany. Or to prepare for a stifling of its gas to Europe 2022. Europeans for their part needed uncontracted, cheap, spot gas. Alternatives were few; get more gas from say, Norway – or import lots more liquified LNG from overseas by ship - though latter could mean competing with voracious Asia so high prices - and Germany (then) lacked LNG terminals. Europe needed all the gas it could get in 2021/22, and to build storage. Especially if a colder than usual winter hits say 2020s. And if sparse breezes make less wind power, or as nukes go down for maintenance, emissions are tightened on coal – and Germany aggressively goes for clean renewables by 2030 – then it could get very tight.

Indeed, sparse breezes early 2021 did hurt Europe's wind, nukes were down for repairs, hydro hit by drought. All that combined, meant late 2021 unhappy records were set. Europe's natural gas benchmark spiked up +300%. Gas futures in a key Netherlands basket rose past equivalent $150/barrel for oil. Early 2022 gas rose higher, past an equivalent of $500/oil barrel(!). This all made Europe's natural gas prices early 2022, dearest fossil fuel by far. Ireland's electricity costs late 2021 jumped 10x in a 7-hour period on gas shortages. Gas was so tight late 2021 in Spain & Portugal, electricity hit $165/MWh, worst since 2002. UK electricity prices briefly rose 2x, or 7x over a year prior; next day UK power hit $395/MWh. UK imported 7.5% of its power from France; an undersea cable loss knocked out 2 GWs power from France. On good breezes like 2022, UK can produce at times most power from wind, cheaply! Yet on few breezes, a big UK wind at 24 GW faceplate capacity - can fall to 1 GW. Europe's natural gas once was so cheap – so Russian. But early 2022 Russian gas suddenly became a question-mark; might Nord II not ever open - Nord I cease flows? If so, might that mean replacing piped 150 billion cubic meters (bcm) - with LNG delivered by ships as from Qatar, Algeria, US etc from 2022. Might it mean 15 bcm of US LNG, or Europe using more coal, nuclear? Aiming to replace a huge, once-piped 50 bcm, with new LNG infrastructure.

In past, simmering European fears about over-relying on Russian gas were waved away by how bloody cheap it was; it became 40% of Europe's gas, more for Germany. Until that blew up in peoples' faces. Literally. To win approval for Nord Stream 2, or softening targets was maybe behind Russia's cuts; or to divide Europe or prepare for war. Paradigms shifted fast on fears Russia could invade Ukraine – and fast did so. All as China, Japan, S. Korean buying LNG pushed prices >$15/per million BTUs. US gas rose too for all is interconnected, from $2 mm/BTUs - to well over >$5 – unheard of in a US shale-frack era. Europe Market Winter gas demand competes vs JKM (Japan-Korea Market) – geopolitical urgency meant Europe had to and did fill its gas storage fast. That + mild 2022, 23 helped. But all became scary on ripened reality of war. Europe's storage had reached >95% in Fall 2022; but could it refill again quickly after Hot Summers, maybe Freezing Winters in say 2025, 2026, 2027, 2028, 2029 etc.

2022 had thrust Europe's debilitating over-relying on Russia gas in sobering light. LNG was stepped up swiftly, yet underscored immediate need for more renewables, fast. GWs *more* solar/wind quickly - plus battery storage for firm power. LNG infrastructure, and gas storage vexed – for better clean power wasn't yet big or firm enough. As Europe tried weaning itself off coal, some places off current-gen nukes – other places expanded nukes – was no breathing room for renewables to grow. Wind & solar early 2020s was 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, nowhere near enough to overcome gas' troubles … yet.

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

For US solar, a deployment target was 45% electricity from PV by 2045. From a science/ climate standpoint that wasn't only possible, was *required* given carbon budget. Yet such a ramp would be unprecedented. US in 2014 had only gotten under <1% of its electric power from solar. By 2021, that was nearer 3%, as 15 gigawatts (GW) was deployed 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 rising 4-fold/year over that. On to freshened 60 GW of new installed solar, each and every year, from 2025 through 2030.

By 2035 due to climate crisis, US would need 1,000 GW of renewable power on grid! By 2050, a new 1,600 GW of solar for US zero-carbon grid! More from solar - than generated from all sources including fossils/nukes in 2021. To further Decarbonize heat too, means 3,000 GW more clean energy by 2050. Greening US transportation, buildings, manufacturing, industry. Zero-carbon power to cover every GW of electricity, plus cover 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 may stumble & fall, if future big bills like BBB with its draft $ Trillions instead fail. Partly too, shows why there's such huge volatility here. And why across the Atlantic, small modular reactors are being looked at in UK for low-carbon nuclear - if its 7 big nuclear plants are cut back. Though big reactors had made 17% of UK's power 2021, new 'smaller' gen IV small modular reactors (SMRs) may come in standardized design in China, or France. But can they also be made 100% safe? Less costly, sure – but how about also less risky, too?!? On early 2020s nuclear state of art, that answer's murky, dubious at best. Hence questions swirl around current 2nd generation fission nukes early 2020s, SMRs too. Yet China, Germany, S. Korea, UK, US and others are searching for needed baseload power ideas. Next consider solar/wind/H2 themes and hence the ECO & global NEX Indexes, with too newer H2X/WNX benchmarks. We'll begin with great volatility that ever-dominates across these green themes.

After huge ECO big gains of 2019 up 58%, then 2020 up +203%, it was likely 'unsurprising' as stated to see falls 2021 to 2024. From peaky Feb. 2021, it was unknown of course if clean energy so ECO might fall in a harsh backslash shaped "\" down lasting a few years, or more? Or perhaps an "L" sharply down, then sideways. Mid-2020s *might* go on suffering headwinds due to: *Inflation, *Costs of Capital for clean energy; *Safer Bonds yielded stronger returns; *Regression to Mean; *China, *Unforeseen exigencies pushing coal use past 2025; a *Global Recession, or *Global tensions, … or… ?? All this was despite strong hopeful words at the COP Conferences (blah, blah, blah) about undertaking climate action this decade.

Just a few worries were: *Green stocks had hit 'high' P/E multiples in 2021/2022; with *Inflation/Quantitative Tightening; *War, so perhaps 2021's high was a soft *ceiling?* BBB draft bill was maybe succor if one felt it could bring $3+ Trillion so *might* justify rich Price targets ("P" in P/Es). But 2022-2024 was also maybe fated as an interregnum, a pause between Q4 2020 hopes for clean energy - & clarity on "E" Earnings. Plus, maybe – and as came to pass – rates would rise fast since the Fed had let things run too hot – then years of tight/high rates. Thus stocks here shifting to lower valuations, poorer expectations. On discounted values, capital unsurprisingly went reflexively 2021 from growth - to value: hence not clean energy! Markets may in future get re-accustomed to higher yet historically typical, non-zero Fed rates like was seen in the past. But none of that could lend comfort here early and mid-2020s.

Valuations above 25x EBITDA (Earnings Before Interest, Taxes etc) may be seen again. Yet in risky green themes, few dividends, little positive "E" earnings – went bearish hard. In global NEX like ECO, components fell as one may expect on this macro-picture. A big, long sell-off followed early 2021 peak here – for years. Yes, maybe was overdue; NEX/ECO had just spiked upwards 4-fold/& by 6-fold from Q1 2020 to Q1 2021 – after big gains in 2019 too.

Recall how in early-in 2020 year, ECO had then first fallen -50%. Seeing a plummet again by neat -50% in 2021 thus maybe wasn't so surprising. ECO went from 287 closing high (286.89 intraday) Feb. 2021, down almost exactly ½ to its 142.39 low in 2021. Or note that NEX had once been in low 600s early 2021. We note NEX was later near 400 recent as Aug. 2022; a further -50% drop could in theory bring NEX near 200. Big drops in ECO/NEX can be envisioned. After all ECO in 2020 saw a -50% fall of 90 to 45, so -50%; it rebounded up huge, then fell. We did see a -50% fall again in 2021 *coincidentally*, curiously being a 2nd neat -50% decline in ECO to 2021 nadir. Then near -50% fall to ECO 2022 nadir. Further falls can be envisioned, but given lower starting levels of 2023 and 2024, such -50% decline no longer applies.

In sum, 2022/23/24 was an interregnum rough patch; it may well continue. After this theme had spiked to early 2021 on high hopes after a Presidential win, plus surprise 2 seats gain by POTUS' (blue) Party, fueled by hopes of huge $3+ Trillion BBB – it was then weighted down by very high P/Es, losses and steep inflation. On fear & uncertainty over if a Bill like BBB can ever-pass – then troubles 2023, 2024. Also, on an air pocket 'twixt 2020 election – and next decision 2024. Frankly more skepticism had been then warranted. For instance, as to whether maybe $ Trillions+ of new funding for clean energy is feasible right now. And as we emphasize without a doubt, passive ECO/NEX like newer H2X/WNX may fall more ahead. ECO falling 2021 to 2024 was understandable after huge gains. If P/Es are a useful metric - & P/Es 2021 were 'steep' - maybe far lower P/E levels now are of use – share prices better explainable. The odds green energy again soon justifying nosebleed P/Es can be pretty daunting.

Much was happening early 2020s. Some was hopeful; a US President had aimed to cut CO_2 emissions 45% by 2030 - in theory doable. Other items, not-so-hopeful: renewables' actual growth since that pledge not enough for a 45% CO_2 cut. IRA of 2022 got us closer. Solar & wind were capable of it – but on current trends, we'll Not hit 45% CO_2 /GHG reductions – 'til later. Broadly due to 2 factors: 1) Renewables not growing fast enough to displace coal, oil, gas. And inversely 2) Inertia of global coal, gas not yet letting up. On war especially, burning coal *increased* – so wasn't being shut-down anywhere near quickly enough early 2020s.

Solar & wind clearly, are capable solutions; *the 2 have potential to power the entire world* - many-fold over. On today's technology & available locations, the 2 alone could power the Planet 100x over! They could be generating 6,700 Petawatt/hours (PWh) of clean electricity (1 Petawatt/hour = 1 million Megawatt/hours, or 1 megawatt for 1 million hours). Despite vast opportunity the world in 2019 only captured 0.7 PWh of solar power, 1.4 PWh of wind. Though wind & sunlight scaled up could meet all our global power needs. Forever.

It's been no surprise they're expanding! Solar grew +39%/per year in last decade: roughly doubled capacity every 2 years. Wind grew 17%/year onshore; offshore wind's boom may raise wind's growth higher ahead latter 2020s. Clean energy's potential is eye-opening. Sub-Sahara Africa may generate 1,000x current energy demand, from 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, can see big gains later 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 2021, to 50%+ in this decade; 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 at 15% electrics 2021, more 2022, rising fast to EV dominant. Global EV sales 2021 far outshadowed thr puny US. China had sold 1.1 million EVs early 2021 more 2022, 23. In EU too 1 million were sold – both far better than US. Full-battery EVs made up 12% of cars registered in EU in 2022 – vs 9% in 2021 and 1.9% in 2019. EVs & hydrids made up over half the EU car market late 2022; for the first time more than gas/diesel powered cars. Europe led US in clean power generation by wind/solar - & in EVs too. Meanwhile China was rising very, very fast from near nil, and seems will be beating all ahead. All this while the US lags.

In Western Europe, coal-use 2019 was falling – until war 2022 revived coal! Natural gas may be cut ahead - but again, not quite yet! Instead, gas needs made Europe's energy prices jump 2021. Fell after on big ramp in US LNG. Gas, portrayed as 'transition fuel', may be last pariah fossil; as socially unacceptable one day, as cigarettes now. Yet there's keen need of it to *heat* homes, buildings, industry now, no fast-green-fix 2020s. Replacing boilers with heat pumps is costly – but 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) or methanol – if greener ahead. Maybe: transport hydrogen via benzyltoluene for H_2 released more efficiently from big Liquid Organic Hydrogen Carriers (LOHC) at lower temps. All is but one-side of the 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 by all 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 and seeking their own development ahead, may look towards coal.

So, coal's declines back in 2019 in rich Europe/US were regrettably an outlier. Reversed, got worse in 2022, '23, '24 as China, India, Japan, even Europe coal saw terrifying growth. China early 2020s was growing renewables + EVs: great! – yet also expanding thermal & 'met' coal too to 2025 at very least. Notably China in 1st half 2020 added 11 Gigawatts (GW) more coal. Another maybe >50 GW of coal to come. Of all the world's coal power added say, just 2020, China had made up 90% of that. Late 2022 saw a speed up in a use of coal including by India, given that spiking natural gas/LNG demand had been so tough for everyone back in 2021.

Not only nations are at issue: 33 of world's 60 largest Banks grew their fossils funding in 2020. So all hopes to decarbonize world in 2020s are thus 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 a big coal drawdown needed, according to best science to decarbonize – plus big cuts in methane – fossils instead expanded globally in 2020s. Sure, there are happier 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 43% reduction. Worse, US in say 2021 (pre IRA) was on track for real cuts of only 12%, below 2005 levels by 2030 – not 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 facts are far worse. Aircraft, ships, methane; each with its big climate impacts, they ought not to be pretended away because they're just, gosh, too hard to reduce right now.

There's Huge Gaps between *promises* to 2030, the 'blah, blah, blah' - vs. reality of science. The data show there's *growing* CO_2 & GHGs worldwide 2023/2024 etc led by coal, gas. With no global action great enough for cuts. So, maybe a high GHGs plateau, CO_2 concentrations & PPMs stay elevated >400 ppm for a very long time. Meanwhile, cuts pledged around the world fail spectacularly. Mediocre actions still not near enough to make a 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 the uncounted methane/gas threat that is forcing deathly heat too.

IRA of 2022 helps reduce CO_2 some from US, one of worst offenders. And Paris Agreement won curious fanfare, in supposedly holding heat to 2 degrees C (3.6 degrees F), or (impossible) 1.5 C or 2.7 degrees F of rises. Assuming science is to be believed, global CO_2 emissions must be cut right now in *this decade and far more* enormously: by some ½ to 2030. Actions worldwide may point to a plateau – first of coal burning, next of gas and oil maybe peaking in 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 accelerated some helpful changes – it also took our eyes off CO_2 and GHGs prize. To be clear-eyed, recent fanfare over a 1.5 C hopes or 2.0 C target wasn't deserved. Not when Paris lacks mechanisms to enforce needed cuts to achieve it. Not when there's no real Plan to meet a 1.5 C target – or even 2.0 C soon breached. Not when leaders talk as if mostly meaningless Agreements can head off likely(?!) catastrophe. Against needed cuts in this decade – vs. lack of global action – any later-on 'net zero' greenhouse gas targets by 2050 aren't worth discussing.

We can squint, for bits of hope. In 2020 a 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. Nice to see 91% of new 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 that was far from 100%, let alone 50%*. Numbers & science show we're near a climate precipice, maybe tipping points.

Overall, the world electricity production pie is growing; the thing is, coal's growing too. Coal vexes in 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 in high heat industrial processes like in making steel, aluminum, cement. Nor coal's big expansions 2024, 2025 etc... Nor of huge embedded CO_2 in products exported like from going Xinjiang China - to US, Europe, and worldwide.

Greenwashing abounds. 'ESG', an awful ugly term can be so meaningless that it misleads – when Big Tobacco, Big Oil companies score higher on 'ESG' than America's leading pure-play EV maker! Far better, are meaningful terms like true Decarbonizing in clean energy 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 uptake. Coupled with distant targets like 2050, words can get meaningless. 'Carbon neutral' is proclaimed – yet Not the Same as Zero-Carbon. True zero-carbon – stands 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 etc. The latter a less-noted GHG super-pollutant, is more climate-forcing than is CO_2. Shorter-lived yet potent at trapping heat - so near-term drives the global heating in this century. Paths today like ending methane leaks, can be smart fixes.

Science & humanity in short may require now an unprecedented clean energy transition. Decarbonization reducing all GHGs, including the less-notorious if science is simply believed. Instead, we hear words that dissemble. Much as Greta says, just: 'blah, blah, blah' like to 'end coal' (later). It follows: No nations yet merit praise. 'Twixt words & strong actions, the void is huge. Gains so far are 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 had elevated King Coal. Later on made oil nearly-the-exclusive fuel for transportation. Later markets, policy had made natural gas so common last century, that gas dominates still today in making electric power. In making heat for industry & homes & business purposes.

Lately, market forces do help renewables. But according to best science, on carbon this clean energy transition isn't happening nearly fast enough. A shift from coal – to hydrocarbon oil & gas – had once taken half-a-century. We don't have half-a-century now, as science tells us. This transition isn't to just one to flop new energy – atop lingering fuels. Instead, it's flipping to new energies only; solar, wind, storage etc, maybe green H_2. Policies could hasten that. Especially as clean gets cheaper, better; it's for sure healthier. We saw attempts 2022-'24 to use fossil gas as a cudgel in wartime, freeze Ukraine. But that cudgel 'broke' – it failed. Capital markets responded fast & matter. Here, now, the pace of change 2020s to clean is of the essence. It's simple. Listening to what science, and seas in fast decline are shouting – matters like never before. We'll turn next to energy Indexes & financial markets.

Stepping back, let's look at ECO/NEX back first in 2020. Given the Indexes/ETFs stood out then as top performers that year worldwide with ECO in particular up +203%: why did these 2 do so well? Several factors enumerated next may help add a bit of colour. They also imply in down years – these 2 volatile Indexes (as we see) can drop harder/faster than most!

One big factor perhaps, is our long use of *decarbonization* as an organizing principle stood out. Another: *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. Fewer analysts then in zero-CO_2 (and those that are, do excellent work!) on a flood of new 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 shorting - vs +12,000% gains in an equity impactful. 4th was 'ESG' baskets may be steeped in greenwash; for example, they still may have natural gas! Our's with true clean focus is instead very unique & has been consistent for 20+ years; that it had come into favor maybe was good fortune.

We'd seen similar in ECO in 2004–2007 as green energy, unknown, first 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 down a bit - or not. Views oft heard 2004 had included 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 oft were solar & wind 'weren't real' - vs. 'always cheaper' coal. Future earnings estimates, on such short-term valuations, resisted penciling anew. Importantly, valuations were based *on only seeming promise back in 2004-2007. Clean energy back then, was itself thought as much too costly.* And true, after 2007 crashed on overcapacity, higher relative costs - clean still just 'promise only' back then 2007-2014.

Re-thinking in 2020s what's maybe possible this/next decade, as *maybe* more than promise. Perhaps: 1-5 million-mile batteries; whole regions competing to make renewables & electric cars; solar-electricity costs falling <under penny a kilowatt/hour, perhaps green hydrogen – all causing new looks at valuations. Past inefficiencies in equity pricing, looked at again. To more accurately see prospects is never bad: disruption, narrowing gaps is an engine of growth. Clean/new displaces dirty/old. Over & over closing gaps from 'state A' – to 'state B' propels. At a quantum-level up to our own macro and visible. From state A - to a state B can push at the macro level, on to our small planet, to our solar system, the local galaxy etc.

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, 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 with Gains of +1,000% from 52-week lows, one +2,600% up perhaps a bit remarkable. It helps explain ECO rising then 6-fold+. Notable on the *Speed by which clean energy shined as Best option, and *by which policy moved towards zero-carbon. Maybe the biggest item, at last was notice of *Climate Risk. 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 other matters dance around it. Squarely within our themes at ECO, NEX, H2X, WNX.

Good: Maybe Reasons for Equities Rising So in 2020

For bit of fun, let's call factors behind that big 2020 change, or 'delta': the Good, Bad, and Ugly. Good, were ***Huge Reductions in costs** of clean energy, solar moved towards becoming the **least-cost electricity* in much of world; wind too. Solar/wind could become *cheapest electric power in history!* Unimaginable to many, just a decade ago. Many models had long foreseen dirty coal, or gas instead, as definitively being THE very lowest-cost power across 2020s! *Lowish-interest Rates, plus a Good driver 2020: ***unprecedented commitments*** by 3 blocs, China, Europe, US. In 2020 China made statements on decarbonizing, announced China's aim to become "carbon neutral" 2060, To be peak carbon 2030. The devil would be in details, fleshed out as new 5 Year Plans are released to much anticipation.

Did that mean all greenhouse gases? Methane/CH_4, HFCs too = climate neutral (probably not) - or just, CO_2? How much, disagreeably, dismal 'carbon capture & storage' (CCS) has a role? Is CO_2 just briefly stored? Monoculture reforesting? May 'carbon intensity' let increasing gas use – be regarded as improving?! Is CO_2 seen wrongly as 'per unit of GDP growth'? The latter could/would all distort the true numbers around 'carbon-neutral'. A terrifying fact was global average sea surface temperatures by 2024 were to soon exceed 21.00 C: first-time-ever.

So it was a big disappointment when China's 5-year Plan of 2021 didn't take steps to end coal. 2022, 2023, its actions were worse. World needed its coal to peak *before* 2025; biggest user China to commit to peaked-coal 1st half of decade. It did not! Instead, saw CO_2 peaking post-2025, steeper CO_2 (assumed) cuts only later. In a fudge, oceans & land called 'nature-based solutions' or 'CO_2 sinks'. Then were yet more coal plans and use in 2023. An alternative – peak-coal pre-2025 could have happened. But did Not. And CO_2 sinks may become sources, reverses ahead - even an Amazon Rain Forest. *Instead, China's renewables were always its best answer*. Glinda the Good Witch, knew Dorothy's ruby-red slippers can take her to Kansas. But first, Dorothy had to follow a gold/yellow-brick road, to gain confidence. China's own ruby/gold slippers, its solar/wind + storage potentially *could* be replacing its coal already. Green energy could have become its very 1st best choice, already, before 2025.

Models by Tsinghua University showed how China can hit net-zero CO_2 by 2050, all greenhouse gases by 2060. Requires big fast declines now in coal for power - and heat – plummeting from >70% – to <5%. To instead cut coal only post-2025, means more, sharper cuts after 2030. Far better, would have been aggressively Decarbonizing now: it would've been preferred by so many worldwide. China, instead, builds more use coal, may ramp its nuclear from 'just' 46 plants for 50 GW in 2021 – to far more nukes end of decade = though equals higher odds of devastating radioactive accidents ahead. Regardless, China's new energy spends may well top $15 Trillion. Or far greater: recent estimates are global $100 Trillion to $120 Trillion must be invested on green energy + climate tech. So it may be 3x, 4x that. Most ambitious efforts the world has seen. Maybe 10+fold increases in solar, wind. Maybe 10x-100x PV manufacturing capacity. Tremendous ramps in storage. New energy technology, say green hydrogen for zero-CO_2 heat for steel and cement. Colossal challenges all needing heroic actions, now.

Consider the batteries in EVs & energy storage. Apart from just Tesla in US - China most has seized opportunities. Like Japan, South Korea, Taiwan. About 1 million EVs were sold in China in 2019, a hefty 54% of world total, 3x the US. Since then, it grew fast; EV sales in China could surpass 25%/year, 4+ million EVs in 2025. Maybe again, some reasons for volatile 2020 moves in ECO/NEX! Such demand had helped push battery costs down, by 80% in 8 years. Already perhaps near <$100/kWh in 2022. In some cases, demand grew 5-fold+ plus.

America's battery leader in 2020 was Tesla, at 35 GWh of lithium-ion capacity. Aimed to rise to 3,000 GWh (3 TWh) by 2030. That 3 TWh give or take, was about all world battery making capacity in 2020, so change is happening. Ford, GM have new goals, more reason for valuation deltas. If all vehicles go electric, maybe >10,000 GWh new battery manufacturing/ year. 2x+ yet more for storage to replace fossils. Battery may move say towards lithium metal anode, towards solid state. Beyond lithium-ion, much more is ahead. Perhaps more iron that's cheap, heavy, but good for stationary uses, deeply discharges, no thermal management for longevity. Cool EV charging; graphene, GaN, SiC fast charges. Vanadium flow batteries, grid storage, maybe all getting cheaper, better resisting degradation over time, etc.

China's early battery focus proved fruitful for it. By 2020 it had 80% of world material refining capacity, it could manufacture 77% of battery cells, 60% of components, had 72 GWh battery demand. No one was close! Europe's fondness for diesel once had held it back, no more! EV incentives moving it forward. Europe's EV/hybrid numbers pulled ahead of US. A century ago, Des Moines Iowa was a world capitol in early electric cars. 30,000 EVs registered in US in 1912. But now, US is again letting its EV lead slip away – which IRA seeks to remedy. Something that China, and lately Europe too seem intent not to let happen to them. There the Nordics could be eco-innovation hubs in green battery materials, zero-carbon power/H_2.

All could = green jobs. China recognizing this, has its foot on the accelerator. Yet coal burning persists; China's 53% share of global coal in 2020, more than its 44% in 2015 – yuk, was growing. Other side of ledger, China led in clean energy growth. In 2019, China added 30 GW new solar capacity, 26 GW wind – a then total of 204 GW & 210 GW respectively. In 2020, China added 48 GW more solar, 72 GW wind. More in 2021. Think of what's needed, with CO_2 now over >400 ppm, and that's why some **Climate** models call for 10x-100x more. For, thousands of GWs solar/wind power for electricity & heat. On basic climatic, carbon-based concerns.

In rich Europe there are European Climate action plans. It laid out a carbon neutral aim by distant 2050, yet may get to >55% in *this decade* by 2030. Little-discussed in US - yet seminal – is Euro area's bigger teeth following war 2022. Perhaps a 2030 target of 120 GW just offshore wind in North Sea, a 5-fold increase from 2020; then on to 300 GW and more by 2050. Greater now, since Russian war. With key aims to start soon, – not later. 9 countries there committed in 2023 to 120 GW of North Sea wind by end of this decade. First Belgium, Denmark, Germany, Netherlands; then in 2023 they were joined by France, Ireland, Luxembourg, Norway, UK hoping for enmeshed grid – renewable H_2 from North Sea. Europe's decarbonizing aims post-2023 grew more voluminous. Not just in energy: also in industry, infrastructure, agriculture, water, buildings etc. Broadly, an accelerating EU seeks new carbon tariffs, carbon taxes. Trillions Euros € spending, carbon border adjustment mechanisms began from end 2023, accounting for embedded carbon – credits costing in future, affecting trading nations. Details are being fleshed out for paths late in decade for (somewhat) more decarbonizing world.

There was coverage of what *might* have happened in US 2021-22, were bigger legislation passed for more green incentives, jobs. But one party lacked 1-2 Senate seats to pass that. 2025 and on, however, if holding Oval Office and a handful of Republicans come over - there *may* be chance for even (small) carbon tax, a National Renewables Standard. For US to out-compete akin to China's green energy ambitions. What might have been: lower-cost US solar & wind, better grid; more swiftly electrified US. More may come in domestic-sourced EVs, batteries, storage, wind, solar, green H_2. Products with less embedded CO_2. Still by being *un*-capped, this IRA may lead to $1+ Trillion in public and $2+ Trillion in private investments. Then perhaps $$ Trillions *more* if a handful of House/Senate new votes are found.

Some ‘Bad’ Factors were maybe at play too in the 200% Equity Gains of 2020
Perhaps to some there were ‘bad’ (irrational) factors behind the 2020 equity gains of 200%. ‘Bad’ in a sense they didn’t warrant exuberance; Hydrogen (H_2) & fuel cells come to mind. Not that they can’t, sooner than expected - be vital. Was more they didn’t justify the hype, ‘til breakthroughs occur. But these are passive Indexes – not active managed – so not trying to predict rises/falls, winners or losers. And H2 fuel cells outperformed big in 2020 – now in a newer H2X Index too. Early 2020s, H_2 is burdened by sparse CO_2 avoided, low efficiencies. But, H_2 *may* grow increasingly relevant. If still from drilled ‘rock’/natural gas, it’s inextricably fossil-spawned, not a worthy solution. That ‘Blue’ H_2 from fossils & sequestration can only pass a very low bar, polluting due to methane sources. Yes, big Oil embraced a chimera of blue H_2 – but ‘blue’ may only compete with ‘green’ H_2 this decade, before green H_2 scales up. Then neither blue H_2 even with ‘sequestration’, nor uglier brown/grey/black H_2 made from coal/gas – could go up against H_2 made in truly renewable and notably, scalable ways.

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

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

Cost is the rub. H_2 has affinity to react, to combine - so much solar/wind power is needed for an electrolysis to split water. And green H_2 has been too costly vs. H_2 as steam reformed gas – even brown H_2 too 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 out 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 had reduced H_2 costs by 80% in 3 years. Going next to <$1.50/kg is targeted, or cheaper <$1 may arrive in innovative new ways.

But all that was 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_2/O – to H_2; then loses more from H_2 – to electricity at fuel cell. A case may arise *if* new green H_2 ‘time shifts’ intermittent renewables, holy grail of abundancy. Nearer term, green H_2 may displace some rock gas in pipes for existing combustion systems – but only to <15% content to not embrittle steel. Renewable natural gas (RNG) used. Uncapped methane be captured, upgraded to RNG, or *truly* sequester C in stable form. Still, RNG is just going on defense vs. climate risk. Not great, but some help near term. In sum hope for H_2 was partly, maybe too why clean jumped 2020, equities are forward-looking. But any case for H_2 was hazier in 2020s - than it was for solar, wind, EVs. That said, green H_2, before was only barely conceivable; it *may be* plausible ahead - *if* renewables bring cheap clean power.

The Ugly: unpretty factors perhaps too for the big gain in 2020
*Ugly, even tangential factors, can highlight how better green solutions truly may be. Take a dismal state of the art in CO_2 Direct Air Capture (DAC). DAC is an energy intensive, non-starter needing gobs of power, so it burns more fossils & so on. But, *if* DAC get sensibly low-energy, then it *could* be big. Less worthy, yet touted by fossil industries, is Carbon Capture & Sequestration (CCS). CCS may extend fossils decades. So might inject captured CO_2 back underground, and briefly help get more oil. But then - a key question is: Why??!! Why, when To Not Burn coal, oil, gas, is where we ought now to be headed in first place? CCS is a non-starter, and is completely unhelpful if used say for more, ugh, 'enhanced oil recovery'.

Issues too adherents like to avoid. What if CO_2 leaks in a few centuries?? At Lake Nyos, Africa, a CO_2 'burp' killed a thousand people. Far better would be stable CO_2 storage, mineralization methods that are inert, safe, permanent. But, as solar's cheaper than coal now, anyway, coal+CCS is no answer! Costs to capture CO_2+pump it underground, render coal 4x too costly!! It's why we might see 'clean coal' (ha ha) in ads only – not for real. To be compelling, DAC or CCS must *Remove CO_2 from both 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 the 2020s, arguably boosts ironically true, honestly green pathways.

Uglier still is 'Geoengineering'. (Seriously, try to dim the sun or our planet's air, or dump CO_2 massively in oceans without knowing effects??!). It of course must be rejected. Hydra-headed, that monster is overshadowed too, by mere possibility of a climate calamity. In 2020s, global heating seems perhaps, maybe to have begun to dissemble stabilities of once-cool planet. This specter concentrates the mind. Better swiftly & sensibly, to avoid CO_2 in first place.

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

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

How wrong! Proving old beliefs wrong, spiffy new electric cars are fast getting vastly better. Arguably they've been fated to do so! Foreseeing it by a bit, favors the bold. Closing gaps, between state "A" (old false beliefs) – and "B" (truth) – can be disruptive, innovative, useful. This can make for delta/changes in equity valuations – maybe 'alpha' too in financial terms. Foreseeing ongoing gaps, even just a bit before others do, can be fruitful over and over.

It's non-linear. Think of big falls back in 2008/09 as green themes crashed, again in 2021/22; they certainly can & will do so ahead. In slumps profit margins go non-existent, can stay down for years. There's often a non-Euclidian or curved, non-flat geometry here. Disjointedly compressed margins, so not straight lines. Solar's margins in time then did becalm; we're learning to make solar now *The least-cost electricity in history!* Learned cost-reductions led fast to virtuous circles. Electric cars getting better in most everyway. Think by contrast, of heat engines, ICEs; unfathomably still all around us, spark plugs explode fuel, push pistons to power cars, trucks. Coal making electricity also by heat difference. Nuclear too = world's costliest boiled water. Delta in a hot vs. cool. It's a difference of state, temps of "A" vs "B". But that difference in heat engines is also brutally inefficient - unlike nature herself.

Mr. Babbage once captured delta via a difference-engine. Mr. Turing created computers; the gap of ‘0’s vs. ‘1’s did the work. We don’t know *when* razor-thin PV margins will again fall; solar equities again plummet as they’ll ever-do, delta booms and busts. Or, if/when maybe a top-line issue appears to our own species: Earth’s physical cycles and consequences. This last one may become so significant it stands out *sui generis*. Potentially, climate risk might impact societies, humanity. Possibly an existential threat, one not yet understood. If tipping points, then maybe there’s feedbacks: permafrost melts, 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 will just counsel calm. Soothingly they’ll remind us that things really aren’t near half as bad, nor as extreme, as non-scientists or some leaders paint them.

Not so, on climate. Singularly researchers here seem ‘shouting’. Maybe is conservative then to heed it – foolish to reject it. One day may hit us not in 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 heat only 3 months? Winters? Cooling nights? In 2 centuries, who may recall living reefs? Sandy beaches? Healthy seas? How to cherish what we bequeath. Especially as sustainable, no regrets paths can make us healthier, happier, richer, safer, more secure. Instead of costly spiraling blood, treasure, disease, pandemics, despair. Better, may be to embrace a certain wisdom in farsightedness, to think prevention rather than cure.

NEX/ECO/H2X/WNX green themes include some look at emerging ideas like decarbonizing. Electrifying all, low and better-yet zero-carbon fuels, energy efficiency including heating & cooling, circular industry. Such emerging, innovative, science-based ideas are sure to be highly volatile – to have nexus to ecology. Consider for instance then, a few disruptive ideas embodied in 14 of the most volatile upside constituents in NEX as seen early 2021. In what was most up over a past 52-weeks going to early 2021, hence the 14 biggest gainers then.

NEX back in Jan./Feb. 2021 was at-highs, so we’d avoided looking right at a peak. Instead, here’s figures from March 2021 as NEX components, innovative equities globally had begun steep falls. These % figures had moderated a bit, looking on March 3rd amidst the then -25% YTD plummet. Nonetheless, like ECO’s story where we saw gains up +1,000% from lows in 52 weeks from 2020 to March 2021 – here, global NEX is showing what’s most up. In these instances of rich gains globally, here’s 14 NEX components with deltas to March 2021. Those that showed gains 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, 2021 in EVs, fuel cells, wind, solar – were followed little surprise afterwards, by big falls in 2021-2024. ECO went down to touch 40; NEX went down <300, then near 210; they could both drop farther yet! Falls too in H2X, WNX. In future as climate bills are vetted, stocks crash, interest rates change, pandemics, wars etc etc - themes can plummet. Other stranger and more remote outliers may happen, a 1st US Debt default, sun-ejecting coronal mass ejections (CMEs) that threaten grids, Miyake events, electromagnetic pulse events (EMPs) etc etc. These risky, always-volatile, once-high-flying themes, could be badly hit.

What was of note about 2020's gainers? For sure, they were remarkably diverse. Some in energy innovation, scalable to go 'on offense' against climate crisis like solar & wind. Names upstream in solar included in poly & ingots, wafers, panel manufacturing. Downstream we saw inverters, PV sales, installation. There was winners in EVs, advanced batteries, materials. Plus in highly speculative themes like hydrogen & fuel cells. Biofuels were diverse, present too. All because new energy innovation reflects a wide-range of today's, mere possibilities.

Some were 'on defense' on climate. Smaller steps, extant infrastructure. Capture methane – otherwise indifferently released to air like to a sewer. 'Renewable natural gas' far from ideal, turning methane into CO_2 – combusting as a less potent greenhouse matter like in rock gas. Or for lowering CO_2 - or near-negative-CO_2 - like sustainable aviation fuel, gasoline, diesel.

Equity gains in 2020 *in no way* foreshadowed gains ahead – as confirmed by 2021-2024's big drops. Indeed, big rises often auger sharp/er falls. Regression to mean, nothing certain. Or, after consolidation, it *may* point towards better paths. Once upon a time, fossils magnified human power many-fold. Yet sympathy for once-magic fossils – can't mean what's bad for coal, oil, gas - is bad for humanity. Wiser, is to go towards broad, sunlit uplands we'd once enjoyed: to carbon back under 350 ppm, near 280-300 ppm. This choice may be seminal.

30 years ago the paths ahead weren't clear. Solar maybe was viable, but could it be cheap? Horizontal, vs. vertical axis wind, a competition red in tooth & claw. Electric vehicles possible on better batteries, but *when* might it happen? May H_2 fuel cells *ever be* economically viable? All Big questions, no clear answers. Barely imaginable then, yet possible now may be electric jets; green H_2 & its derivatives ammonia, methanol MH_3OH; ultra-deep geothermal; unboxed EV manufacturing that replaces assembly lines; sequestering carbon as mineralized rock. So much is yet to see in this decade. All debatable, inherently uncertain. We recall risks are like it was late last century/millennium, only some 30 years ago, or even 20 years ago.

Thus to passively pool diverse clean energy *possibilities* in single Index, a basket, made great sense then – & arguably still does. Victors are unknowable, which competing technologies may win the day. Hence to mitigate individual single-stock risk via a basket was compelling then: just as it is now, more so! One can't know *which* stories *may* survive in energy storage, solar, wind, green H_2, electric vehicles, decarbonizing themes, etc and more ahead. Which equities, all being very risky – will Crash and burn – which Survive. Perhaps thrive. This vexed matter bedevils. Helping explain why passive Indexing like here, is arguably rather compelling.

Volatility, is a differing beast. We say with great confidence that oil prices will move *very sizably* ahead. That fossil fuels may decline very long-term - yet acute events overshadow that at times. Maybe an oil/gas shock, storage issue; accidents, attacks on grid/ infrastructure, drought, floods, hot days, bitter cold snaps, even solar weather CMEs, EMPs. Any may mean big price swings. To not weatherize against extremes = Unpredictability. That's predictable, in a sense. Droughts, weather extremes stalk fossils and nukes that need cooling always to work. Or, stratospheric heat in a changing climate may occur say one-month; for a weakened Jet Stream next letting in super cold arctic air South, freezing temps. Or a slower Gulf Stream, ironically, may dramatically alter weather in Europe and US Eastern seaboard. In past, stability of both key Streams: the Gulf Stream + the Jet Stream, was crucial. Yet now, on less temperature contrast 'twixt the Poles vs. Equator, that stability may falter. Fossils, might be in very-long-term decline – yet we'll certainly be seeing huge volatility.

Foreshadowing this, disaster hit Texas 2021 when a freeze took down its electrical grid. That big blackout also showcased battles going on in the public square. What does it take to build a reliable grid ahead? Mainly more gas & nukes? Or mainly renewables & storage? Natural gas has long dominated – yet lately, it's finding itself on back heels. Case in point, amidst that crisis, was an argument hastily put out during the blackout that it was due to clean energy - and to Texas' own 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 this was a current Texas photo of flailing attempts to drop chemicals to unfreeze stuck turbines. They claimed it was proof wind was a ***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 from a Swiss helicopter company testing hot water drops from off a boiler truck (no chemicals) in Sweden – for a turbine lacking usual de-icing features. That compelling photo was shown at a 2015 conference – now it made a powerful, fictional 2021 false narrative. This meme was shared widely by publicist, website, & others: 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 days and weeks later, after this memorable photo & 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% by gas for all grids on gas nationwide. What was key, is how well Forecast / Actual energy Supply – matched Demand. That week the Electricity Reliability Council of Texas (ERCOT) had expected 82 gigawatts (GW) power would be available. Greatest expected supply percentage expected was to be from natural gas. That was huge projected 50 GW availability.

A review of just what in fact happened 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 as 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 February 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 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 Kabuki theater, a one-time narrative for opponents to rail against clean energy. Like Summer 2023 a photo of melted traffic light was 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.

That relatively small underperformance in wind vs expectations, was narrower than for coal. Latter was off by a larger 5 GW from where '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 wind. 18% was coal, plus, nuke losses. Thus, each source of electricity was hit. Truth is wind's shortages were smaller (near least) among all disruptions in that crisis freeze over 3 vexing days.

The key shortfall was 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 warm to hot place; much equipment left unweatherized, so tanks to divert the oil from the water & from gas, during a freeze became solidly blocked off.

If not frozen, they 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 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 skyrocketing.

Normally gas producers might sell product at around $2.50 per million British Thermal Units (BTUs). But contractually obligated to supply gas they couldn't provide, instead some had to buy (to provide elsewhere) gas at ridiculous prices like >$200/BTU. On Exchanges where gas prices hadn't gone up to $200, they'd added 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 ever-ample feedstock gas. And had expected wholesale power rates around $24 per megawatt-hour. But as gas was unavailable on freezing temperatures, and chaos sandwiching between needing to find gas right away any price, the prices they charged shot up for each MWh – from $24, to in some cases a really crazy $9,000/MWh! Reminiscent of crazy gas pricing seen at first in Europe in 2022, with start of war in Ukraine. In Texas, power producers needing 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 described 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 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 for 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, perhaps surprisingly were not always the cheapest.

Cold wasn't at fault, *per se*. Plenty of gas infrastructure works in deep-freezing places, where 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 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 here. Or, the State could continue hands-off, and just blame renewables like before (though next blackout its true fault is better known).

More *storage* too 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 pump freezing was cheap to prevent in first place, a no-brainer. Ensure *critical infrastructure gets power in crisis. Hard to protect against is drought. Big thermal coal, gas, nukes may *have to* shut on low water – not only hydropower's dams. In Texas, Arizona, the West, drought stalks – broken by floods from big atmospheric rivers.

If it feels like playing at edges of 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; that adds 10% to turbine costs but is done round the world. Wind energy works fine in the Arctic, US Upper Midwest, places 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 – like they were for wind!). After Texas' freeze it later came to light a blitz campaign was fast mounted to call renewables 'unreliable' – and deem fossils 'reliable energy'. Even though its natural *gas was the most to blame in 2021.*

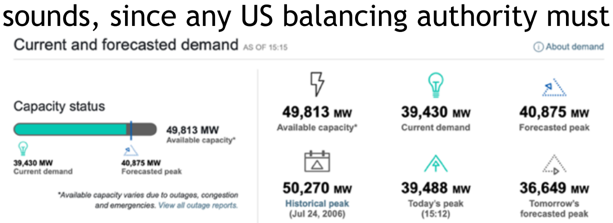
Texas' 2021 disaster, bad as it was, was minutes from far worse - if frequency stability were lost. It did fall from 60 hertz – to a critical 59.25 – nearly crashing whole system. Had transformers caught fire, or high voltage lines been destroyed, it could be weeks, months - not days of no power! We don't realize how dependent we are on electricity 'til it's gone'. Only by shedding 7,500 MW of demand (effectively turning off ~1 in every 8 homes in State), were they able to take a first emergency step. That was twice 2011 emergency shedding that had then lasted 8 hours, 4x longer than a blackout of 2006. There were 3 emergency load sheds/ rolling blackouts – and 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 saw unprecedented heat – 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 dropping to nearish population centers, yet it remains just North of US, Europe, Asia. We're saved by historic Jet Stream 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 changing climate Jet Stream shifting, wavering, weakening: bitter arctic cold descending then further south. While that may not sound harsh to hear, consequences would be. Both flooding, and longer droughts too, from air that's warmer, so holds more moisture for occasional bomb cyclones. Those increasingly imperil the big thermal coal, gas, nuke power plants, and dams. Terms like 'Climate Change', 'Global Warming', too benign for what may be Calamity. Better maybe is 'Climate Crisis', 'Global Heating', 'Broiling' - even 'Global Weirding' should decades and centuries see a blazing Planet. Perhaps an uninhabitable equator; temps not too apart from 'Hot Poles'. Getting there may not be slow, or incremental. Maybe in non-linear ways. Not pleasant. Not a desirable, pleasant warming, made of gradual gentle change only.

Halting Gulf Stream *can* paradoxically mean centuries+ of bitter change – Colder or Hotter. Look westward - or eastward away from a North Atlantic warmed by Gulf Stream – and it's soon frozen. Should that Gulf stream heat train fail, science is unsure if its then a Frozen Europe? Or a Baked one? But impossible is no change at all! It's a difference engine yet again as in stocks (finance) – and in natural world. Gulf Stream slowed as meltwaters dilute salinity, and/or Antarctic overturning current slowed, all would hit ocean currents worldwide. And we all lose. Solutions present in myriad ways but *more renewables, more energy storage, EVs & better grid, in short Clean Energy and decarbonization-* is where attention ought turn.

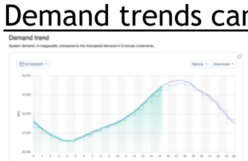
Despite the benefits renewables offer – curiously some strongly oppose them still. For example despite anti-renewables views held by some Texas politicians in 2021 – just 1 ½ years later in Summer 2022 heat they were ironically saved thanks to fast-growing renewables. Then, amid a record Texas heat 2023, and 75 GWs(!) of demand, wind+solar (with nuclear) were heroically making 27+ GWs, ~40% of demand! Plus that kept power prices cheaper than gas & coal. By 2023 zero-carbon power in Texas (with nuclear) was beginning to eclipse the ~40% made from gas. Yet renewables are NOT firm. And grids in Texas – like many places, are exposed. July 2022 Texas had teetered on edge of record Demand, 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 goes down, a 'black start' may be needed – whether can be done fast is unknown. As 2023 saw new heat records, we look forward: more green energy, more grid storage, better transmission, all needed for the grid. We fundamentally need a better, modern, more stable and resilient system, much more renewables fast. And yet some politicians in 2023 were working to cut back on all renewables, and to increase coal/gas.

Texas is a bit similar to California, though California has less energy demand being a less-industrialized State. In both cases, renewables have only met about ~35% to 45% of demand, typically (40% was a new high for Texas in early 2020s). For California, consider 2 separate Summer days: one in July 2021 – and one a year later, in Sept. 2022. 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 when State grid was in peril. As seen then, all available power sources were generating 2021, roughly for 50 GW (or 49,813 MW) of electricity. Demand was forecast to peak that day in 2021 at about 40 GW (39,488 MW). But peril was closer than it sounds, since any US balancing authority must keep at least >6% contingency reserves:



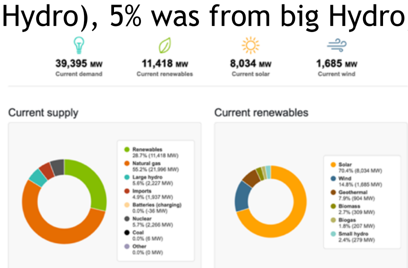
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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



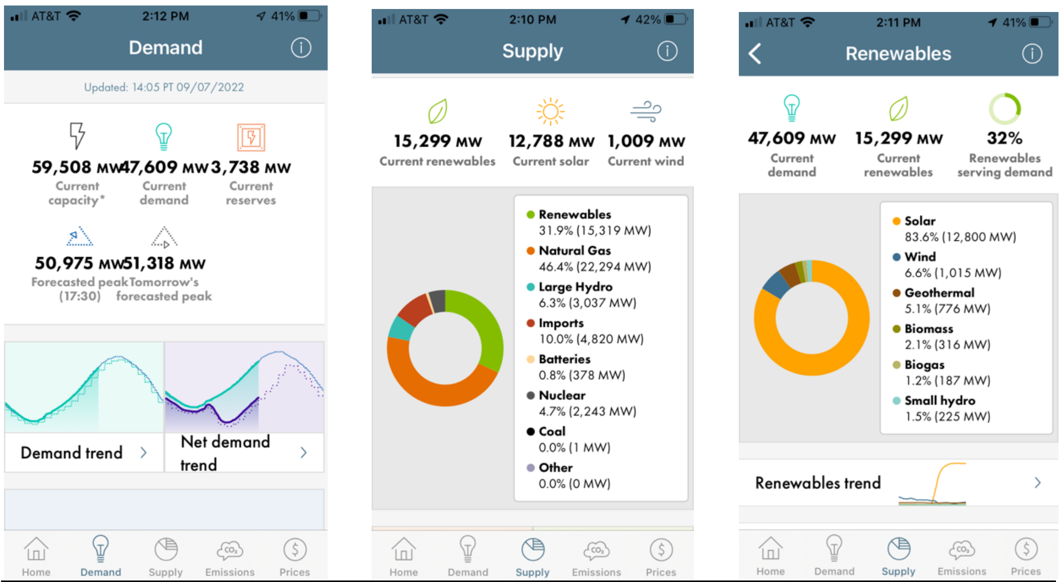
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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



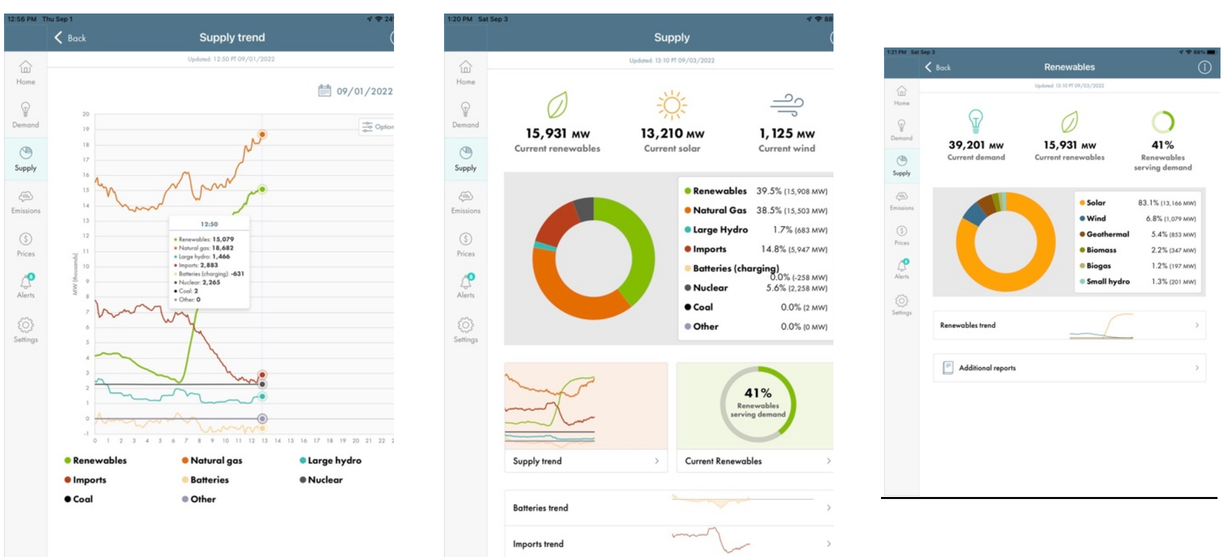
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

1 year later, Sept. 2022 again heat, near blackouts, plants produced flat-out no maintenance. It maxed out higher, making 59 GW. Threw everything at it but kitchen sink. Peak Demand was higher too 2022 than in 2021, here a 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 that hot mid-day hour were by solar at 2 pm (about 13 GW for some 84% of all renewables):



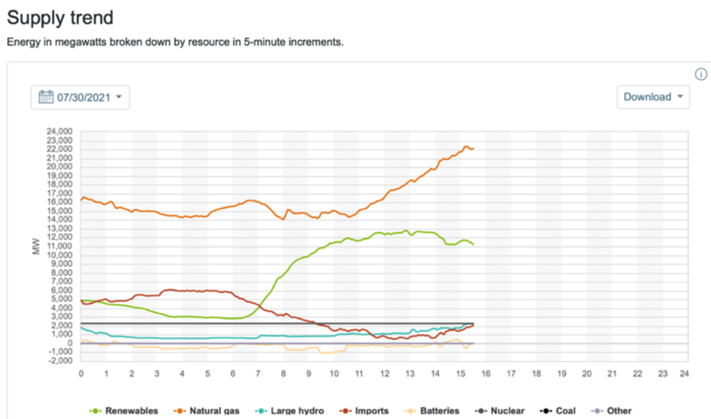
Source: CAISO.com Today's Outlook - On Sept. 7, 2022 at approximately 2 p.m.

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



Source: CAISO.com Today's Outlook -

Put together, a should-be expected-hot summer day in 2022 (above) had flirted with disaster. Renewables served just 41% of California Demand. Far too low in a changing climate. Yet good news is renewables are eminently scalable. Grow solar by doable 5-fold, fast, so solar (above) that made 13 GW (13,166 MW) – is, instead, solar making say 65 GW. True, demand will expand too – so grow 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 new offshore wind should grow many-fold, much more than just 6 GW, fast. Coupled with green storage for nights/windless days to meet all California demand. All this on modern grid, importing solar as desert sun & wind as Midwest winds. Clear how supply arc in green, daily, ends each day in an eminently expectable solar 'issue': the Sun is simply setting!



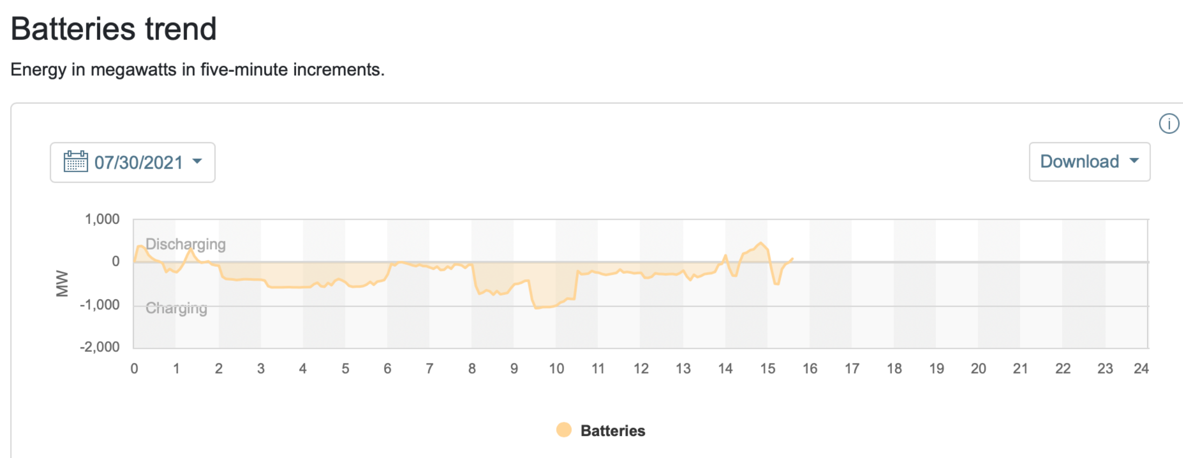
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

We must expect this, solar's huge renewables contribution here, green, is about to drop 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 those 'lost' GWs from solar in an arcing, soon to plummet **green** line above.

Key going forward is to 'fix' this Not by reverting to more fossils. Not more natural gas. Especially as we see big impacts of fast-changing climate - and gas used as weapon in war. Oil/gas prices are set by global factors; American fracking makes much oil/gas – yet is not a low-cost saviour: gas scarcity anywhere makes gas prices jump everywhere, even in US. In 2022, Europe looked to tax gains fetched by zero-carbon wind & solar; they beautifully stayed level, as fossil energy costs skyrocketed. Meant wind/solar producers derived far more net profit per kilowatt/hour. But such windfall tax discourages new investments. And, left unsaid, a real story underneath it all, was how superior the renewables can be vs. fossil fuels.

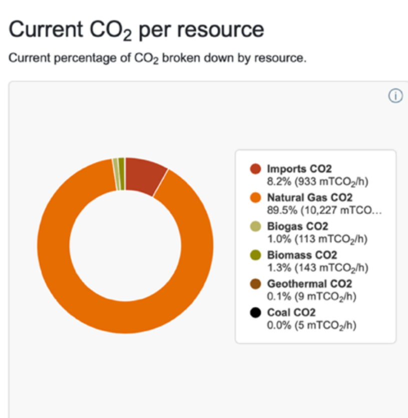
Fast-scaling renewables are favourable. But not perfect. They're not firm. Drought in changing climate & flooding are hard on hydro. New wind patterns tough for wind energy. But distributed generation, like infill solar – doesn't show up in attractive figures for Utility-scale renewables. These ECO Reports have been written for 20+ years in a building using 2 solar systems for power, with 3 electric cars (no gas/petrol needed). Solar is powering our cooling - and our heating – with 2 heat pumps. Our electricity is solar; hot water from large passive solar tanks on roof. All this with a battery backup – linked to solar PV. So when local blackouts do occur, or say, if gasoline prices may spike, we're always left blissfully unawares. Repeat this, millions of times over, especially given that for over 20 years it has Saved us $$$!

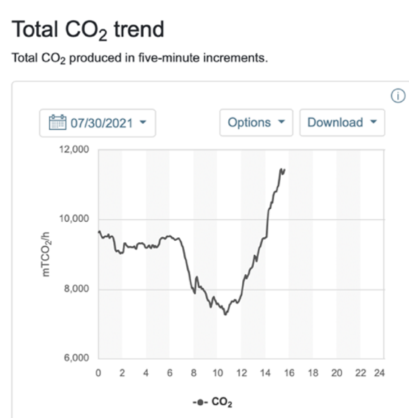
Back to the grid and how millions of homes/buildings are now powered in US: most of course are Not yet on solar – and Not backed up by (costly) batteries: so there's little resilience. In theory one might think much energy storage today exists on grid; that it would/should kick in fast as the sun sets. After all that's an infinitely predictable happening each, every day! To foreseeably make up for lost solar after sunset, grid could store green power during the day, replace 100% of the GWs once from natural gas. But ... reality today is still energy storage is almost entirely… non-existent. Geothermal is tiny. Batteries still so small they help only puny, temporal ways - delivering bits of renewable power at times - then only for brief time gaps to 4 hours. Hence keenly need now 2020s is Vastly More Storage – and better Grid transmission. To help spatial ways too given there's frequently far-off winds. Batteries can become heroes, but a meager less-than 1 GW was in play in say, 2022 – when we really now need 50x that! We need 50 GWs (50,000+ MW) storage! Shows here as negative this day (a bit of charging) – only scant power thus available when the sun (no surprise!) goes down for discharging:



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

Wickedly Insufficient storage early 2020's meant we'll go on suffering ongoing dependence on fossils. Using natural gas in California, Texas and US, Europe, Asia etc etc – huge carbon emissions. Big hydro can't scale up; indeed, once-great reservoirs Lake Powell, and Mead may one-day become dead pools. Natural gas is not quite as awful as coal CO_2 per MWh, but its methane leaks vex Earth badly. And we *know* while *measured* CO_2 is an issue – the unmeasured leaks from methane may be making it a climate killer given that methane is a potent GHG.





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

Scarily tight electricity supply is a Given, hottest days even in wealthy Texas, California, US, Europe, Asia. In drought even in once-hydroelectricity-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. That's No solution! It's left to hope, as is seen on Hot days when California's Governor has to give 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. Dirtier backup generators used freely. Ships allowed to burn dirtiest fuels in port, rather than use far cleaner shore-based electricity. All scary, when nearing blackouts, it threatens lives.

California grid means in Flex Alert, allowance lets CO_2 Emissions spike to get Supplies as high as possible, >50 GWs. Gas peaker plants may run flat-out 100%, no maintenance, dirty imports from out of State. Demand in a very foreseeable Heat Wave like in 2020, 2022 etc outstrips State's capacity. Given efficiency strides so far, look more to green supply, and storage. Yes, California ever-adds (yay!) more electric vehicles – those can charge at night, leveling out demand (and not a threat to grid some might worry about). But in fewer and fewer years to 2030, that 1 lone California nuclear plant making 2.3 GW will close; that will mean a big 5% loss in the State's firm generating capacity. Blackouts surely see, ever-looming.

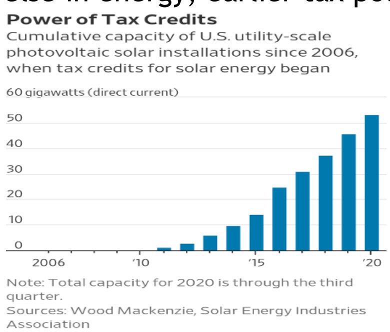
The State's using band-aids. Importing electrons from elsewhere, even in regional need. That may be power from dirty coal, gas, or 2nd gen nukes – all hit by weather issues; all will suffer more than renewables in heat waves. Or in drought: little cooling water is growing threat. As Texas showed in 2021 - cold knocks out fossils & nukes. Grid can be knocked out by deliberate attack/s too – or nature. Hence, what will help: newer grid with links to a windier Midwest profitably exporting its bounty to California, to Texas etc. A modern resilient grid better protected from wildfires, makes more electrons available. Storage + resilience latter 2020s. Especially as droughts loom soon over hydropower, gas, nukes, coal! Global change hits our planet with new extremes. More remote exo-planet risks: maybe CMEs like a past Carrington event – or worse scarier for grid a Miyake event; what MI5 in UK calls '4 meals away from Anarchy'. All calls for stronger/shielded too renewables + storage + resilient grid!

In sum war complicated all for energy prices are set globally. As Europe scrambled sans Russian gas, it paid record prices for gas from other than 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 2023, 2024 2025 etc. More gas no answer; takes many years to build terminals for LNG. Yes, is years too for renewables & grid, but they alone solve much. Crises may stretch out over this-decade.

Used to be, the proponents of US natural gas pointed to it as energy transition fuel, saviour for America. But they hadn't figured on gas crisis, war in Europe adding volatility as prices are set globally. True, fracking in America helped prevent natural gas price spikes, as does filling US oil storage. Still… Take say, Sept. 2022: US natural gas already more than doubled that year – that hit utilities hard. US electricity nationally in Fall 2022 averaged near 15 cents/kWh, up 7.5% over year earlier. CPI for electricity costs was up 16% over a 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/kWh. Due to gas rises, utility wholesale costs tripled from 2020, to $130 per megawatt-hour. Recall again now wholesale Bidding cleared prices in UK in £GBP/MWh 2022: offshore wind just 37.35 pounds; onshore wind 42.47; solar 45.99. How better!! On war, weaponized gas was an Achilles Heal worldwide. But a take-away is it doesn't need to be this way. Nor reliance on gas, nor on China for key minerals. And in 2023 we were really 'hit over the head' by growing look at climate risks.

Those who'd shaped the IRA, had thoughts on sourcing & processing vital minerals in the US. On building green industries at home. On energy storage – a theme in light of China especially, but that even an oft-lugubrious Europe was far ahead on. Many wanted a pro-US trajectory: for mining & processing here, the IRA to reflect that. To give say a 30% tax credit for stand-alone energy storage (it had needed before to be coupled to solar, so by 2021 fully 93% of storage was tied to solar). Developers could benefit from extra 10% ITC, if 40%+ components were made in US. Another 10% if in areas once heavily in coal, oil, gas. All that was foreseen in previous to IRA draft bills. With newer IRA incentives, the aim was that key minerals should begin to be sourced from within US (or North America). Biggest US EV makers expected to build in this decade new US plants for processing lithium (even if it's mined elsewhere).

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, per IRA post-2022. True, earlier 'omnibus' BBB bills of $ Trillions had failed. But, some language carried over from BBB. Solar once needed both cheaper panels & favorable (tax) policies to light a fuse, prime a pump. Both. This chart shows how fast solar then grew, after, thanks much to tax credits from post-2006. Solar stands better on its own now – but like all else in energy, earlier tax policies for solar had once greatly mattered:



Sources: Wood McKenzie & SEIA

Storage credits that previously needed links to solar, were of little help. With the 2022 IRA, unleashing storage alone, much can 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 for batteries & storage - what recently happened in fast-growing solar and it can be of great benefit to, and for, all.

Just one upstream example is tax policy may 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 make lithium hydroxide, without water waste. Freed from intensive evaporative ponds, needing no sulfur. Co-locate battery/EV makers – like poly plants+solar PV makers - decarbonizing as one organizing principle; that can build lower-costs and efficiency. Ever better is a circular economy with new zero-CO_2 solutions.

For EVs, that Senator's thumb on the IRA didn't help high-income electric car buyers; and it excluded non-US EV manufacturers from subsidies. Batteries made of materials sourced overseas or processed there, were excluded. All thorny for big mining & minerals processing capacity in US will take decade+. And there's other issues: WRO, and anti-circumvention had dominated 'in the weeds' PV news 2021/2022, for over 90% of global solar wafer capacity was in China. An issue for US PV buyers in 2021 was whether panels were 'built' in China - or in Vietnam, Malaysia, etc given tariff Uncertainty. But there was some green light to grow 2022. And new hopes that permitting could at last be better streamlined 2023 and after.

Useful non-Correlation as between our WilderHill Indexes - versus Fossil Fuels
Our ECO/NEX plus H2X/WNX themes - show good *Non*-Correlation vs fossil energy. What an example of diversification! There may be differences sometimes, eg, when clean alone gains... Or sometimes, clean falls hard - as dirty fossils are up like in 2021/2022! Yes, all are *energy* themes – yet clean can march to a distinctly different drummer vs. coal, oil, gas. Take say a 2020 vantagepoint and look back from there: an interesting thing had happened. Dirty energy few years to 2020, was THE worst performing sector of S&P500 in 4 of the prior 6 years; it was down -30% in 2020 - when clean energy roared. (In S&P500 'energy' is mainly still fossil fuels). In sharp turnaround, fossils jumped in 2021, some 2022, after long doldrums. Still, past several years were notable for all energy, so look a bit more closely.

Consider what transpired, as a 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 (mainly thus dirty fossils) was strongly down -51% in Q1 2020 – while a whole S&P500 was down then 'only' by -19%. Partly, that gap was due to 500 Index's cap weighting methodology. Just 1 very big component within a market cap weighted S&P500, say an Apple, may potentially be heftier than all its then 2020 dirty fossil fuel energy names/weightings, all combined!

That major Index is slowly greening, albeit at snail's pace. An electric car firm was added to 500 in 2020 – already as America's 4th biggest company – and curiously was marked in the 500 as 'consumer discretionary'. A solar inverter firm was only added in 2021. As 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: 7% in 2015, 11% in 2010; 16% in 2008. In 1980 dirty energy was 7 of S&P's top 10 by market caps, 25%! By contrast in 2020, fully 28% was in tech, up from 18% in 2010. Some observers early 2020 had hoped a big EV maker addition to 500 might have come mid-2020, to be 1.4% of the Index. That would have been significant on $4 Trillion in trackers. But it was then passed over, 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 a price-weighted Dow Average needed component/s to better keep up with other baskets. (Dow had sizably lagged in performance then). New representation was chosen - but not from fossils. Instead, they added in 2020, 3 tech-heavy names. Dow Industrials dropped Exxon that in various incarnations was in since 1928; once a long-serving Dow component, no more. Only Chevron in oil, stayed. (That was due to a prior decade perhaps when dirty energy had fallen – yet it would rise big 2021/2022; indeed, energy became bigger slice of S&P500 after 9 of its 11 sectors fell, and energy gained +14.3% in e.g., Sept 2021; in retrospect then Dow maybe should have kept in 2 fossil fuel names – which really later jumped up 2021 and 2022).

Make-up of financial baskets, matters. Battles quietly going on influence hundreds, thousands of Billions of $ dollars. Back in 2018-2020, a then-Administration's Dept. of Labor on ERISA had wanted to know of any 'discernable trends' in how retirement funds were being invested in energy (FAB 2018-1). There'd been sizable outflows from fossils – to new sustainable energy themes. It's been reported fossil industry & climate skeptics were an impetus in trying to slow inflows to 'ESG' (Environment, Social, Governance) – much better thought of, decarbonization investing. They'd perhaps hoped to see 'non-pecuniary' goals like climate change, get subverted. After a new Administration moved 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. Again too in 2023 in Congress -vetoed.

Real-world Returns for clean energy in the 2018-2020 window were Up hundreds of percent, hardly 'non-pecuniary'! Then, ECO was up +300% - as traditional Indexes were up more modest +85% (Nasdaq), +40% (S&P500), +25% (Dow). Fossil gas was then *Down* some -60% though it'd soon spike - and fell 2024. 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 ESG assets 2020 were up 2x vs. 2019, to $246 billion in 2021. Decarbonization may grow, yes, *but will surely be hugely volatile, oft down.* And yet. Attention to climate (IB 2015) saw unworthy Federal attack 2018-2020 reportedly by fossil interests and skeptics under ERISA. And at a State-level in 2022, Texas moved to divest from funds it felt had 'boycotted' oil – even if just new energy in their name (like NEX)!

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 and so went with an attractive winning bid of 4.0808433% from a major multinational investment Bank. But the State halted that deal; it claimed that big Bank was 'boycotting' fossil fuels. The 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 that Texans as a result paid a much higher 0.41 percentages points interest rate for Bonds – that can costs its taxpayers a Huge $22.5 Billion over 30 years! Talk about their cutting off their nose to spite their face! Of being hoist by their own petard! 'ESG' however is much different – from our clearer focus on a Clean Energy transition, not to be conflated. In sum if proposed rules/attacks like in Texas sought to prevent any look at CO_2 or at climate risk by deeming it 'non-pecuniary', then that's a bit curious given these quite glaring Performance facts:

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

Source: finance.yahoo.com

Is an artificially narrow window above, yet makes this point of highlighting differences (from fossils), March 2020 to March 2021, ECO had ranged from 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". Doubtless future crashes in clean like seen 2021-2024 etc lay ahead. Yet 2021, China aimed to go from 11% solar/wind power generation – to 16% by 2025. Wind developers jumped then on expiring subsidies – installing 72 GW of wind 2020, 3x that of 2019 (solar up 60%). But because their government's 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 that proposal was dropped. Point is regardless of certain ongoing volatility, decarbonization has begun to figure, though early 2020s decade supply chains and war vexed globally.

In 2022, 2023, 2024 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 the fact of climate crisis, doesn't mean smooth sailing ahead; no nation has yet risen to occasion. And for host of reasons, volatile ECO, NEX, H2X, WNX will surely fall at times, *hard!* And each nation has its own issues… one problem as a practical, domestic matter has been that America lags behind badly in producing lithium, nickel. In Rare earths too that in fact aren't so rare, yet needed in motors, turbines & strategic uses. As Sen. Manchin observed 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 nickel, for instance in batteries, electric cars, grid. Yet in 2022, nickel spiked briefly on a short squeeze from $20k - to $100k/ton.

This 'ain't our first Rodeo' in seeing a 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 to cheaper Vietnam, Malaysia, Thailand. By 2020 the 3 biggest PV makers had HQ in China. It is seemingly happening again in crucial batteries, and EVs. Such needn't occur. And the IRA is changing things – including notable Sec. 45X as of 2024. But 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; ought to be many more. Meanwhile, these 'US factories' may include S. Korean etc-owned factories, just built within the US. The IRA should help it be US owned factories. By 2030, so in less than 10 years, China is smartly on track to 140 big battery factories! Europe may have 17 big factories. On projected US electric vehicle demand, should be 20+ US battery factories 2030. Not inspiring 2021 saw only half that, 10 on track, to be up & running 2026. They should have been in planning in 2021, their construction already begun by 2023.

US is far behind China in green manufacturing, even behind a more committed Europe. If the US expected 200+ electric & hybrid car models 2024, it should have been producing far more rare earths minerals for motors. Rare earths needed 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 so rare). While rare earths are necessary eg for magnets to generate electricity in spinning wind turbines, or that take amps of (clean) electricity & convert that into lovely electro-motive power pushing new EVs, fast aircraft, ships at sea, etc.

As said by Mr. Nikola Tesla regarding his & later amazing inventions that would become 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 pedestrian, electric parlour tricks by comparison, the rotating fields of rare earths are awesome; they make possible unmatched blue-sky advances. Myriad technologies need too rare earths 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 'greener' lithium from hot briny waters & zero-carbon geothermal power is better than water-intensive evaporative ponds and sulfur. So too is avoiding mining bankruptcies upending cleanup. Ecologically sensitive places surely must be protected from any and all mining. Meanwhile, some places are more amenable for it. And places like West Virginia welcome sourcing minerals from ample disturbed sites, extant waste piles of old mines – creating good jobs.

Sens. Manchin, Capito, Murkowski had in past bills tried to get rare earths from coal waste of which they've got rather a lot. So wasn't a surprise to see echoes in 2022 IRA. Studies show greenhouse gas methane is bad at Appalachia's old coal mine regions. Places unemployment is high like coal country, arguably special attention should be given jobs in minerals, cleanup. Legislation before IRA considered incentives for US solar & semiconductor manufacturing, a proposed LIFT America Act for battery-making incentives, support US critical supply chains. Still given how far ahead China is already and how fast Europe is moving too, it's questionable if US can move fast enough in producing needed minerals, rare earths, batteries and EVs without a huge push. IRA is just a start. But sadly, US is still dependent near-term on importing strategic materials. Oft means buying from ambitious and many times goals-conflicted, far dirtier China. And late 2023, Sen. Manchin announced he wasn't seeking re-election.

Subsidies too for fossils are unlikely to change-soon. Those were even written into the 2022 IRA, plus new subsidies for nuclear, sequestration too. And oil & gas can write-off expenses, intangible drilling costs, benefits in lost royalties deep-water drilling. There's Master Limited Partnerships for fossils. While G20 has advocated eliminating ALL dirty energy subsidies and their removal could cut CO_2 emissions by 0.5 to 2.0 gigatons, like removing to 2030 all annual emissions from Japan, that's unlikely soon. One initial Covid relief bill initially even had $8 billion in tax breaks for 77 fossil firms. And more $$ was given to fossils following outbreak of war in Spring 2022 in order to hasten gas exports. Cutting those fossil subsidies is sure to be stridently resisted, and that's always been a non-starter in both the House & Senate.

Still oil & gas have a fight ahead, as coal can attest. In 2021 the International Energy Agency (IEA) predicted that to be climate neutral by 2050, means No new coal mines; no new oil & gas fields; un-sequestered coal is cut -90%; oil cut -75%; gas use cut -55%. IEA is funded partly by OPEC nations, yet it had predicted per capita fossil earnings there may fall from $1,800 in 2021, to less by mid-2030s - if fossils are slashed as suggested. No surprise that several of its donor oil-heavy nations had called the IEA's 2021 findings "fantasy" – not realistic.

Yet the IEA has criticized too the rich nations for cumulative emissions. For its puny Pledges nowhere close to what's needed for a 2 degrees goal. Calls them out, stating rightly "fewer than a quarter of announced net zero pledges are fixed in domestic legislation, and few are yet underpinned by specific measures or policies to deliver them in full or in time." And it notes vague pledges by corporations are combined often with very distant target dates.

IEA says annual low-carbon investments must rise 2x+, to $2 Tn/year, then to $4 trillion/year from 2025. It expects in <30 years, 2/3rds power comes from renewables. It sees in 10 years, EVs going from 5% to 60% of vehicles on road (China's vehicles boom mainly electric). Planes run on biofuels, ships ammonia – much *green hydrogen* H_2, ammonia NH_3, methanol CH_3OH, LOHC, biofuel. Carbon pricing worldwide with China to be effective. Subsidies are ended for fossils including in US. Green hydrogen for achieving high-grade heat needed in industry.

Change is afoot. In 2020 an oil Index crashed -70% *down* when oil fell. It rebounded strongly 2021/2022/2023. A few words about that oil index. Quite unlike ECO/NEX/H2X/WNX, that oil Index instead is based on a commodity - rather than on equities. 'Worse', it was based on the front-end oil futures, price in turn influenced by tracker that can't take possession of oil. It was constrained by known rules, subject to pricing attack. So, when nearest front-month contracts 'broke' into contango in 2020, near tank tops, limited storage tanks, that oil index went down very fast - unlike further out 12 months Oil Futures. It's been amply shown there's a floor beneath which oil prices cannot easily fall – unlike either solar or wind power.

We'll discuss this ahead, but a point is, the oil price crash in 2020 *was a crisis* for it. Until oil rebounded in 2021, with its production restored. By contrast, the green themes solar/wind - can & do move very differently. Clean energy's future, thankfully differs too. Key drivers differ for green energy. For instance on consolidation, 2020, 1 US solar maker sold operations & management arm to another O&M. An integrated solar name split in 2; vertical-integration had been seen as positive: before it both made panels, and installed & serviced them too. Split by spin, newly specialized, parent refocused downstream selling PV/storage in North America. That's a big market, thin margins: storage allows it a premium branding here. It's also more in-country work that can't be outsourced, nor done so much overseas by cheap commodity competitors elsewhere. While there was briefly, solar inflation in 2021, 2022, some 2023, longer-term, that solar PV should once again see *declining* prices.

Shines a light on downstream margins & consolidation. Post-spin that parent *may* see better valuations in heated space. A separate merger 2020 had brought 2 US solar installers together as 1 behemoth. Post-2022 the latter *may* see robust valuations, more comparable to seen in another standalone solar name less dependent on Net Present Value, NPV. As all seek lower-cost access to needed capital, unclogging of PV supply chains, lowering inflation.

Upstream at spinoff premium PV maker in 2021, it had China patent protection, pricing power (2-4 cents/Watt commercial, ~4-8 c/W residential). But margin pressures were unrelenting; it soon shipped cells rather than panels – just to shave transport costs. Commoditization across PV upstream ('just get good lowest cost PV') pricing was down ~80%, 2012-20. Module capacity rose, then too was hit. Downstream, efficient premium, back contact panels may help hurdle razor thin margins. In 2021 module prices were near $0.20/watt on price inflation, those spikes *may* subside. It'll be interesting to see how performances of 2 solar 'cousins' unfolds. In 2022 their mutual exclusivity had softened, one premium solar product with shingles too – other separately focused on PV sales & installs. 2023 such commoditized yet special solar was hit hard: maybe it should be valued at 10-14x adjusted EBITDA in context of 10-15% revenue growth, and EBITDA growth about 1.5x that. On this metric, valuation down hard.

A roller-coaster recent past, exhausting, thrilling, stock drops remarkable; little seen like it. ECO Reports grew to over 100+ pages. Overshadowing much was pandemic first great lockdown. Many markets cratered – may do so again. Oil imploded like not seen in 100 years, then bounced back. Attention to climate and clean energy solutions that briefly was derailed by pandemic – had first resurged some, then was eclipsed by war, weather extremes, fears of recession, debt. New action from Europe/US to get past dependence on Russian fossil gas.

Moving on, let's first briefly consider that until a few years ago, ECO's picture past few-years in-the-mid 2010s, was oft *down*. Breaking that end of 2019, ECO (alone) left a long spell of negative past few years. By end of 2020, this became a striking divergence: clean alone then up some +300% as green jumped. While fossil themes were down -30% to -70%. Then in 2022, dirty (nat. gas) shot up, clean was down hard. Late 2023 saw drops in gas (down near -50%) – and clean down moderately. At any rate past few years captures only a small sliver of time. Corrections happen, trees don't grow to the sky. And after once monolithic early 2010s when all of 'All energy was going far down, fast', clean changed all this in 2020 - by a lot. Clean was up 6-fold seen from its bottom to the top 1st in the year or so at start of 2020s. Then, clean next plunged as we've noted from Feb. 2021 at 270 – down to 40s in early 2024. And frequently major traditional energy source, natural gas – a competitor to clean ECO theme - was far down in 2023. Clean ECO/ Global NEX themes 'beat' this fossil fuel considerably.

Next, is a 10 years chart rolling. For a decade prior, the past 10 years was oft a relative ‘dog’ - our apologies to all dogs. What’s changed? In a charting sense 2019/2020 was far up – then 2021-2024 far down. There’s been steep declines at times, so including any of the big falls bends performance downwards. Yes clean energy at times can relatively outperform vs. dirty – or will also fall hard! Still any plunge warrants attention. Thus here is a rolling chart for past 10 years June 2014 - to end of June 2024. In change of view, instead of ‘just’ natural gas for energy comparison – here too with ECO/NEX trackers is oil, and added excellent, passive, solar-only theme. Notably, gas & oil can be barely seen, so far down at very bottom.

Interestingly, for past 10 years now that excellent passive **solar-only theme (in gold)**: is 2nd from top, lingering high bit it finishes here down by ‘only’ -10%. It sits just below the **NEX at -4% (light blue)** so nearly tied. So beating all the global NEX is doing far, far better than fossil fuels oil or natural gas. 3rd ‘highest’ but yet well down by -42% is ECO that fell considerably. Thus passive ECO after for years ahead just post-2019/2020, has fallen to come in negative. Still, these three being all energy themes, have each relatively Trounced the fossil fuels!

Much harder to see here being very far down, underwater rather absurdly bad past 10 years - are oil in **purple** – and natural gas in brown. They’re very Far Down by around -74% for Oil, & by -95% for natural gas! Of course oil had jumped some in 2021-2024 which had helped it. But, put in context of the past 10 years, it did not much make up for arduous, prolonged declines the fossils had suffered for a decade! So this period below does leave behind a Great Recession that had thunderously dropped all 2008-2012. That had put in some bottoms in many tech stories; much there in non-energy went up afterwards. But not so energy, which got hit harder, stayed down longer. Especially (the most dirty) energy themes fell badly:

Rolling Past 10 Years, June 2014 - to end of June 2024:

Source:Yahoofinance.com

Notably, clean energy had done ‘best’ back in 2019/2020, as Clean themes were then, briefly, especially strong – versus fossils. Versus all major Indexes too. That was a tale of 2 cities, Past 10 Years showed often Big Declines in Dirty energy – vs Clean Up by varying degrees. Since then of course, 2021-2024’s reversal in clean – was in context of some gains in oil & gas - as clean plummeted. Yet as time rolls on, good or tough times *may* tell a new story. How a theme is defined is especially cogent. Seen next is how a theme like NEX captures global clean energy is key. How a theme’s defined is no backroom matter; it’s consequential.

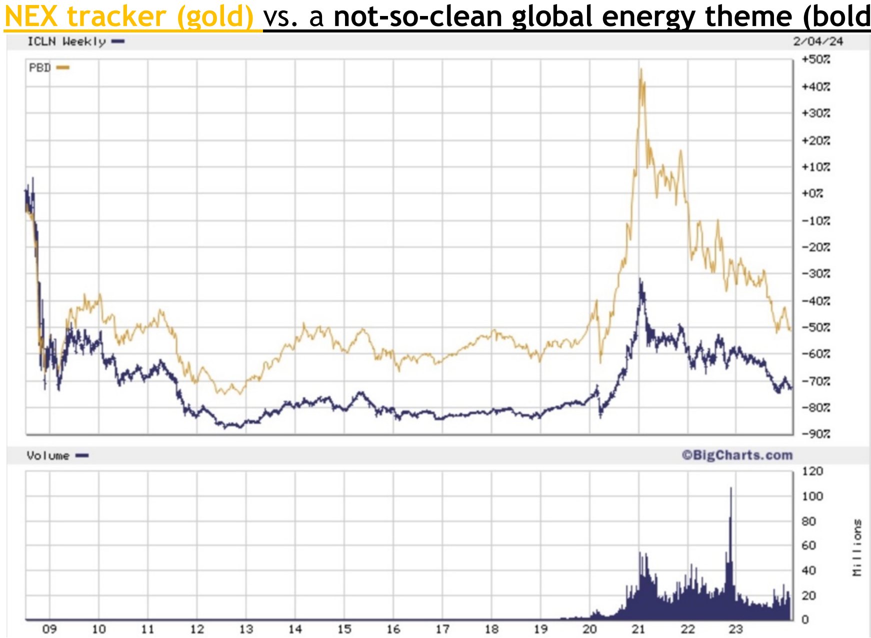
Global Clean purer-play NEX – vs. a competing Not-so-Clean theme's Mega-Caps:

Consider next many big differences between Global NEX with trackers in the US & Europe – vs. a differing, competing, global 'just-cleanish' energy Index also with US & Europe trackers. That other, global Index has several characteristics that have set it well apart from NEX. One, long was that this other Index was maybe a fine choice, if wanted a very 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, skewed, and not-as-clean - it differed very much from NEX that's instead clean and purer-play in diverse solar, wind, EVs, energy storage, hydrogen, decarbonization etc. There's also several more contrasts too.

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

Yet consider too that their most key divergence has been: Performance. Briefer periods, NEX vs. other Index trade leadership back & forth a bit. Shorter-horizons, one Index may lag other in sizable ways. Briefer time frames, often a wash, no clear leader. For example, in 2022 that other 'not so clean' theme out-performed. Then in 2023, NEX out-performed beating that other 'not-so-clean' Index. But longer periods, a key fact very clearly stands out: the **Global NEX (via tracker here in gold)** very strongly Outperformed that **other Index** that's also for a global clean energy theme **(seen via tracker at bottom in bold).** This persists for lengthy periods, whether since their trackers' inception (seen here), or past 15 years etc. This chart captures both Indexes via live trackers, for all data more than 15+ years, from start of other Index (went live after the NEX) tracker in 2008 - to early 2024. Interesting to see how divergent performances are for 2 Indexes/tracker funds. *In sum the **global NEX (here in gold)** clearly has had far 'better' (though both end down in this period) performance:*

NEX tracker (gold) vs. a **not-so-clean global energy theme (bold):** 2008 – to early 2024:



Source: Bigcharts.com

As seen above, clean NEX Outperformed though both down, by doing some 20% better. NEX may go up very strongly rising periods; even as NEX drops hard too in downturns. Why may that be? 5 factors may help to explain why other theme has been well far behind the leader **NEX** for global clean energy. Perhaps it's because that other non-NEX basket was, or is:

* Heavily Restricted to not-so-clean bigger-caps – so to far fewer themes & stocks;
* Heavily concentrated too in its top 10, as it was 30 names total (more after 2021);
* Heavily skewed by having to use modified-market capitalization style and weightings;
* Unable to hold so many stories – eg missed storage, EVs, alt. fuel, H2, storage, grid etc;
* Less Diversified across stories and nations – with also relatively dirtier themes represented.

Nothing wrong with that other theme *per se. For example that other Index did much better in down years like 2021 and 2022.* 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 in early 2021, the NEX had 125 components. That other global basket instead & for years since its inception, long had only 30 components to 2021. Just 30 didn't allow real clean energy scope at all. So, wasn't possible for it to capture the 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 make up near half of its total Index weight!! In truth global clean energy reflects far more than just 10 names, of course. Yet concentrating that way meant biggest few, might push up fast if momentum narrowly did well – or might pull that down. Shorter periods, say past 1 or 5 years - these 2 Indexes can trade leadership back & forth – but longer periods, NEX has done significantly better. Equal weighted NEX, eg early 2021 had much greater 125 names so far wider reach. And helpfully equal weighting lets more & smaller names be heard: each has a voice. With No Overweighted Top 10. Given such a huge performance gap, long periods, it seems equal weighting may allow this passive NEX (& tracker) to better capture more - especially small & mid cap inherently clean purer plays. *Please note though: <u>neither approach is 'right': they're simply 2 differing methodologies</u>.* 2 varied ways for global clean stories to be captured. The other concentrated, only 'cleanish' style allows less-clean names, is biased towards mega caps – while NEX is notably purer, cleaner, more equal, and wider-ranging.

As a practical matter, that other Index's tracker has helpful, notably low expense ratio - though at times swamped by performance difference. And heavy-trading gives liquidity. Overall then 2 takes on a fast-growing theme. Equal weight NEX truer to clean theme - vs. a cap weighted less-clean other skewed to Top Ten & brown Utilities. Quite useful real world having 2 such differing benchmarks for an-emerging global story. But: that other Index also faced vexed issues given how was designed/built. One arguably was excess concentration. Its tracker too faced real liquidity risks, given that design. As big, growing sums flowed in, a few concentrated names in a tracker there might be overwhelmed even in '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 rebalance given the regular or above average trading $ values, or ADTV.

After it did 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 big 52 more – and 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 story is growing ahead. Such could allow too for that other Index to better reflect an evolving story over time.

However, problematic, the other then could & did add *Non-Pure-plays - outside clean energy*. That can mean less closely adhering to *clean* energy theme, instead only a 'somewhat' 'cleanish' energy theme, simply less pure. So that was a difference from 2021, vs. consistently purer NEX - that other Index which previously might have some fossil fuels, natural gas, nuclear, changed after 2021, such that it could become bigger yet perhaps even browner.

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

We recall years ago when 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 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 thinned out, or were diluted out of target concept – not pure. A ramification of fast-rising popularity of 'small caps' was it got harder to hold any equities less than big as inflows grew in active Funds – or passive Indexes. Consider now then green thinking today. Green 'words' are seeing tremendous interest. There's an upswing of activity. In 'net creations' especially for ETFs in decarbonizing themes. One result may be as investors open their Prospectus to see their Holdings, what's in funds, they're very surprised by what's inside! Confounding, many so-called 'ESG' funds hold oil, gas companies! Perhaps even names steeped-in-coal!!. That failure clearly should & must be fixed. Greater truth, and understanding of green aims arguably ought to prohibit any dirty inclusions.

Arguably, priority should be staying true to clean/green. Not be pushed out to brown energy. Otherwise, prior focus on good targets (like robust zero/low-carbon) might drift off-theme. How in the world, can oil & gas be included in a true green (or less-green 'ESG') basket?!! Or, make a claim to be 'ESG'??? They can't. But an unfortunate way is via a 'carbon-intensity' metric. It allows a big fossil producer, say on revenues of 70% oil & 30% natural gas – to massively ramp its gas to be say 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 – higher $$ profits misleading to greenwashing claims. Nothing of the sort is actually true, of course. But 'carbon-intensity' schemes can lend false numeracy, a seeming quantitative rigor, when opposite is true. Left side of equation is correct: carbon footprint Is measurable tons of CO_2 Scope 1, 2, 3. But right side of equation, 'intensity' grafts 'value', as revenues in Dollars, Renminbi, Euros. *Air cares not a whit 'how profitably' each CO_2 molecule was made* – if on more *revenues* - or less! But sadly, the (ahem, intended) upshot has been that dirty fossils and companies get a free pass.

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What ‘carbon intensity’ wickedly does, is lend fossil fuels a fig leaf. Sounds quantitative, yet lets polluting firms claim ‘green’ say going from oil – to gas. Sadly clever marketing, it enables fossil firms entry into ‘kind of clean’ (really brown) baskets – ‘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; won’t score well ‘carbon intensity’ with few sales. By contrast, a fossil oil huge cap massively growing brown gas sales for gobs of revenue, 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 true clean Index performs, return to Weighting Methodologies. Interestingly, we see that the equal-weighted NEX has far outperformed since its inception – vs. a market cap weighted Index. For equal-weighting’s benefits, consider a Chart below:

Much better real-world results are obtained by the Equal-weighted NEX - vs a Market-cap weighted Index over long periods. As was observed by *The Economist* at right in 2021, a model portfolio constructed Green Index seen right when straight Equal-Weighted, very nicely doubled, it went up swiftly from 100 to over 200 in 2020; thus went up over +100% … But a Market cap weighted version instead went up much less, from 100 to about 160, ‘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 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: 1) it’s dismaying to see big oil & gas names - in any ‘ESG’ fund. Especially 2) in global clean energy Indexes or funds. Beyond this, Europe SFDR/BMR aims to help rectify that. And for NEX/H2X/WNX, a floor $1m average daily trading value (ADTV)/$750k continuing components, looks at ESG/severe risk ratings, ***and*** carbon. In sum NEX/ECO & new H2X/WNX all much greener, avoid that ‘greenwashing’ pitfall.

Of minor note is that a sharp thematic volatility seen here isn't necessarily due to *Global* aspects. Consider say *global* NEX - vs *US-listings only* ECO. These 2 have industry's longest track records (16+ years, 14+ years) - so put aside for a moment that separate, other global Index. Glancing just at NEX/ECO, a few thoughts come to mind. One, is the US-listings-only ECO basket *can* be hugely volatile too. Seen head-to-head, day to day eg first 6 weeks of 2021, the NEX tracker saw a sizable 14 days with 3% or more change/day to March 15. Yet the US-listings-only ECO tracker, saw even more: fully 24 days with sizable 3%+ change/day.

So, *global* itself may not necessarily = volatility. But technology & innovation, may somewhat. There's risks in solar, wind, EVs, H_2 & fuel cells, as is 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). So, was long over-dependent on Russia. Post-2022 it may seek green H_2 on security, on climate concerns too. Says nothing of how these equities may perform (maybe *down* like in 2021, or up like 2020). Just reflects a very risky theme that's volatile, always uncertain. Whether domestic US listings - or listings worldwide in clean/new energy innovation.

Of interest re: this volatility is in 2021, International Renewable Energy Agency wrote that (not $100 Tn, nor $120 Tn - but) a startling $131 *Trillion* might be needed in clean energy by 2050 to avoid heating >1.5 degrees C. Now far more than a $100 Trillion suggested. Gas use had spiked up in Europe 2022 on horrific war; yet gas use *may* peak mid or latter years this decade. In its place, electrolyzer capacity for green hydrogen *may* go from puny 0.3 GW 2020 – to 5,000 GW. With an H_2 feedstock 'green ammonia' - or methanol/CH_3OH (but not if from fossils; that's greenwashing). Europe potentially *may* latter 2020s become a green H_2 leader. And China may ramp nuclear – while only reducing coal use by a bit (if at all) before 2025.

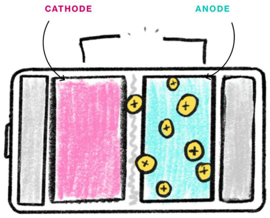
So great uncertainties abound, giving rise to volatility, tremendous risk. Myriad sub-themes *may* see advances: some incremental, some may be non-incremental, perhaps disruptive. Advanced green energy storage & batteries plainly merit focus 2020s, areas ECO & NEX have had exposure to since 2004. New attention also for Hydrogen Economy, and Wind Energy. And China continues to be a major presence across all these themes in the 2020s.

Energy storage is a big deal, the world needs far better, cheaper, and much more batteries. A fine piece in Bloomberg Businessweek was useful and 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 may have constellation of materials besides lithium. Such as Iron, Nickel, Manganese. And there's much effort at using little to no cobalt. While different chemistries favor varied characteristics, all batteries basically consist of a *Cathode, *Anode, *Separator, *Electrolyte. The anode was largely settled as graphite, maybe silicon – maybe say, nickel niobate (NiNb2O6). But that too changing too in a shift by some away from any nickel; maybe towards say pure lithium anodes ahead also replacing graphite.

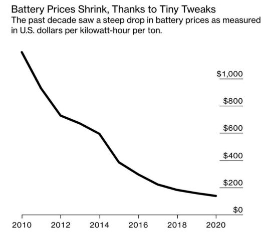
A few key chemistries dominate at Cathode. Particular traits/materials selected for strengths favored: batteries are in fact named for the materials at cathode. Traits balanced might be: cost, energy density, weight, calendar longevity, cycle life, fast charging ability, temperature range etc. Favoring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

a) 4 basic battery parts:



Source: Bloomberg Businessweek

Battery prices are falling hard:

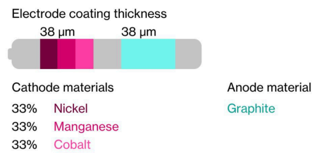


Source: Bloomberg Businessweek

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

Source: Bloomberg Businessweek

NMC Composition back in 2012:

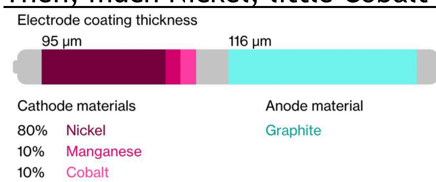


Source: Bloomberg Businessweek

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:

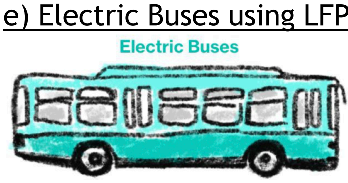
Source: Bloomberg Businessweek

NCA, light strong battery, no manganese:

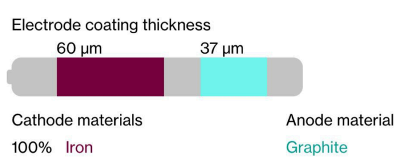
Source: Bloomberg Businessweek

Popular was NCA, or NCM with 8:1:1 ratio of Nickel, Cobalt, Manganese. So, a 'lithium' battery might be mostly nickel by weight. Better, LFP's cheap iron & phosphate eliminates vexed cobalt, costly nickel. So LFP is gaining and more profitable. Especially in low-cost uses. Heavy LFP's iron once hadn't the same performance as NCA, but it's safer & LFP's improving fast. (We'd had an early electric bike here 2001, LFP chemistry). LFP is in buses as its lesser range and big weight are non-issues; cheap, it may have gone <$100kWh(!) already in 2021 in China. In price-conscious ever-faster EVs, it can be charged more fully to 100% and with less fire risk. Consider 2022 pricing: war meant 80 pounds of nickel in NCA electric car battery more than doubled adding $1,750 in costs. Concerns over Russian nickel, short squeeze sent its price from $10,000/ton to $30,000/ton – then briefly to $100,000/ton(!). Hence the look 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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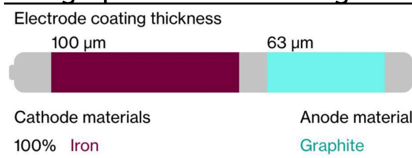
f) Modern LFP, a bit less-energy dense:

Source: Bloomberg Businessweek

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



Source: Bloomberg Businessweek

Efforts are ongoing for all: better cathodes/anodes/electrolytes in cell phones, ebikes, EVs etc 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 let it improve profit margins sizably – over spiffy/costlier NCA (nickel, cobalt aluminum) performance cells. A huge LFP supplier in China (where else?) is seeing new LFP competition, which gives 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 the anode, without swelling, may show promise. Farther ahead exciting metallic lithium batteries could be – should be - very impressive. Here fire risk was untenable 2022 since 'dendrites' can penetrate electrolyte. But new-generation solid-state batteries may be tantalizing. The drumbeat of wistful ever-on horizon solid-state batteries hopes in past so-elusive, *may* be getting closer. Possibilities of non-incremental advances towards solid-state batteries later this decade may make one hopeful.

Recent research has shown a self-healing hierarchy of instabilities, *may* fortify separator at cathode/anode, ensuring no puncture. Liquid electrolytes replaced by a solid-state core for ultra-high current densities. With a fire-safe boundary, energy/power density might improve significantly, shortening charging times dramatically. A lithium metal anode paired with an $LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$ cathode showed 82% capacity retention @ 10,000 cycles! Not long ago, a standard was 80% capacity @500 cycles, at which point a Li-ion battery was dead for EV purposes. Thus, early EVs once strove for a 200-mile range, 500 charge/discharge cycle limits: 200 miles range added up to acceptably a 100,000 miles electric car battery. Afterwards the pack might then have 2nd life uses like stationary storage with <80% remaining acceptable. Should instead 10,000 cycles or obviously well short of that happen in solid-state batteries, *possibly* near production this decade, it may be like going from vacuum tubes (we recall building radios with these in '70s) – to far superior solid-state transistors. Or leaping to wondrous modern computer chips. Solid-state *might* be game-changing. Or not happen.

Near term it makes some sense to shift from nickel - to iron in batteries. Making batteries from iron so abundant, cheap, easy to use is a good strategy. Unlike nickel, iron is non-toxic and benign. Consider iron the most abundant metal. Not on Earth in pure elemental state, in a sense iron is also a bit like H_2 (an energy carrier so reactive, latter is found eg in water, hydrocarbons, carbohydrates etc). Pure element iron is only found newly arrived from outside our planet, like in meteorites. Once on Earth iron rapidly corrodes: it rusts on exposure to moist oxygen/air. It's the 4th most common element in Earth's crust and likely our planet's core is mostly iron. Being abundant on Earth and in our solar system, one would hope to find use for it in batteries. So ubiquitous & benign it's been adopted by life and adapted to over millions of years. Iron unsurprisingly, is now essential to life. It's grown vital for instance in plants – for making their chlorophyll they need to survive. Animals depend on iron too like for carrying oxygen via hemoglobin in bloodstreams, that makes blood red.

Iron is so basic to our planet's backstory, its likely that life was fated to use it abundantly. A star like our Sun burns by fusion. Starts with lightest element, hydrogen – then fuses to 2nd lightest helium, releasing both light/heat. Over billions of years fusing, stars create helium atoms, then in turn fusing 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 (gives life in turn, after death). On reaching terminal iron core, no further energy can be released by fusion – for it takes energy. More energy would be required than released, so it may go supernova. That resulting explosion spews immense amounts of iron, oxygen, carbon atoms etc into space. If and when gravity later coalesces those elements as 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, the molten core gives a magnetic shield protecting life from intense solar radiation that otherwise kills. Miners already are starting to look at making '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 the US) leading.

So much is possible. One interesting idea may be iron-air batteries to discharge 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 a 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 to resist degrading. Or a zinc anode. If we reverse engineer, Design for X with benign, abundant, low-cost, eco-friendlier materials most prioritized, that helps win a storage game especially in big ramp up.

Expect battery technology advances. Fundamentally differing from a greenwash that only dresses up carbon in spiffier-sounding names. Beware of a greenwashing perpetuating dirty. Please be aware too some phrases mislead just a bit. As noted a lower 'carbon intensity' isn't actually same as lower actual CO_2 - but instead, based on a rather duplicitous profitability. Or, say a strongly-scoring E Pillar 'ESG' number - doesn't correlate necessarily with low-CO_2. Or 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 the responsibility of buyers. Or 'carbon credits', or 'offsets' gaming true emissions reductions. For example 2000 to 2008, 12.4 million offsets were created by 3 dirty projects growing dirty oil extraction(!) – then sold as supposed carbon offsets (that process thankfully no longer can creates credits – but those ugly offsets are still traded). Often artful dodging like 'net zero', 'sequestration' or 'offsets' coupled with distant promises of 2050 - divert from true goals: real decarbonization now.

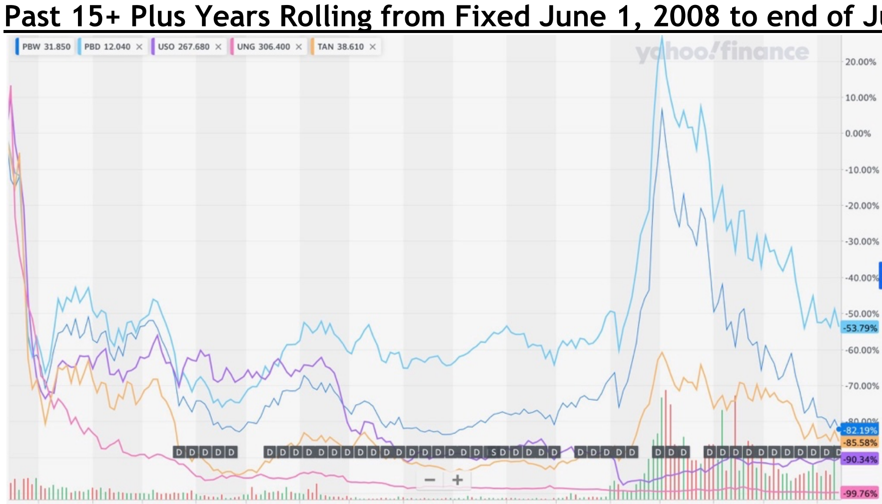
Lest that disappoint, gaslighting, greenwash and dissembling oft last gasp of waning industry. Fossil interests can/do see writing on the walls. Solar & Wind vs fossil fuels – like driving EVs vs gassers - arguably is superior technology already at start – and gets only better from here! Green has 'won' in one sense. Next decade+ is an important but granular filling in of blanks. Mid-term, incumbent natural gas competes with batteries + storage ahead, especially on gas' 2022 price spikes, modern war. Longer-term, riskier, just maybe: perhaps green H_2 *might* viably heat buildings and industry. Yet as always, they're all very risky in baskets capturing evolving themes. And on climate, are much too late. From here in an early in innovative-rich 2020s, future uncertain - let's briefly look back at a past 15 years+ of Indexing here since a fixed 2008, with 2009 drops too in a brief elucidation on time frames and Charts.

First a point re: Charts. An issue with r**olling** Charts past 5, 10 years etc, is they *may* show very different returns in future for ECO, NEX, H2X, WNX. As charts leave big falls 2008-2012 and tough energy times too 2021-2024, big drops removed, ECO/NEX/H2X/WNX *may* show big relative gains. For that reason, a view is needed too with great ECO declines like 2008/09, 2021-24 etc preserved. Hence this Chart below. From a fixed, not rolling 2008, looks onwards. 15+ years & growing, this *non-rolling* chart will always show times of very Big declines. A period fossils lag behind green too. But relative to a rolling 10 years, one vibrant difference is global green plummets 2008/09 and 2021-2024 etc are highlighted, forever preserved.

Farther back, we'd note an ECO predecessor, original Wilder-hill Hydrogen and Fuel Cells Index was informally run 1999-2007 and world's first – was calculated in-house, posted Online with Commentary. Original worldwide. It differed from work we later did on formal live Hydrogen Economy index (H2X) since 2022. Given ECO's chart below starts from 2008, we've uniquely been capturing hydrogen & fuel cells for 25+ years, since 1999! For H_2 & FCs one can visit our 25+ year-old 'predecessor site' at Hydrogen Fuel Institute, http://h2fuelcells.org

Note at start, that *Everything* below in this Chart is well Down, Negative, all underwater! Starting from bottom, fossil oil & gas are Farthest Down, hard to see, -90% and -99%(!). 'Above' them/ so down but less so is an excellent solar-only theme here off -85%. 'Above' that yet still well down, up steeply at times yet with big falls 2021-2024 is ECO at -82%. Clearly 'highest'/or least down energy here is global NEX though down -53%. Broad major Indexes all did *far*, *far* 'better' – though they differ sizably since energy is but only a sliver there. Generally speaking, volatile ECO/NEX/H2X/WNX at times may really rise in climbing markets; yet clearly, they also can and do *plummet hard* in declining markets – down like a rock!:

<u>Past 15+ Plus Years Rolling from Fixed June 1, 2008 to end of June 2024:</u>



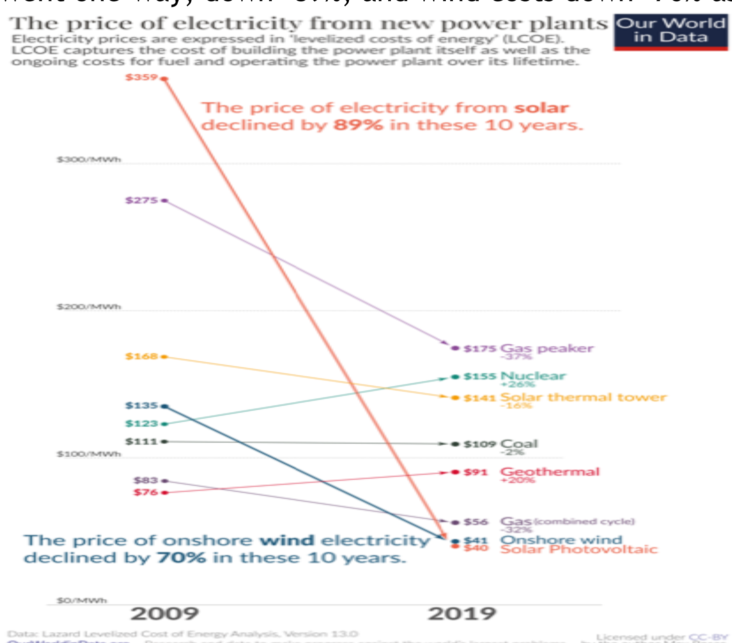
Source: yahoofinance.com

So that's looking backwards, to decade/s in the past, as clean energy was just born. A flip side of US having then had near-zero-green power in say 2008 - is despite growth since - where we stood on renewables absolute terms in 2020s is still *Awful*. Offshore wind 'should' already be in hundreds of GWs, instead of it being near-non-existent. US had had a puny total of 7 offshore wind turbines in 2021; Europe had 5,400! Solar 2021 made but 3%, and wind 8% of US electricity. Solar/wind *Could* Have already Met All US electricity demand. Instead, electrified cars, trucks, ships, planes were just a tiny rounding error 2020s. It may 'feel' like we've come a long way – *but it's due to how dismally we'd begun.* Yet not for much longer.

In a political sphere, with green themes past 15+ years so down, we offer a mere observation. Looking back, it's counter-intuitive perhaps, yet clean energy stocks and so ECO jumped in Bush II & Trump, though neither loved green energy. Inversely, ECO fell hard in Obama & Biden who'd favored it. At times conservatives held smallish House majority, liberals Senate, for mainly mixed leadership (rarely one Party holding all 3 branches). Meanwhile in all energy more broadly, oil producers had once oft hiked output to keep a lid on those prices - but after sparse profits in a past decade, they're keen to keep oil supplies tight, prices higher.

Or seen ahead longer term, PV may wallop dirty energy on costs; former's price plummeted 89% in 10 years to 2020 as solar, wind & storage costs all dropped hard. Coal/oil by contrast, grew relatively-costlier: they pay for fuel. Gas fell hard as noted, but too has a floor. Fossils are bound to be costly to operate given their fuel costs - plus must pollute and are powerless to reduce those follies by much. Unsustainably, they'd created 87% of global emissions of CO_2. Estimates are their air pollution alone caused 3.6 million deaths every year. That's 6-fold more than all annual war deaths, terrorist attacks, and murders combined!!

Coal's the most harmful energy source. In 2020, it generated 37% of electricity and most CO_2. Natural gas 2nd worse, 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 cost had dropped sizably in a fracking era going down to very low costs mid-2010s – shooting up 2021 in a gas shortfall (outside US). Still such changes there are dwarfed by renewables; solar costs went one-way, down -89%, and wind costs down -70% as seen here from 2009 to 2019:



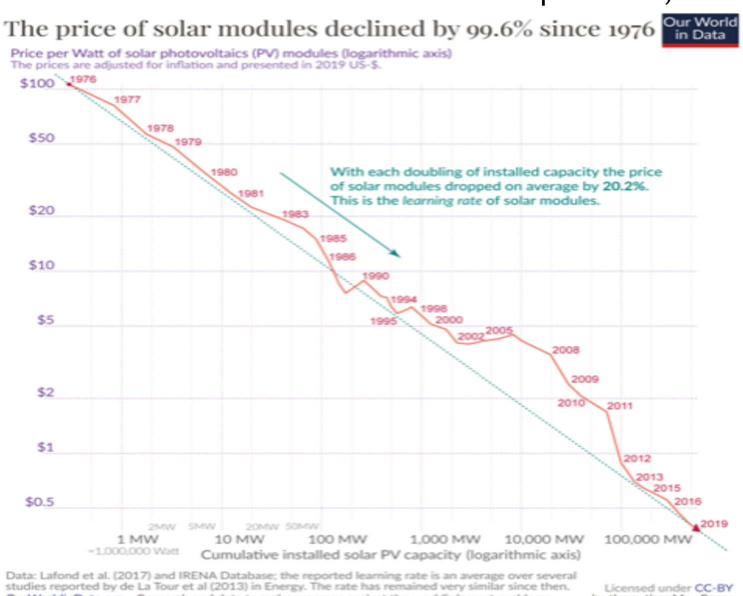
Source: Roser, Why Did Renewables Become So Cheap So Fast? Our World in Data (Dec. 2020).

Thus fossils & nuclear are poorly-situated 2020s as long-term ways to make electricity ahead. They're vexed by eg *Fuel costs, *Wastes (and nukes must store for centuries!), and *High Operating Costs with hundreds+ of employees for costs that won't decline. And of course, CO_2. Even for less-GHGs nuclear, each new non-standard US nuclear plant costs yet *more* to build on risky 2022 technology – exact opposite of cheaper solar/wind/batteries. What they had going for them was a firm, dispatchability, but renewables will 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, when gas spiked, Natural gas has spiked far higher in Europe (and Asia). Coal did too as carbon trading meant significant new costs. A downside also was China backed off ambitions when it too faced an energy crunch in 2021,

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 & nuke, can they hope to reduce costs significantly until extant plants age-out. Compare like for like, and new solar/ and wind simply are much more affordable on levelized costs/LCOE – than is dirty.

That OWID Report found 1 early super-pricey, solar cost-point: in 1956 solar cost $1,865/per watt(!). So just one 300-watt solar panel today, if installed theoretically on a rooftop, could have cost $500,000+ at that rate! Of course, unaffordable back then. Applied nonetheless, in say 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 all grew far better at cramming lots of performance in ever more cheaply. It's a virtuous circle which goes like this, Ever Greater Deployments = Prices Falling More = Newly Competitive, fresh markets open up = so the Demand increases 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 fell enormously -99.6% since 1976(!) on technology. In 2022 US tariffs on PV made in China were temporarily stopped so it enters US freely, cheaper still. Fossils – by contrast - are Not all about technology; they may be doomed the long-term even apart from carbon. Costs declines in wind too are impossible for dirty to catch. How can coal, oil, or even gas hope to keep up for decades with this lovely curve? They can't if economics is the metric. But fossils have inertia, influence, capital, lobbying are deploying it all. No doubt they will Not go gently into that good night. Natural gas & nukes have notable roles yet in this 2020s decadal energy transition. In sum, it's no wonder solar & wind power make up most power plants built today – along with growing storage. Plus, here in green basket/s, storage is crucial. How an Index is constructed, where it aims, as we'll next address – is very significant.

Very meaningful are initial choices made by & for an Index. They shape it, that vision in turn impacts its later performance mightily. Passive baskets are informed by/at theme's creation. Let's look at a well-known 'FTSE 100'. Based in the UK, often called '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 the most widely used short-handed measures for how well Britain's stock market and firms domiciled there, are doing.

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

This (not so great) return was 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 hit 8,000, in Feb 2023. But a stronger growth rate was seen 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 an inflation that then was at +4.7%.

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

What can account for such lugubrious showing by FTSE 100? One is that its big components at start included BP, so was 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 - to 2021. Hence, it's not been BP per se, but rather, maybe was just partly a bit about oil & gas in that regard.

As a market cap weighted Index, it *could* auto-adjust for awful returns in CO_2 heavy oil. As its once-biggest firms declined, lost prominence, then that could have let faster-growing smaller firms to instead take leadership positions. But a problem 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 in 2021, but had been 12), retail, tobacco. Not in innovation or technology. Therefore, it's not been similar to S&P500 (that recently added its 1st EV maker). And surely 'olde' FTSE is not at all similar to an innovation-heavy US Index like say a popular Nasdaq 100.

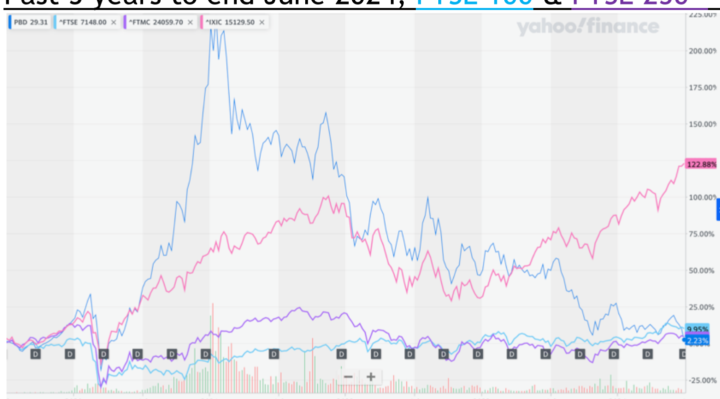
What's was in FTSE 100 in 2021? Royal Dutch Shell was near its top. Of 277 past components in FTSE 100, many were retail, like Boots (health beauty retail), old energy like BOC now part of Linde. Banks, once UK giants in FTSE, have faded. British American Tobacco and Imperial both tobacco – do not enjoy thank goodness any great prospects like tech/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, the 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 their clean energy gains of 2019/2020, the huge volatility in NEX and ECO Indexes also meant they fell below FTSE by mid-2024.

As pointed out, a part of the FTSE 100's issue is 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. A more innovation-heavy Nasdaq 100, Nasdaq Composite - or S&P500 are different. As seen in MoneyWeek, an S&P had 19 technology stocks in 2005 – when FTSE 100 had but 1. In 2020, more tech names did join a FTSE 100. Still, by contrast, US Indexes reflect considerably more in tech. A middle caps & smaller caps FTSE 250 did enjoy some momentum 2021 vs. FTSE 100 – but that FTSE version lost even it.

In this chart below, 2 bottom performers most of a past 5 years to end of June 2024 - were FTSE 100 in light blue ending +10% up – and mid-cap FTSE 250 in purple at about +5% in these 5 years. Above those two most of the time, is **ECO tracker in blue** – which after spiking up 200%, then however crashes and ends just below the 2 FTSE variants at about +2%. What difference in Volatility! Ending at top is tech-rich NASDAQ in pink finishing well up, +122%. To be sure tech themes are always very risky: at times they'll drop very hard. More Conservative themes, may well = less risk. Some periods clean energy tech may outperform – and others clearly is awful. So much so, one must be wary of a bubble – and recall that the NEX, and ECO like also risky volatile H2X & WNX - can and will at times surely 'drop like a rock':

Past 5 years to end June 2024; FTSE 100 & FTSE 250 - vs. (Most volatile) ECO, **NASDAQ**:



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. Some factors may be additive, like emphasis on small cap/ innovation recent years – or, conservative themes may do better down years. In FTSE 100, big older energy firms in 2021 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; 10% of Europe. In the US, tech was 28%, plus healthcare was 14% of S&P500; in a European-wide Index (ex-UK) they were still 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 removed coal, men's suits from its basket for consumer price index, put in (Covid!) antibacterial wipes, and sport bras. In sum, an Index's rules, construction, & goals, definitions vitally shape a theme. They matter hugely. Next let's look at a few possibilities for clean energy ahead in a world fast changing.

Early 2020s, Changes – and perhaps possibilities ahead:

US energy Bills proposed early 2020s were just a start: there'll be much more legislation debated this decade. What happens next years *may be* historic for clean energy. *Just possibly* impactful for decades. Consider our future: young voters rightly demand a more sustainable, equitable, zero-carbon future, than us 'oldies' contemplated. Though most bills shall fail, some can pass: it's clear that youth worldwide are demanding a greener future.

A glimpse of what may be sought later in this decade ahead is seen in a 500 page Select House Committee on Climate Crisis Report from Summer 2020 that is still relevant today, https://climatecrisis.house.gov/sites/climatecrisis.house.gov/files/Climate%20Crisis%20Action%20Plan.pdf It's is worth a look for voluminous changes contemplated. Not near all will be tried, or accomplished – but some will. Work shall unfold over years; with most aggressive aims dashed on rocks of reality. Yet any steps begun this decade, towards real decarbonization, would be a big change.

Plan was no small beer; far more ambitious & aggressive than ever contemplated before. With ever-changes in Oval Office, House, Senate, this decade **may** unfold like nothing before. "Transformative" is a big word - yet it *could* be, along with ambitious Europe, China. Yet bear in mind if expectations get too ahead of reality – say fossil interests frame each energy crisis, each price spike, as a fault of renewables - expectations may shatter. Great change requires much support, legislation, and US Senate home to compromise, inertia, realpolitik.

Consider as well, how little was done for US clean energy say, 2020/2021. In summer 2020, federal pandemic aid for fossil fuel-heavy sectors had reached $68 billion: much of that went to prop up airlines. By contrast $27 billion went to only slightly green-related areas, all outside of clean energy. Conservatives fought directly against wind, solar power, EV spending.

Direct fossil interests got $3 billion in forgivable small business loans, back in 2020. By contrast little specific help went to clean energy. Impossible to know if we're in calm before another pandemic wave. Still, solar businesses in 2021 had re-gained momentum. Utility scale PV grew some 43% in 2020, to 19 GW. Many big installers re-reached their pre-Covid expected levels. Early 2021, US residential solar installations grew 25%-30% for 2021 YoY.

Likewise, 1H 2020, new offshore wind globally did especially well - despite onslaught of Covid. In fact first 6 months of that year were the then best yet recorded for offshore wind! First part of 2020 more investments went to new offshore wind, $35 billion, than in all 2019. This had tripled the world figure 1H 2019. Major offshore wind array decisions in 2020 had included to green light 1.5 GW Vattenfall project off The Netherlands, then largest to date at $3.9 billion; a 1.1 GW SSE Seagreen offshore farm in UK for $3.8 billion; a 600 MW Changfang Xidao project offshore Taiwan at $3.6 billion; and some 17 installations being financed by China such as the 600 MW Guandong Yudean that was expected to cost $1.8 billion.

2 big drivers were huge declines then in wind costs – mind you, before inflation started latter 2021 - plus looming subsidy cliffs. Unlike solar similar to semiconductors cramming ever more capacity in chips, wind is more about advances like in heavy fabrication, bigger blade designs. From 2012 to early 2021 levelized offshore wind costs had dropped 67%. Onshore-wind rubs up against limited space, while oceans are immense, windy places for massive turbines far from view. Big wind farms provide good returns on capital too. Renewable investments rose even in a covid-addled 1st half 2020 to $132 billion, vs 1H 2019 at $125 billion. Wind power both onshore and offshore - was already growing strongly in diverse places worldwide.

Despite Covid-19, 3 nations in 2020 saw big renewables investments partly thanks to offshore wind. China, rose by some +40% over 2019; France tripled; The Netherlands in 1H 2020 had grown by 2 and a half fold - vs 1H in the prior year. Let's take a closer look at one particular aim for offshore wind development in 2021 that stood out. This was oil giant BP's winning bid of £924 million for the option to develop 2 offshore wind sites off North West England and Wales. Their winning Bid placed in 2021, perhaps said several things.

One maybe, was BP with big money was a bit late to the party. Their bid with German partner Energie Baden-Wuerttemberg was well outside norms for bids in wind. It meant they'd pay the British Crown Estate near £231 million per year over 5 years, for each of 2 sites end of which they'll only then decide whether to proceed. It was £150,000 per megawatt/per year. Compare that with £93,000 MW/year paid by a differing winning bid for Crown-ocean property by Cobra Instalaciones y Servicios alongside its British homegrown offshore venture partner, Flotation Energy. It surpassed too £83,000 MW/year by joint Total & Macquarie to another site. And it was way more than £89,000 MW/year & £76,000 MW/year in 2 bids made in 2021, won by big German company RWE for big wind farms at Dogger Bank.

It hammered home that BP, bit late to offshore wind in 2021, was paying a price. In a sense its hand was forced: it has promised to go carbon neutral by 2050. But there's a cost to coming in late. Its shareholders had earned high-returns from older oil production. So, BP maybe felt some considerable pressure to earn something like those rich 8%-10% prior returns.

Problem was, BP paying so much at start makes it harder to reap high returns later. Arguably 10% returns are a very tough target, anytime, especially aiming for low-risk. Too, oil & gas had earlier showed poor returns years prior to 2021. US behemoths like ExxonMobil had been hit considerably. Even with 2021's gains, past times were hard to match. A 23-year-old oil rig roughneck once earned $100K+ working part-time: that bubble may be largely gone. Hard to think of a job matching what fossils paid, let workers stay same place their whole lives. Today in green energy, a worker in wind, years of experience, training may make a salary around $80Ks/year. Geothermal with drilling, in $80Ks. Solar with some years of experience, $70Ks. But unionization rates have dipped everywhere including in fossil production. In work like pipefitters, unionization rates are relatively higher, come with sizably better Wages/Benefits. Hence fossils have been hard for most anything else to beat.

Wind farms, once built, can offer investors a stable return attractive to capital. Still, it's a province of business venture where fortune has favored the bold. Best returns in new energy innovation, likely enjoyed by first-mover risk-takers. Otherwise, lumbering fossil fuel giants like a BP or other supermajors following others' prior leads, may instead experience lower returns nearer say 5%-7% - rather than perhaps a hoped-for nearly risk-free 8-10%.

In sum a number of serious bidders lost out to BP. Shell for instance offered nowhere as much. Yet in offshore wind, Europe's supermajors: BP, TotalEnergies, Shell may at last be starting to genuinely transform towards 'energy companies' (not mere greenwash) That puts them well ahead of US supermajors – who have instead made clear they do *Not* wish to venture into renewables. For contrast, take Orsted, of Denmark. It has divested out of its old oil & gas - to focus on true green energy. And a leader like Orsted, or even slow-changing BP, Shell, or TotalEnergies of Europe – all contrast sharply with America's Big Oil. US oil may cling to 'sequestrating carbon', to blue H_2 marketing ideas – soldiering on in fossil-centered business models. All those probably non-starters, as was reflected in market caps early 2020s.

Raymond James 2020 data on renewable clean tech investing at big cap oil & gas firms showed that of 7 Big Oil firms committing to net-zero emissions for 2040 to 2050 - fully 6 were based in Europe. Of these top 7 all from Big Oil, those earlier data showed name/country (estimated % of capital expenditures on clean energy figures) in 2020 were: Repsol from Spain (at 26%), TotalEnergies, of France (15%), Equinor of Norway (13%), Eni of Italy (10%), Royal Dutch Shell of Netherlands (7%), BP of United Kingdom (4%), and Occidental of USA (2% to 3%).

A 4% cap ex spend at BP for renewables & clean tech might not be terribly inspiring. However an ExxonMobil in US, the spend was much less, then under 1%; same for Chevron. And big Oil hadn't made net-zero pledges until 2018. By 2021, pace quickened a bit as partnerships, acquisitions, activity by Big Oil in Europe showed biofuels, biomass, wind, solar, H_2 leading. Plus, as one may expect, talk of 'carbon utilization' & of 'sequestration' grew. Shareholder actions will likely see some increasing success at prioritizing climate action.

Following huge 2020's oil supply cuts & return of demand, prices rebounded; oil leapt 2021 & 2022. But look back further; Big Oil stocks valuations mostly had Declined in a prior, past 5 years. That's of note. Perhaps the longer fossil behemoths defy change, the more they **may* head long-term to 'Not-So-Huge'caps'. The firms most wedded to highest-CO_2 may, possibly (Ahem, no polite way to say this) move towards Irrelevance later this century. Like coal or steam before them. And Yet. Q3 2023 shares in wind-giant Orsted plummeted 25% one-day on supply-chain + other issues. Yet take for instance a window of 5 years to Q3 2023. On big Oil's Gains 2021 & 2022, even after rising, **BP, in gold -** Big Oil was then down -13%. In contrast was **Orsted, blue, up just +4% -** but better (it once was in oil & gas, but sold all that & now is in clean renewable offshore wind). Up in this prior period was a tracker for decarbonizing in our **global new energy innovation Index (NEX) light blue**, then up – though later fell:

Source: GoogleFinance

Denmark's Orsted is rather a posterchild for a past oil & gas firm, fully transitioning to clean new energy – successfully so. Growing more profitable to boot! No half steps, nor dithering in 'sequestration' to prolong fossils. Orsted, robustly, launched into wind, solar, bioenergy. Benefits since shown in its market capitalization - as for example PB trailed. Results are underscored in Scope 1, 2, 3 rankings for emissions. Scope 1 is direct emissions by a company's own operations. Scope 2 is indirect, say by power suppliers; these can be reduced even if a firm goes on selling fossil products. Big Oil could stay in its dirty fossil lane while reducing its Scope 1 & 2. But, Scope 3 refers to their customers' carbon footprint using their product. Hence only a green transition (like Orsted) to sustainable energy will satisfy this measure. Even if Big Oil is determined to stay in dirty energy with facile CO_2 accounting. Or by claiming 'offsets', an oil company may pretend that its rock gas is 'clean' or 'green'. Making dubious marketing claims – yet its true Scope 3 nonetheless will grow ever-tougher.

Big Oil Europe moved into offshore wind, ahead of US Oil. Europe's BP, Shell, TotalEnergies, arguably were right to do so: wind is clean/green, unlike oil & gas. Big oil has cash, experience, engineering know how – like Equinor Norway for US wind. What's needed too, besides wind and potentially in big oil's wheelhouse, is magnitudes more energy Storage. Much more Geothermal. Big oil could help like via pumped air in existing caverns (not CO_2 sequestration!). Weights for gravity storage mounted on old rigs - although physics dictates gravity storage can provide only puny energy/power – far less than does hydro. More potential, is in Geothermal. Maybe lithium-rich hot brine for cleaner power & 'lower-carbon lithium'. Maybe ultra-deep new drilling to produce geothermal power – done anyplace on earth!

UK's lessons learned can assist US, like in undersea cables. Facilitate off-taking power, as US badly trails UK. In 2021, UK had just 10 GW offshore wind – yet was a world-leader. Then UK aimed in 2022 to more than quadruple offshore wind this decade – a good start; yet could do more. The US 2021, pathetically, had near-zero offshore wind power. Though a vast country with windy lengthy shorelines. Just one Vestas 15 MW turbine – those began operations in Europe in 2023 – could each power 20,000 European households. China's launching 18 MW turbines, each 1 able to power 40,000 homes: think 1,000 of them plus green ammonia for storage; these can power 40 million homes, fueling new energy transport.

Data from Bloomberg New Energy Finance (BNEF, our long-time prior NEX partner) & US NREL in 2021 showed how badly America lagged Europe & China in offshore wind. All can use big turbines – GE's Haliade 12 MWs, Siemens 14 MWs, Vestas 15 MWs, 18 MW China CSSE turbines developed in 2023 - yet a key Wind US obstacle has been: Permitting. (Like in Grid, Solar etc). All America 2022 had but 2 tiny, not even-commercial-sized offshore wind farms, 1 a 30 MW site so like say 2 big turbines! That figure ought to be huge; is growing a bit – but the first commercial-scale US offshore wind only opened in 2024, a modest 132 MW, so still much too slowly. Breaking down US wind Pipeline, there's 1st a Project Planning stage (developer or Agency initiates site control), then Site Control (lease/contract), Permits (plan+offtake agreement), Approval (regulatory OK), Financial Close (sponsor investment), last Construction (build), Operations. Doesn't include myriad lawsuits along the way. Nor political opposition. Sparse infrastructure to offtake power all halting offshore wind, in mid-2020s before it begins. Perhaps little wonder then wind power's been so absurdly absent from US shores to 2024.

Now changing like a 'pig in a python' are projects bulging near start. Projects in site control, or offtake had increased +200% from a small base in 2018 – to 2021. In 2021 some 28 GW of various US projects were early development stages. Installed US wind was a joke at 30 MW, 12 MW approved – as 0.1% of 28 GW planned in 2021. 6 GW more US offshore wind were advancing to permit offtake or 22%. 60% of 28 GW pipeline or 17 GW, was in lease/site control steps. A tiny bit of progress finally starting in US, with projects also canceled in 2023.

US states farthest along in 2021 in Site Control/Permitting had been: Massachusetts' 8 GW to come; New Jersey, 4 GW perhaps; New York 3 GW; N. Carolina 3 GW; Virginia 2 GW. Only one State had offshore wind in construction 2021, Virginia's 12 MW energized. Overall, was a US 'progressing' but too slowly, though 2020s ramped. Confoundingly all but 2 of 11 US States in wind back in 2021 were East Coast. Despite great Pacific Ocean wind resources! One might've guessed there'd already be tens of gigawatts off US West Coast - yet California & Hawaii in 2021 had only potential sites. A mere 1 GW in planning – needing submerged cabling. US Gulf Texas was not-desirable on low wind speeds except in devastating hurricanes!), little required offtake. That said, BNEF raised estimated US offshore wind projections by +70% from an 11 GW by 2030 as estimated in 2018 – to 19 GW estimated by 2030, in 2019. Growing since.

Big changes may lay ahead in offshore wind, relevant to Index themes, WNX, ECO, NEX, H2X in US - and world. For scope of potential changes, consider how puny all offshore wind was recently. Then, imagine what *may* come later this decade – escalating fast by 2030 and just after. Until 2019, global cumulative offshore wind capacity had only reached 27 GW. And that was still mostly concentrated then in just a few places: UK, Germany, China, Denmark, Belgium, Netherlands. Moreover, just 5 nations had in 2019 accounted for 99% of offshore installations. A fast-growing China then was beginning its offshore wind boom; it soon would swiftly add nearly half (47%) of all its new global capacity in just one year, 2019.

A decade prior, steadily growing UK had built most all installed offshore wind: 8 GW. Germany started later, grew faster. But China, more recently, saw sharpest ramp. Lately, there's been a spurt of growth worldwide. If one lumps together China with Europe & US as one, then the world's pipeline for all estimated offshore wind 1990 to 2038, *could* go from just 27 GWs operating 2020 – to a 230 GWs projected in 2038. China especially, going from just 10 GWs of wind in construction in 2019, to clearly leading the globe on offshore wind late 2020s.

More granular, it gets interesting from 2024, as when the US may become a big player in new *floating* offshore wind. With its immense tracts of available space. Offshore wind fixed to seabed has 'mainly' (barely!!) been on America's East Coast; its geological trailing edge margin keeps waters shallow there. But floating opens up US West Coast waters thousands of feet deep: a new ballgame. Thus floating platforms tethered to deep seafloor can be a game-changer. The US may actually start to hold its own, a significant change vs. Europe - vs. Asia. In this new arena, each one: Asia – US - & Europe - may come to be about 1/3rd of floating pipeline. A 25 MW test Float Atlantic in Europe went operational in 2020 and proved potential. Early days yet. And Asian leadership floating wind isn't just in China only, nor just Japan. It may include South Korea (1.7 GWs), with Taiwan (1 GW) in pipeline. Also, UK, France, and Spain have proposed much for Europe, each has had operating floating test units.

A startling change may be America's 2.3 GW *proposed* pipeline. Castle Wind off California at 1 GW may float 900 meters' depth. 7 proposed US projects may use steel semi-submersible platforms, easiest of 3 main types of floating substructures. On shallow draft they might be built dockside, towed out without heavy lift install vessels. That design has made up 89% of substructures where a choice was made. And note for fixed wind towers on the seabed, with huge 12-16 MW wind turbines, the number of vessels able to install nacelle mass >500 tons hub height >100 meters & rotor diameter 200 meters(!) is vanishingly small. So highly specialized vessels (WTIVs) for installing offshore wind must be built, for monopiles on seafloor, jackup depths over 50 meters. New US vessels too given America's Jones Act. Port infrastructure must be built from scratch, as well, to grow both fixed & floating wind.

Most crucial in wind, is pricing. Like solar, it fell in 2020, wind more modestly so, than solar – but down nonetheless (unlike 2022/2023). Renewables growing favorable too, vs. costlier current technology-nuclear, or coal, oil & gas. Once enough energy storage enters the scene, older energy though firm can't compete with similar price decline trends of their own.

In Europe, levelized offshore wind had already fallen by 2021, from 18 cents/kWh to near 9 cents. US offshore wind was 9 cents 2020; Mayflower Wind off Massachusetts one of world's better-priced ocean wind projects was 6.9 cents. And US tax changes could make it better. Floating wind may possibly fall farther, ahead, post big inflation spike of 2021/2022.

Once *offshore wind* gets a better US toe-hold in 2020s, regulations in place, *floating* wind can have far greater presence. America's 1st floating ocean wind project only began in 2020. Meanwhile China's wind, and solar is fast advancing; China confounded expectations of a slow solar 2020 from Covid. Instead, China's PV making *gained* speed in pandemic. First half 2020, China produced 59 GW of solar panels, which was about 15% greater than in 1H of 2019. Nations there with **more* renewables in 2020 – had enjoyed *cheaper* electricity prices – obliterating a 'higher cost' argument oft leveled against green electricity. Critics may ding renewables as 'suffering' from intermittency. Yet Europe saw stable electricity supply in 2020 - unlike power interruptions seen in California & Texas. And a crunch in 2021 in Europe/UK – was mainly due, once again, to burning *fossil fuels,* especially to its natural gas issues.

Back in 2020, a pre-war EU-27 had made 40% of electricity from wind, solar, hydro, bioenergy. Fossil fuels then 34%. Plus, notable standouts Austria made 93% mainly from its renewable hydropower. Portugal made 67% from its renewables, Germany 54%. In Denmark in 2020, wind & solar made 64% of its electricity; Ireland 49%. Germany 42%. In absolute terms, Germany in 2020 continued building its growing fleet of renewables - with moves away from coal. Its wholesale electricity prices then (pre-war) went *down* near just 3 cents per kilowatt/hour (kWh). By contrast in neighboring coal-dependent Poland, wholesale electricity costs using dirty coal were higher - nearer 5 cents kWh. That was all Before horrible war.

Wind & solar are growing - from making just 13% EU electricity in 2016, to 22% in 2020. Yet more renewables, more ability to export excess green power, new transmission, batteries, all needed! Post-2022, immense moves away from Russian gas has put everything on the table. The US has been making less progress. Renewables met just 18% of US electricity demand in 2019, fossils were 62%. Recall again how European nations with *more* renewables, often see *lower* *Wholesale* electricity costs, rewarding green. EU chooses to add energy Taxes, not to frack, rendering retail power costs higher than in US – but that's a differing matter.

One surprise in 2020 was the US extended 26% ITC tax credit by 2 years for solar & fuel cells; PTC $0.15/kWh for wind. Yet hoped for 'in lieu' cash from Treasury didn't then materialize. Batteries alone again couldn't get credits unless bundled with solar. Nor was a $7,500 credit re-extended for 2 big EV makers. But, things since 2020 have changed fast. With the newer IRA of 2022, Production Tax Credit (PTC) first established for wind that offers tax credits per kWh generated and once went 10 years – and an Investment Tax Credit (ITC) for solar that offers projects tax credit based on percentage of eligible equipment costs – were both greatly extended. Far more so, than any short term extensions seen in 2020. With that 2022 IRA, for projects put into service after 2025 credits instead remain until the later of 2032, or until US electricity sector carbon dioxide emissions are equal to or below 25% of 2022 levels. Wow!! Because a threshold that CO_2 emissions must fall <25% 2022 levels, won't be reached until well after 2032, maybe in the 2040s, a net effect is that the new Tax Credits can last decades – and provide not $ billions – but $ Trillions for renewables! Incentivizes new names in wind, solar, plus storage too. Likely to lead to many new start-ups. Long ways from just a very few, small solar listings possible for ECO and NEX as we well recall, back in 2006.

Facts reveal an energy landscape changing so fast, it challenges all we 'know' about energy. Clean energy now can begin to better fossils on price. Compellingly, soon *beat on no subsidies* – growing more affordable than fossils & thus current-gen nuclear. Economics is changing everything. And yet. In 2023 there was strong inflation that hammered growth, maybe ahead stagflation. Not our Grandparent's energy world - or maybe, it's one simply different!

For years, coal's price had hovered near level – yet renewables & natural gas got far cheaper. Thus, did renewables (& natural gas too) become leaders. Especially 2020 pre-war, on demand loss as Utilities turned 1st to their lowest-cost sources, renewables, and natural gas. Coal was left out. Gas is big, capable, flexible. Fracking had pushed gas costs down to <$2 per million BTUs – but later in 2021, it went to $6+. In 2022 on war, $8+! But still, fossils lack prospects for sustainable growth ahead – especially vs. ever-cheaper, decarbonizing themes today.

So possibly, green thinking *may* flower. In some cases, like never before. Consider say electric vehicles. Here Carnot's Limit helps explain why electric cars were destined to outdo traditional, oily 'gassers'. Today's best gassers are inefficient, sadly archaic at very best. Their diesel or gasoline heat engines in such cars/trucks only let them reach silly theoretical bests near 40% efficiency. Typical car heat engines sadly 20% efficient(!). Gigantic heavy SUVs anchored down by non-torquey gasoline heat engines, are relegated to stay so slow, that they may suffer from oft silly model differentiation like on the number of cupholders.

Unsurprisingly, early 2020s is seeing an outpouring of fresh-faced electric vehicles globally. Equity markets all 2010s under-appreciated what lithium-ion batteries - lashed to efficient (>90%) torquey AC motors, can do. Next, improving better, cheaper batteries, after 20+ years of non-linear enhancements. As a consequence, there's often much volatility (down/up too) - with strong *non*-correlation as between EV equity pure plays - vs. the broader markets.

Or consider, big thermal power plants today. Again what Mr. Carnot observed back in 1800s. Today's sad, natural gas turbine plants oft only reach efficiencies in 40s%. 'Cutting-edge' combined cycle gas power plants bump up against theoretical efficiencies in 60s%. How silly! How ineffective, what plainly dottery old way to achieve electric power generation!

As we'd learned 100 years ago from Mr. Einstein, later in quantum science, flat to increasing entropy (disorder) gives us Time – a second law of thermodynamics – and Time moves one direction (centered on basic C, velocity of light). What's notable is time's arrow here, given entropy means that what we've learned in past, 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 panels better over 50+ years. Researching wavelengths, new solar panels might enjoy maximum efficiency ceilings higher still, vs. silly heat engines. And since fuel (sunlight) is free, doesn't 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 costs per watt. Unlike fossil fuels, there's now a learning curve here. Profoundly it pushes ever-downwards on solar costs, often very rapidly.

It goes deeper. For centuries, Newtonian Physics had well enough explained 99.99% of a world around us. We'd built entire industries, societies, made fortunes based around it. Nothing in our human-made world could approach C, velocity of light. So approximations of how the real world actually worked served us well enough – yet it was actually really quite wrong.

In a metaphor, fossils served us for centuries. We 'learned' within their limits, constraints we still accept today. Yet much we came to 'know' about energy, was wrong. For instance, we've long known from them that electricity generation – must closely match demand. Given great power plant costs, to thus avoid waste. We'd never build generation 'way too/overly big'.

Beyond Newtonian physics, what was once ‘known’ – can mislead. Semiconductors at nano-size have quantum strangeness at scales space/time differ from past Newtonian suppositions; we make use of that. Weirdly different quantum actions, once bizarre, better explains reality. Understanding that weirdness, technology usefully harnesses say, how quantum entanglement might allow charging EV batteries far faster in future. Physics essential to cell phones, GPS, Lasers, MRI Imaging, LEDs; to ubiquitous Computers on quantum effects not-known in prior centuries. Ahead may lay speedier computing on quantum kernel algorithms. Revolutionary ideas: a superposition in 2+ states. Einstein-Podoleky-Rosen paradox of 2 entangled particles, linked in real-time appear to share information inconceivably faster than light (entanglement & Copenhagen interpretation is a thorny quantum puzzle)! Physicists Aspect, Clauser & Zeilinger won a 2022 Nobel for closing John Bell’s alternate loopholes, eliminating variables – thus to Einstein’s chagrin, quantum theory more seemingly complete. We’ve progressed as we learn. Einstein built upon – really not so much Newton – as on James Clerk Maxwell for electromagnetic waves, a Constant C/speed of light. So space not true vacuum, and virtual particles can briefly snap into & out. Photons may act in 4 possible ways, 2 may be observed, and 2 options just cancel each other out. Wonderful Richard Feynman’s Rules of probability very weirdly, profoundly deterministic. All fresh new tools, derived from the truth.

A point being that in new clean energy, too, we learn innovations that at first seem so strange. Fresh energy ideas may be embraced – given *it is how the world actually works.* A few sacred old ideas, maybe thrown out as progress! Jarring yes, but leverage for how we advance – including new energy innovation. Especially as we move (one hopes) faster towards true zero emissions, for zero CO_2 – truly no methane/GHGs, for softer, natural energy paths.

Lashing newer batteries to AC motors for electric cars, is but one recent example. So too ahead, novel thinking on solar: oversizing renewables may actually save money – thanks to advanced storage! May feel weirdly brain-spinning, to oversize solar farms. Yet there’s room for it: just 0.3 per cent of world’s land, 450,000 sq km of 150 million sq km could power the globe on solar. Not far from land used by coal, oil & gas infrastructure; dirty energies use 126,000 sq km. Just 100 miles by 100 miles could power the US. If solar grows super-low cost, ‘over-sizing’ solar may compensate for storage. Oversizing solar – as fuel’s free – may mean No penalty like in over-sizing a nuke, coal or gas plant. Moreover, solar may in time be shared widely by grid, or green H_2. Ever over-size a nuclear plant? ‘Fuggetabouddit’!! That nuke is then so costly, inflexible, vexed by wastes needed to be stored for centuries/millennia, that is a cul-de-sac of an idea. Makes no sense at all with current ‘old’ 2nd generation nukes.

Intriguingly it’s clear solar/wind *will* get very-cheap. And as electricity must be used right as generated – we avoided oversizing, costly ‘curtailment’; yet wasted ‘extra’ wind power cost UK consumers GBP 806 million (USD 1Bn, EUR 942m) in 2020/21; 82% of it ‘excess’ wind in Scotland. In 2022 curtailment in Spain jumped to 715 GWh, from 67 GWh year before, costing 1.1 billion Euros. But long-duration storage, or green H_2 may avoid overcapacity on sunny/windy days. Preventing brown electrons with downsides. If clean abundant renewable electricity is already at very low-cost, then H_2 & fuel cells (‘fool sells’) once so staggeringly foolish only a few years ago, *might* just begin to make sense.

Leaving academic musings, let’s return to applied capital markets & needed decarbonizing. Where even solar with its many green credentials, like much else new, suffers from unneeded, very undesirable, emotionally-trying applied setbacks. We’ll address one sadly, emotionally-fraught troubling notion next, that’s both wholly unnecessary and shocking of late. This is a possibility of acutely-unwanted, not needed, maybe forced labor in a unique region.

A solar issue lately come to light is allegations of forced labor in Xinjiang Uyghur Autonomous Region, northwestern China. Xinjiang does much silicon manufacturing: polysilicon (poly) is in solar PV made worldwide. And poly prices had plummeted for years to cheap commodity; 3/4s of 2021 global PV polysilicon was from China. Of that, over ½ in 2020 was from Xinjiang. In 2021 there was not clear evidence of forced labor in silicon manufacturing. But allegations are grave, must be looked at very seriously; lately there's been a US legislative response.

Several companies were listed in a 2021 report as having Xinjiang-regional content. A couple used poly widely, in US and global products – seen in many active/passive funds. One in 2021, was in some 135 mutual funds; another 165 mutual funds. Again, no doubt, mere possibility warrants serious attention. What's tough is there'd been then no independent confirmation. Solar companies all strongly denied any connection. And there's surely No need for any forced labor, anywhere. In response a US Solar Energy Industries Assn. sought 2021/2022 to ensure no forced labor in any part of solar chain. Strong protocols ensuring Zero forced labor.

Nonetheless 1 firm was downgraded 2021 to a Neutral rating on possibility. Again no evidence, but without clarity, US and others can & did act, given 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 factories & across supply chain. While the US did not at first call out specific Xinjiang manufacturers, possibly-abusive labor rightly was raising warning flags. Just a possibility of such labor has got to be of great concern. By 2022 GWs of solar PV were withheld from release at US border; several named firms were then being 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 a UFLPA (Uyghur Forced Labor Prevention Act) – but with a long lead time to prove Absence of forced labor. Allowing say traceability protocols, or moving to source materials all outside Uyghur region. In a less-thorny transparency matter, the US 2022 named companies non-compliant with a 2020 Holding Foreign Companies Accountable Act (HFCCA); they could face US delisting from 2024 – 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 in 2022 for on the ground inspections & investigations on whether mainland China/Hong Kong firms provide requested, timely, unredacted documentation to PCAOB via its CSRC. Discussions aimed for China/US Agreement in 2023 to resolve this topic and avert delistings in 2024, https://crsreports.congress.gov/product/pdf/IF/IF12212

In conclusion, a burden is on Xinjiang-based materials: solar, wind, quartz, textiles 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 positive 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 – in 2022, GWs of solar PV were kept from entering US on UFLPA. Europe is looking into this as well. Separately China Auditors are 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-*coal-use* in manufacturing, decarbonization in upstream manufacturing everywhere. Green circular manufacturing has begun of late, as seen for instance in the Nordics.

We avoid politics ourselves. So just a side-note is zero hope had existed in 2020 for a US green energy stimulus. 180 lawmakers did then ask House Leaders for relief when 600,000 clean energy jobs were lost in pandemic. But a calculus then for US green funding – even if far short of what was vetted in Europe – wasn't aligned 2020. Senate leadership was opposed. Plus, it was a non-starter idea then-in-a-2020 White House to boot. But that, was then.

Musing on dynamics from 2022 and IRA, backdrops change. Much stays incremental. Yet big new $ Trillions *may* be invested globally, this decade, on new climate solutions. Infrastructure improvements growing green. In a US utility-scale solar for example might grow by over >100 GW/year. US battery storage, could grow by >50 GW/year, in time approaching today's total installed all electric generating capacity. In the US that long had been such a laggard.

This decade of the 2020s, new attention is being paid to greening Europe. Stolid economies, once-long (overly) dependent on foreign (Russian) gas imports, fast re-assessed. 2 things seem certain short-term. One, is as Europe moves away from Russian natural gas, it will see repeat energy crises this decade – *but not due to a fault of renewables*. UK for example, had earlier shuttered much of its gas storage capacity. Little's left. With less natural gas supply to Europe – and UK in 2022, that engendered higher gas prices on little storage. This meant in turn gas-fired heating, and power generation including for cooling can at times get very costly.

Spikes in costs of gas – on little storage, is far more an issue about gas – than it is about renewables. And such crises would have happened anyway, had solar/wind never existed. Yet renewables will be blamed – rather than vagaries of gas markets. Gas draw-down – with little energy storage – risks price spikes and populist backlash if all energy prices spike. Yet, around the world, people are also on a steep energy learning curve. Past mis-directions like in Texas where blame was first put on wind, *when natural gas* froze – in time face the truth. Still on China's voracious demand for coal, oil & gas, and Europe's early moves away from fossils - whilst energy prices are high - means energy crunches & crises are certain ahead.

Also certainly, new Opportunities. The Nordics for example may turn their own cheap wind & hydro baseload power into green manufacturing. UK can ramp wind power exports. Morocco, Tunisia, Namibia its solar. Iceland its geothermal. Spain & Portugal export solar across EU. Ukraine might even try to modify pipelines to export diluted green H_2 – within brown CH_4. New undersea cables, could allow green-made power to be exported to grids far afield.

Just maybe, a flowering of green growth. A US carbon tax arguably is one simple direct way to get there, though politics continue to get in the way. Countless energy crises, obstacles lay ahead. So too, do opportunities. Think of low hanging fruit. Cheaper batteries are one hardy perennial – lodestone to improving intermittent renewables & EVs. Battery capacity may improve going from <300 Wh/kg to >500 Wh/kg. "Made in USA" can = good jobs. Solar manufacturing on climate risk alone needs to go >100s+ GW/yr. Scary new climate scenarios, along with power crises – all call for *Terawatts* more clean batteries and storage.

Next 15 years, a laggard US *may* pivot towards a carbon free grid, saving money to boot. In a drastic change, yet it's now feasible! We'll look at freshening US possibilities next. It *may* become a transformational 15 years, even more for Europe and Asia. But let's start with the US here to envision possibilities to 2035. New ideas lately show renewables can truly become dominant. Something far, far beyond what was just a few years ago thought possible.

First, where had a US power grid stood recently? And what will it then take for zero carbon? Have a look at 2019 data from US Energy Information Administration. Electricity generation 2019 accounted for much (though far from all) US CO_2 emissions. Power generation made 4,000 terawatt/hours of electricity: much power, 38% came from natural gas plants; 23% was from coal fired plants; 19% nuclear; 7% wind, 7% hydropower. Only roughly 2% of US power as recent as 2019 was coming from solar power(!), and 2% from miscellaneous other sources.

When US coal power waned in Covid-19, gas & renewables became cheapest power – so some CO_2 drop resulted at first from simply shuttering the most highly polluting coal plants in US (and Europe). But it produced only an awkward, short, unintended blip of reductions. And renewed energy demand in 2021/ 2022 ensured that carbon would NOT be dropping. Instead it implied what huge slog is ahead to get to a zero-CO_2 American grid. That said on pure economics of it all, to start now/early 2020s & to go hard will actually be the most profitable path. Current-gen nuclear can't offer much help; unlike solar & wind getting cheaper & better – US nuclear instead has only gone up in cost. And it's impossible without enormous subsidies like a Price Anderson Act that limits nuclear's vast liability. Nuclear plants once had cost 'just' ~$7 billion each. Now a ridiculously-costly plant in Georgia was $25 billion+! Inflexibility once touted as an asset, instead has been flipped to become an issue vs. renewables.

Getting US to zero CO_2 means eliminating in 15 or so years all 668 coal plants, most of 6,080 gas-fired plants. Fast-ramping solar 15% faceplate capacity, and wind – just 9% of US energy in 2019 as they're non-firm, intermittent, nada from wind on windless days, no solar at night.

We'd started in 2020 with just US 104 gigawatts of wind power. 36 gigawatts solar. Then, about 12 GW of new wind, another 16 GW solar was built 2021. At that recent growth rate, 50% faceplate capacities, we wouldn't get the US to 100% use of renewables until 2070.

That's far, far too late on CO_2. So instead consider tripling 2021's growth in renewables. Back of napkin we'd need to replace 791 gigawatts of fossil generation, to be 100% clean by 2035. For a rough $ cost estimate, 1,500 MW (1.5 GW) of wind power built in Oklahoma 2019, had cost around $2 billion; March 2022 a private-held global firm turned on 531 its turbines there. Extrapolating that, means a figure of $1 Trillion really starts to sizably replace US fossil power – or really over 2x that to account for intermittency (resolved too by new storage).

Happily, renewables are getting much cheaper – so actual costs will likely be less. Renewables also enjoy free fuel, so as coming pages show – this actually leads in time to Americans paying *less* for their power in 2035 – than they did in 2021! From there, savings snowball. Factor in reduced hospitalizations, greater health - and it gets only better!

It's been assumed by opponents this all requires unwanted top-down *diktat* from government. But fast solar/wind growth in Texas – vs. slower rates in heavy-regulated California - suggests opening markets to competition can spur renewables. It's estimated US solar and wind can naturally get to 55% by 2035 just based on their better price alone. Add wonkier mechanisms like tech-neutral 'clean tax cuts' – 'Clean Asset Bonds & Loans', or a US carbon tax - and doubtless it gets us nearer with not much help needed. Yet the pace is what's key.

Because this seems (and does) fly in face of what we've 'known' in energy last half-century - that 'intermittency is a problem' vs firm power, that 'solar/wind are also much too costly' – we'll take some pages ahead to outline a plausible US scenario for next 15 years.

1st let's assume climate science is correct. We must then act far faster to cut CO_2 emissions by ½ by 2030, for 'only' 1.5 degrees C ravaging warming. Yet we're nowhere near 50% cuts. Actual global trends in 2022, still went on languidly, for decades before decarbonizing. That creates much, much too hot a world, with genuine zero-CO_2 goals realized far too late.

If action occurs soon, note how plunging solar, wind, energy storage costs *immediately could change everything*. A US grid with 90% (or in our case, 100%) less CO_2 is not only feasible, it is reachable in 15 years – on *cheaper* electricity. Competing analyses differed on last pieces of 100% zero-carbon puzzle. Yet models often *agreed* at 90% – (we're using 100% as a goal), so a 2020 Report blueprinting how to get there from U.C. Berkeley was important. Also, a 2020 Report, Larson et al, 'Net-Zero America: Potential Pathways, Infrastructure and Impacts' by Andlinger Center and High Meadows Environmental Institute. Additional Reports have since bolstered this case. But we'll cite here to this Berkeley Report, and one from Princeton.

It shows how carbon-free can be achieved swiftly in 15 years to 2035, retail electricity costs in 2035 at 10% less for consumers than today. Past assumptions thus got it wrong on how hard (for it can be done) - and on how costly (for it saves money) in a clean US path.

Remarkably too zero CO_2 is a 'no-regrets' path sensible in its own right, better than status-quo No New Policy. The "2035 Report: Plummeting Solar, Wind, and Battery Costs Can Accelerate Our Clean Electricity Future" (2020), https://www.2035report.com – offers a vision that interestingly differs sharply from reports of a dozen years ago. Those had once foreseen carbon-free electricity as *adding* many new costs. Instead, this portrays how today:

> "Given the plummeting costs of clean energy technologies, the United States could reach 90 percent zero-carbon electricity by 2035, maintain reliability, while *lowering* customer electricity bills from today's levels, on the path to 100 percent zero-carbon by 2045. To reach 90 percent, this infrastructure build-out would productively put about $1.7 Trillion dollars in investment to use over the next 15 years, supporting about 530,000 more jobs each year and avoiding at least $1.2 Trillion in cumulative health and environmental damages. And it would reduce economy-wide greenhouse gas emissions (GHGs) by 27 percent by 2035.
>
> Building a reliable 90 percent zero carbon electricity system is a huge opportunity for economic recovery – a fantastic way to invest in a healthier economy and support new jobs, without raising electricity bills. But America's current electricity policy framework is not on track to deliver this economic opportunity."

The study allows for all known 'zero-carbon' generation options. As expected, its focus is on cleanest: solar, wind, energy storage. Yet baseload with also hydro, geothermal, biomass, even nuclear may be permitted. (And in theory too, fossils with carbon capture/sequestration – but least-cost models do not allow current nuclear, nor sequestration). In contrast to Zero Carbon path, a No New Policy is merely the state & federal trends status-quo ante. That latter model reaches only to 55% clean by 2035 so would fall far short of what's required. Crucially this better, cleaner plan means reliably all firm fully dispatchable power, as needed. It meets all demands in every hour of each day. There's no compromise on performance.

To reach zero-carbon target by 2035, annual US deployment of solar & wind would need to first double each year in 2020s, then triple historical bests early 2030s. This rises up hard from a roughly 15 GW solar installed 2016, and from a 13 GW of wind installed in 2012.

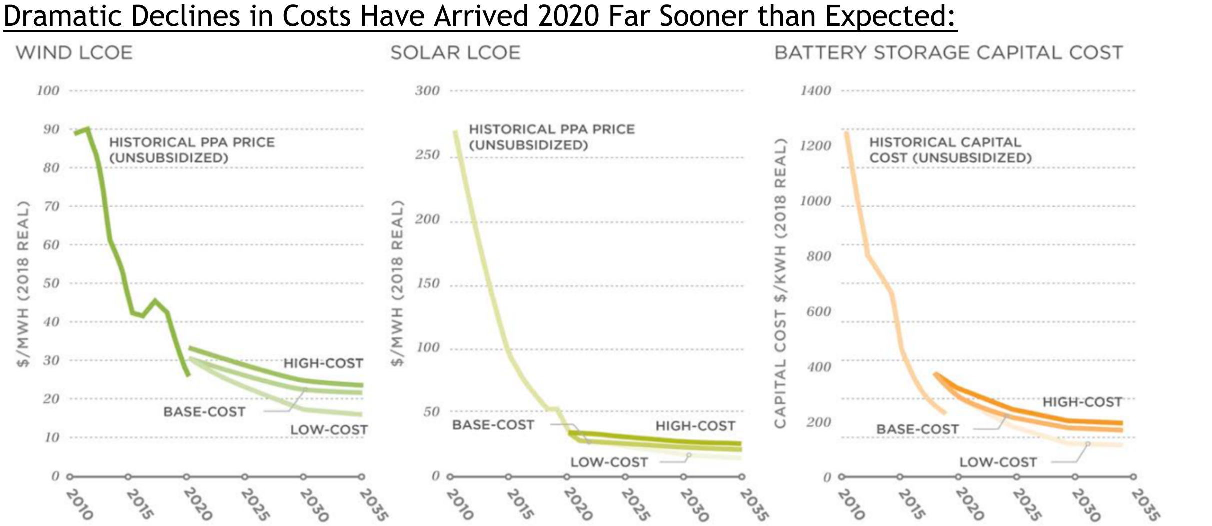
US energy generation growth had gone big before; natural gas grew by 65 GW in 2002. Now what's needed, changed: *energy storage* is 3rd leg triad to solve intermittency of renewables. Key new storage deployment needs to grow by 25% each year. Starting from a measly 523 megawatts storage in 2019, it should grow immensely from early 2020s through 2035+.

Happily only modest new transmission necessary to interconnect expanding clean power, so less pressing need for slower-to-build intergenerational lines. No tough overturning of grid infrastructure, requiring long lead times. But some grid modernizing needed and the 2021 Infrastructure bill provides much. What changes, is composition of generation & storage over this now fast-arriving 15 years. Texas may connect to US East/West grids for resiliency, but that's a different matter. First off, all US coal plants need to be permanently shuttered by 2035 under this plan. Places like California, it's done. Extant coal elsewhere ofte were running so many years now, the 15 added years in this Plan leaves time to recoup capital investments. It is doubtful coal owners would want to burn much longer, given high costs and liabilities vs. clean power – but recouping those costs going out to 2035 is addressed in this Report.

Second, *no new* U.S. natural gas fired plants are built. Existing gas plants and any going up now can remain; they'll play a key but decreasing role in grid stability as new storage grows. Again, capital investments are recouped this period – ending with a zero-carbon grid. Currently there's about 540 GW gas capacity operating in the U.S.; in this Plan, most or 361 GW of that dispatchable gas is kept to 2035, another 90 GW in reserve for reliability. Natural gas meanwhile, is used for only generally 10% of generation – going down to zero.

Since gas-plants must pay for fuel, the reductions help achieve wholesale electricity costs in 2035, *10% less* than now. And that was based on earlier much cheaper gas, than seen in 2021 – so renewables get cheaper still. In low solar & wind generation periods, gas does have key backup role – but utilization rates only 10%. The Plan suggests a federal 'clean' (carbon-free) standard: 55% by 2025, 75% by 2030, and 100% by 2045. In past, when renewables were much more costly than fossil fuels, such a standard was not yet embraced. But times change.

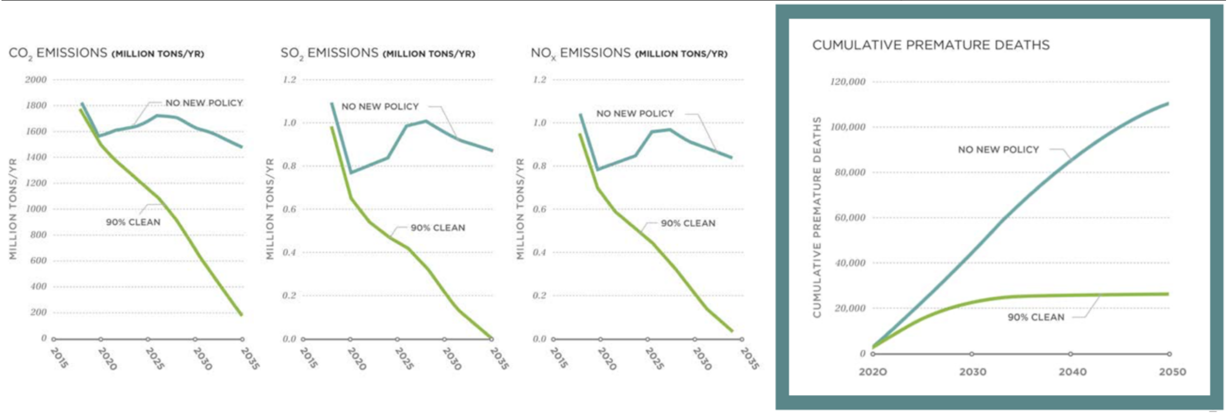
Dramatic Declines in Costs Have Arrived 2020 Far Sooner than Expected:



Source: 2035 Report: *Plummeting Solar, Wind, and Battery Costs Can Accelerate our Clean Electricity Future*, slides (June 2020).

Relative to a currently trending status-quo No New Policy, this 2035 Plan would instead slash CO_2 emissions from energy generation by whopping 88% by 2035. A direct human health consideration, that reduces human exposure to polluting fine particulates (PM 2.5) and Nitrogen Oxides (NO_X) & Sulfur Dioxides (SO_X) emissions by 96% and 99% respectively. This clean Plan separately also saves over $1 Trillion in health and environmental costs!

<u>2035 Plan Avoids $1 Trillion in Human Health + Environmental Damages vs. Business as Usual:</u>



Source: 2035 Report: *Plummeting Solar, Wind, and Battery Costs Can Accelerate our Clean Electricity Future*, slides (June 2020).

So, in 3 fundamental points: it's *feasible, *saves money, *and lowers climate risks to boot. Getting there, means constructing 70 GW of new solar & wind capacity a year, on average, for 1,100 GW total by 2035. Contrary to conventional wisdom, renewables can go in most of country. The public may assume solar needs warmest climes, but in fact solar power does very well thank you in freezing temps – working even say at Poles - or literally in space.

Electricity in this model is made by solar for under <3.5 cents per kilowatt/hour (kWh) places shown in yellow/green: thus, most of US. Wind power similarly made at less than 3.5 cents kWh in much of the country, shared widely via grid etc, or stored. Such zero-carbon renewable prices are, remarkably, less than any fossil fuel. And one wonders given 2021 high natural gas prices, if this projection is off; by 2035, renewables may be relatively cheaper still!

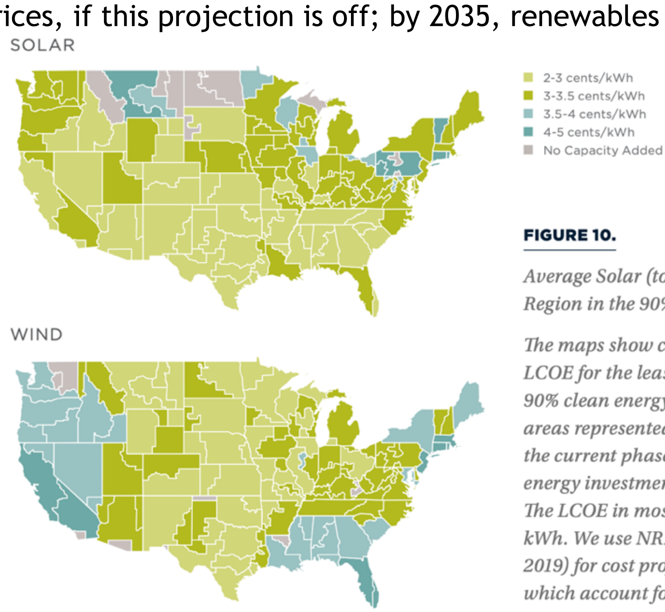


FIGURE 10.

Average Solar (top) and Wind (bottom) LCOE by Region in the 90% Clean Case in 2035

The maps show capacity-weighted average LCOE for the least-cost portfolio to meet the 90% clean energy target for the 134 balancing areas represented in ReEDS. LCOE includes the current phase-out of the federal renewable energy investment and production tax credits. The LCOE in most zones is lower than 3.5 cents/kWh. We use NREL's 2019 ATB Mid-Case (NREL 2019) for cost projections with some modifications, which account for the cost reductions already benchmarked to recent PPA pricing.

Source: 2035 Report: *Plummeting Solar, Wind, and Battery Costs Can Accelerate our Clean Electricity Future.* (June 2020).

Relative to a No New Policy case, this Clean Plan can create 500,000 new jobs/per year. From 2020 to 2035, a cumulative 29 million job-years. Many new jobs can & should be located near closing fossil fuel plants; new jobs building solar, wind, storage going in where fossils shutter. Jobs will be front-loaded & prolific as construction - not so much later operations since neither a fossil fuel, nor much maintenance is required. It's surely crucial here to assist local communities too, once dependent on coal: shoring up pensions, healthcare, jobs & training programs in moves to green energy. A Survey by World Economic Forum in 2020 laid out goals for a *Just Transition* - and more than half those surveyed, favored working in renewables.

To keep to 'only' 1.5 degrees C warming of the IPCC Report, global emissions would have to be halved by 2030, so this green Plan alone isn't nearly enough; it offers a -27% reduction in CO_2 in US electricity generation. It doesn't provide total US -50% cuts by 2030, nor is it global. But there'll also be (one hopes) big reductions too in industry, buildings, etc. And under this Plan's glidepath, finishing at roughly 100% CO_2-free grid 2035 could prove compelling.

Delivering *less-costly* power in 2035 that's also *cleaner* – wasn't regarded as feasible before. Studies done a dozen years ago, or mid-2010s, didn't foresee how drastically solar, wind & storage costs could fall. Now that they have, modeling for a far-less-costly electric power may be undertaken. This lets us see how storage is key, on non-firm renewables.

Dependability in modeling for this Plan is defined as at minimum meeting all power demand needs, every hour of the year. Hourly operations were simulated in America's power system over 60,000 hours. Done for every hour, across 7 weather years. In each one of these hours, sufficient power was assessed as meeting all of the demand in every one of the 134 regional zones of the model. Ramp rates and minimum generation levels were included for more than 15,000 individual electricity generators, and 310 transmission lines.

A key ingredient in making it all possible, is how far storage costs have dropped – *and will do so ahead*. By 2035, models seminally found adding 600 GWh (150 GW for 4 hours) short-term battery storage, cost-effectively can achieve a 90% zero-carbon grid. 20% of daily electric demand is met by storage. Limitations to computer models keep battery storage capabilities envisioned to 4-hour window. Real world data too, as was shown here in Appendixes noted how hard it's been for California to meet 50,000 MW of demand; again, storage is key.

Renewables are oft criticized, as their faceplate installed capacity must be built many-fold beyond what's needed - compared to firm always-on power due to intermittency & variability. That's been portrayed as a Liability, vs. nuclear, coal, and natural gas. And it means aiming for a 100-fold more PV faceplate capacity vs. now - by 2035. But, it's just a characteristic.

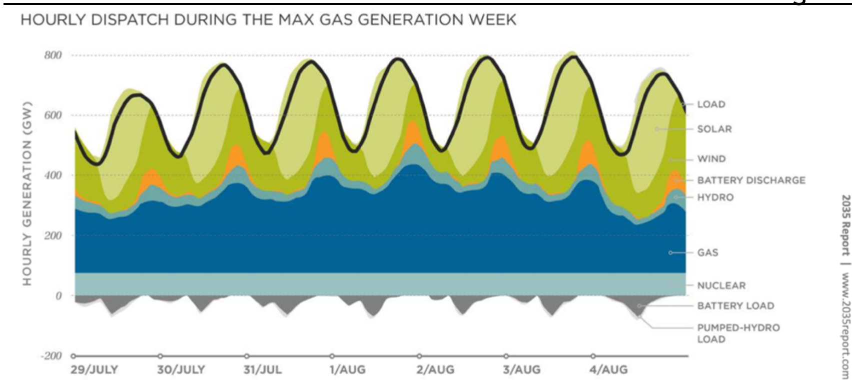
Over 7 weather years modeled, in normal conditions, wind, solar, battery storage generally, regularly provided 70% of annual generation; hydropower & nuclear provide 20%. But when there's very low generation by renewables solar/wind – and/or unusually very high demand, existing natural gas plants, hydro, and nuclear together with batteries can in cost-effective fashion interim compensate for mismatch and are able to meet needs. Natural gas-plants still only contribute around 10% of annual electricity generation these bridge years. (Thus some nuclear is retained, as opposed to California shuttered its last plant 2025). Remarkably, this Plan is so different from what's seen today, that one may naturally ask: How is this done? We know solar is binary, each 12 hours it makes zero power all night long. So, what happens when a high demand evening – overlaps with a time of little wind – drastically curtailing output? When there's a 'wind drought', as expected higher seasonal winds don't show up?

Let's start with a tough-case; no-solar, so evening hours East Coast, little wind as well. Total solar & wind generation 94% below their rated capacity, a puff of wind somewhere in grid - hence an enormous 1,220 GW of rated capacity – is making only 75 GW actual generation.

That's 80% below annual average yearly output for combined solar/wind generation. Over 7 weather years modeled, such very toughest hour/s come on August 1st, with a largest gap between green power (solar, wind, storage) – vs. dirty generation needed to compensate.

8 pm Eastern time so in evening, no wind or solar - the greatest natural gas capacity needed to meet demand, would be 360 GW. Intermittent solar + wind were making little, despite far higher nameplate capacity. With total demand of 735 GW, immediate dispatch needs are met partly by 2 other zero-carbon sources, hydropower & nuclear – and 80 GW battery discharge. And as noted a key 360 GW of natural gas capacity. That's in such worst-case scenario.

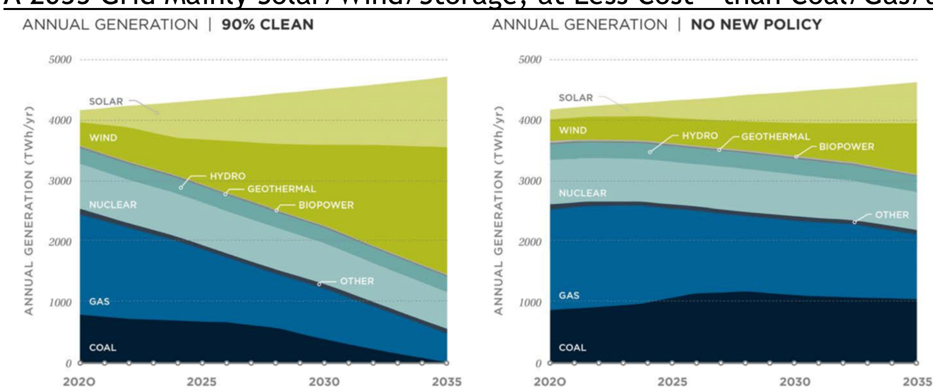
A Worst-Case Generation Period for Renewables: Still Moving Off of Fossil Fuels/Nuclear:



Source: 2035 Report: *Plummeting Solar, Wind, and Battery Costs Can Accelerate our Clean Electricity Future*, slides (June 2020).

Over 7 weather years, highest US demand for natural gas baseload is always at August on least wind - in evening Eastern time, so zero solar. But gas-fired power needs of 300+ GW are still kept here to below 45 hours per year. In sum, decarbonization progress is suddenly real.

A 2035 Grid Mainly Solar/Wind/Storage, at Less Cost – than Coal/Gas/and Nuclear:



Source: 2035 Report: *Plummeting Solar, Wind, and Battery Costs Can Accelerate our Clean Electricity Future*, slides (June 2020).

Capital required is some $1.7 Trillion new clean energy investment. Enormous, yet akin to COVID stimulus rounds, with enormous positive lasting benefits. (Add efficiency improvements ahead too, like barium sulfate painted-bright white rooftops, to better lower demand).

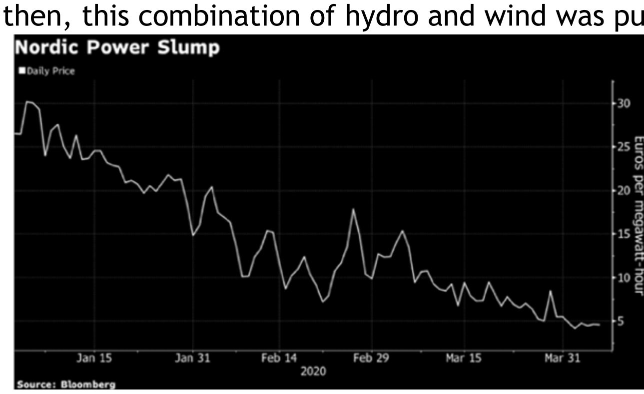
Recall some ‘normal’, pre-Covid, *applied* clean energy trends back early 2020. As renewable prices were falling in good & snowballing ways (unlike oil/gas). Start with Solar; costs had then hit a new record low: *only 1.35 cents per kilowatt/hour* at a big 1.5 GW solar farm going up in Abu Dhabi! True, that’s in excellent solar circumstances, desert for instance. But there’s great deserts in Western US; arid Southern European regions too, and 1.35 cents is cheaper than new coal today, tomorrow, or ever. New solar for a penny is much less pricey than new natural gas. Frankly, no new fossil plant comes close. Inflation in 2021 was soon vexing solar – so the future is uncertain. But competing natural gas had jumped too in 2021, far more.

Or in practice, consider pre-Covid, how 2 renewables joined up at say a world-leader, Sweden. There, clean energy tells a startling story. For as more renewables get built, new synergistic eco-possibilities could be repeated. We’d noted how in April 2020, when a Swedish then-large onshore wind farm had opened, right away it changed the context in which firm yet inflexible, nuclear plants work. Given how wind, hydro, and solar power can all in good circumstances heartily underprice the costly non-renewables like nuclear. That new wind farm owned by a Dutch Pension Fund has 80 large turbines at each 3.6 MW, together near 300 MW of installed capacity expected to annually make 900 GWh. That is ‘biggish’ – but certainly is not gigantic now especially for wind in Europe, see https://www.vasavind.se/askalen-eng.aspx

Wind wasn’t only big renewable operating there. Sweden already has hydropower plants, so it’s been harnessing water in addition to wind. Indeed, most all the planet could be tapping myriad (untapped) renewables, even if inexplicably they’re being ignored. Perhaps blowing winds onshore /offshore, or sunlight for solar power, or geothermal, or run of river small hydro that ecologically can be much better than static big-hydroelectric etc.

Now Sweden already had/and has hydropower making power. So very rapidly, indeed just 1 day after this wind farm opened, with hydropower too already making abundant cheap power, 2 units at big costly nuclear plants near Stockholm had to ratchet down to just 50% production. With 2 other units at an older nuke plant also shut in a national shift away from nuclear, the two robust renewables, wind/hydro were obviously fast becoming impactful.

Now if it happens that wind farms are each capitalizing on windy days – plus good hydropower conditions – then together they make good use of all for ‘free’. Such increasingly crowds out fixed fossils & nuclear plants, that must pay for fuel & operations. An upshot was Sweden’s electricity prices in April 2020, had hit welcome new Lows. Note too wind farms in Sweden, like in the Arctic, in Minnesota etc work great in freezing areas, putting a lie to critics who’d wrongly claim in a tragic Texas freeze 2021, that renewables cannot work in the cold. Happily, then, this combination of hydro and wind was pushing down Nordic prices very nicely:



Source: Bloomberg, ‘Giant Wind Park Starting Up is Another Blow to Nuclear Industry’, Apr. 8, 2020.

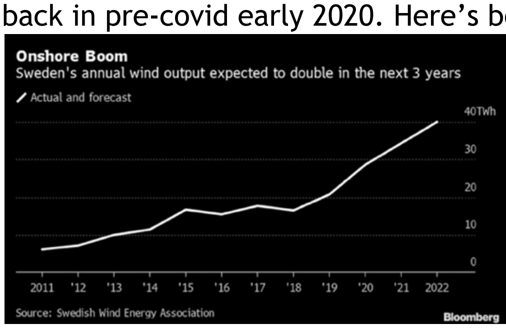
Yes, renewables wind/solar are intermittent. Winds not always blowing, no sun (night), or no rains for hydro. Yet at such times, then other renewables may be tapped. For instance, geothermal might possibly grow well as firm power. Especially when oil rig counts drop, geothermal may grow attractive. Idle drilling capability harnessed to hasten geothermal as baseload power. Capital is what's needed, since geothermal may require deeper wells than oil, and wider bore holes. Firm power understandably also costlier upfront vs solar or wind.

US big Oil 2021 hadn't yet looked seriously at big geothermal projects. But when oil falls - if geothermal improves, renewable projects could bring new revenues. Geothermal is costly now – maybe 3x more-than wind/solar. Yet its build-out needs skills well-understood by oil/gas: how to drill holes deeply into the ground and in time, geothermal might grow more affordable and its energy may be exported too, like from say Iceland in varied forms.

So natural situations like in Sweden can be exacerbated in good ways, windy days coinciding with high-hydro output. 2020 charts by Bloomberg New Energy Finance (BNEF, a prior longtime partner on global new energy NEX) illustrated well how wholesale power costs in Sweden were driven down naturally by hydro/wind to their then lowest-ever. In a pre-Covid early 2020, electricity day-ahead prices fell by half. For comparative break-even, let alone profitability, that region's nuclear plants have needed a much higher price floor. Still current-generation, (costly) nuclear, thus faced a thorny dilemma, given how low renewables *can* go. Especially if a region combines many resources like wind, perhaps solar, wind, geothermal too.

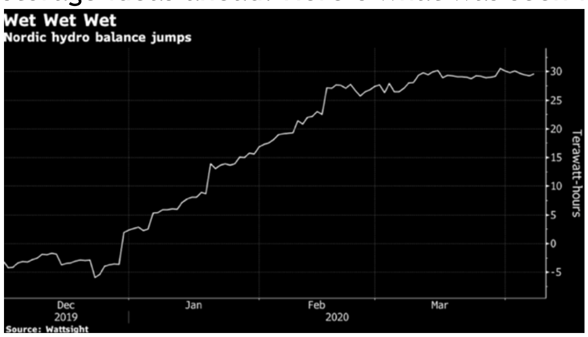
Dirty cheap northwestern China coal, had long attracted industries like PV; cheap electricity eg Liuzhou was an incentive to make EVs too. Yet Northern Nordics may potentially do it one-better ahead! If cheap/er renewable power can make green steel, aluminum - industries shall welcome that – as low embedded carbon. Sweden's mills, smelters, miners, manufacturers are energy-sensitive. Big hydro static, its potential capped, is limited to big dam-able areas with ecological burdens. Wind power instead, can scale up in green major ways. A BNEF article aptly entitled "Sweden is Becoming Europe's Texas for Wind Power" – showed how Sweden along with Norway/UK a bit like Texas, was pre-Covid 2020 in a midst of a wind boom.

Indeed in 2020 Texas added near as much new wind capacity, as prior 5 years. Solar there too jumped from 3,800 MW, to maybe 20,000 MW in 2023. This US renewables leader had 29,000+ MW solar & wind – maybe adding 35 GW more solar & wind 2021-2023 – beating 13,000 MW in California 2021. Texas' huge ERCOT queue may mean tremendous new solar + wind ahead. Because wind power like solar, hydro, geothermal enjoy free fuel, they get *very* inexpensive in abundant times. Painful to the Utilities that must compete if using nukes or fossils – yet a bonanza to off-takers. Combine hydro + abundant scalable wind, or solar, and benefits can snowball. Clean power potentially goes very low-cost, even near - or below zero! Woohoo for off-takers! Little wonder then wind power pricing in Texas had got low as 2.6 cents per kWh back in pre-covid early 2020. Here's booming 2019 Wind as was then seen in Sweden:



Source: Bloomberg, 'Sweden is Becoming Europe's Texas for Wind Power', Nov. 25, 2019.

Energy-intensive industries in mountainous Northern Nordics may enjoy booming renewables, abundant hydro/wind pushing down energy costs bit reminiscent of coal in northwest China. China's aim of "climate neutrality" might in time, avoid coal, just not near soon enough – and its effort got relaxed in its own 2021 energy crunch. Sweden by contrast in 2021 had world's highest carbon energy tax: $137/tonne. Partly as a result, its carbon emissions per capita at 3.5 tonnes fell well below green Europe's 6.4 tonnes. And a goal ahead for it is to avoid "carbon leakage" seen in importing say, cheap high-carbon 'brown' cement like from Russia, Turkey, Belarus. Yes, intermittency's a fact in renewables; they're unpredictable as seen in wind/hydro. Yet we're in only early innings and one hopes for a flowering of varied renewable storage ideas ahead. Here's what was seen in just pre-covid days; 2020 in Sweden:



Source: Bloomberg, 'Giant Wind Park Starting Up is Another Blow to Nuclear Industry', Apr. 8, 2020.

As for the US, it had started making some progress in 2010s thankfully going beyond big hydro. A decade ago, all America's renewables had made just 10% of US electric power in 2010 – much of that was big hydro with vexed ecological impacts, little room for growth. Noteworthy then, US renewables' slice of pie since grew to near 20% by end of 2020, thanks mainly to more scalable and greener solar & wind. The latter two have enormous room yet to grow.

End of last decade, by 2020, US installed solar capacity had risen to 100 GW. Each gigawatt might be thought of as roughly like a small nuclear plant. Yet solar is intermittent – hence unlike firm nuclear, coal, gas. So, by 2020 solar & wind had gone from nearly zero in 2010 - to 10% of US electric power combined – but not always On. Hopeful yet underwhelming: we need 10x, 50x that! Note too how growth happened. Partly by China pushing down solar costs via consolidation. Its world's biggest PV firm went bust 2017. 180 solar firms died 2016-2020. In 2010, 1,000 employees at a Chinese solar plant made 350 MW of product; by 2020, 1,000 people could make 6,000 MW. Price per watt solar crashed by -90% that decade. After a US 2009 meltdown, US jobs lost at huge rate, a $800 billion stimulus American Recovery and Reinvestment Act (ARRA) gave then-crucial $90 billion to clean energy, EVs, efficiency etc.

Back then, in 2009, solar made up only 0.1 percent of American electricity(!). Wind, less than 1 percent. So, those were vanishingly small in total US energy mix. ARRA sought to change that while creating jobs and growth. It gave a then-large $25 billion for renewables, a big $20 billion to energy efficiency, $18 billion for transit, $10 billion for improving the grid, and more for other varied green programs. Tax credits unusable to many then, lacking profits, happily became usable liquid cash payouts. Developers were allowed to 30% of project costs, as cash instead of tax credits. That 2009 ARRA stimulus helped prime a pump for growth. Also of help that decade was a US SunShot Initiative that reached goals early helping make solar more competitive vs. dominant dirty energy. Over a decade following the 2009 ARRA, US solar power generation capacity grew 48-fold to 2020(!) though starting from a minuscule base. Wind generation capacity grew strongly too, by some 4-fold plus (from a greater base).

Of key importance then was China's gathering strengths in solar & wind. Seeking market share in big way, it began pushing down prices per watt dramatically. It soon put many established firms out of business - in Japan, Germany, US. Profit margins dried up. Legacy firms just couldn't keep up, as China's firms often enjoyed lower capital costs, cheap labor, free land, far less environmental regulations. Local governments were glad to see jobs and employment gains these factories brought. Solar costs and price margins, all plummeted.

Germany ramped solar power using the newly-cheap imported China-made PV in 2010s. In 2012, it put in 7.6 GW of solar panels. It and European nations like Denmark embraced wind. By 2013, subsidized wind reached cost-competitiveness many places with coal & gas. Where winds are plentiful, wind has grown *very* favorable: America's Midwest saw power auctions just 2.5 cents per kilowatt/hour (kWh) some bidding for power, making it a best choice.

New wind power hit a marker in 2015, when more US renewables were installed, 150 GW – than all fossil plants added that year. Diverse kinds of renewables were growing common in Europe & to lesser extent, US. Various clean power together good days, began to briefly even meet 100% of demand on occasion. In 2016 all Portugal ran just on its renewables alone - solar, wind, big hydropower for some 4 straight days. Greece, on 7 October 2022, ran for 5 straight hours on just 3,106 MW made by its renewables alone. Aiming for 30 GW by 2030.

By generation type, renewables pulled ahead of nukes. In a first in its industrial history, UK made more renewables power in 2019 – than from fossils combined. Unsunny, it still made much renewable power from wind, hydro, & solar - plus not-so-green biomass. April 2020, UK solar made 9.7 megawatts meeting 1/3rd of its power demand; yes, a one-off 10 times what it normally produces in a day there. Yet, oh, what a change! 2010 dirty fossil fuels met ¾ of demand, 10x the renewables. Yet its renewables had jumped to 40% by 2020, gaining as UK coal-power fell from 70% in 1990, to under 4% 2020. Coal might have ended in UK this decade – were it now for war in 2022 and so a push for energy of any kind 2023, 2024 and on.

Globally, annual solar panel production gained enormously from a once-puny 15 GW in 2010. Yet as emphasized, a key issue for many renewables (apart from geothermal / big hydro) is their intermittency. That's held them back - but needn't so do that ahead. Like overcoming high early costs in solar & wind – a need for firm power spotlights batteries & energy storage. Intermittency's an issue, *yet it can surely be overcome*. By coordinating renewables in grid, maybe innovations like flow batteries, carbon taxes, storage, green H_2 as energy carrier etc (with needed breakthroughs) – green should ascend. We *can do much* in renewables.

Asia launched its own commitment to batteries years ago. Lately Europe is trying to catch up in EVs/batteries, with leadership in technology & manufacturing. Decarbonizing everything. Yet inexplicably, the US has ceded much ground early in an energy storage and batteries race. And China, having once missed out on prowess in making 'regular' gasoline powered cars – seems determined since not to make same mistake twice with coming new energy electric vehicles. Essentially an EV is a big battery, surrounded by 4 wheels. And China may soon 'own' much of this fast-moving batteries/EVs space. Innovations across various storage will be part & parcel of renewables progress worldwide beginning right now in this decade.

So much is ahead worldwide. Solar cells may yet utilize more wavelengths: say group III-V semiconductors that allow 'more sunlight' to be captured than ever before. Or concentrate the sun with mirrors; it may be possible for innovative solar cells to capture 400 times more solar power, than before, over an equivalent surface area! We're just beginning.

Or consider Perovskites for solar, where we're in early innings technologically speaking. That material's lattice structure may grow a cheaper PV, one day perhaps delivering 50% more efficient solar cells than today. Ability to capture less light may open new possibilities ahead. Solar is already getting cheaper still – yet as we emphasize, clean energy early 2020s is still crude, and nowhere close to what's now needed – given global heating crises.

Confronting all, is that the Earth doesn't care renewables 'so strongly' grew from zilch. And we ought not to pretend impacts to us alone, are all that matters. As air-breathing mammals, we see only the terrestrial impacts. That's a mistake. Earth's surface is mainly covered by seas: their health is declining fast. Skeptics of CO_2 role in warming, have no ground on which to stand with ocean acidification. For oceans' CO_2 uptake is undeniable. Rising CO_2 concentrations doubtless will equal acidifying seas. Devastation ahead for reefs, for kelp forests, fish populations, shellfish, marine mammals, more. Marine life weakened by that acidification - stands less chance of surviving stresses, marine heat waves, collapse.

Ways shellfish for example, calcify growing shells in surrounding seawater are understood. Hence, it's perplexing how we know acidification lowers pH, have no doubt it enfeebles species essential to ecosystems. *Yet we care not a bit*. Shells get too thin, accreting calcium from seawater gets too difficult – likely soon tipping points, catastrophic collapses. Naturally perturbated places nearby 'acidic' waters, say nearby volcanic seeps, the fish and habitats are already negatively impacted by CO_2 levels that are only a little above those of today.

Post-2050 deep seas may warm at rates maybe 7x now – climate velocity sure to overthrow life evolved in a very stable, deep thermal setting. There will be tipping points. Complex & cascading losses. In sum the renewables are vital. Still, we perceive of clean energy – and life in oceans - as being 2 quite separate matters, but they're intimately linked. All is one.

Since the industrial revolution, ~1,700 gigatons of CO_2 ($GtCO_2$) put into air has left room for only some ~200 Gt more - before we go over 1.5 C warming. By releasing 40 $GtCO_2$/year now, we have close to no extra time left at today's rates, before we're in real trouble. That's why distant promises about say, 2050, are so absurd. Reducing CO_2 Right Now is vital.

We already know from ample science that the threats to seas include greenhouse gases CO_2, methane, more CFCs; overfishing; non-point source pollution; habitat destruction, ocean acidification, and more – all harmful to marine life & biodiversity. Each one complex, cascading. Each also appears at first daunting, prohibitively too big to solve.

Seemingly most intractable, most vexed, hardest to remedy, is CO_2 & climate. It's surprising then, that the solutions here are both economically and ecologically sensible, saving life & money to boot! Key, of course, is renewables: the sun shining on our cheeks, winds blowing overhead. Thus, a key question is, how to get from brown now – to a green soon, given inertia? What, will it take, to power the entire world off mainly solar & wind - with energy storage? Seen another way, given the lane imposed by CO_2, how much solar is necessary to actually reach a Paris Climate aim of keeping all to under 1.5 degrees C of global heating?

Solar manufacturing capacity worldwide back in 2020, then under 1/10th, maybe near 1/100th what we'll need - to build PV fast enough. In 2020 we'd made around 100 GW/year worldwide. (Tiny, yet better than puny 0.250 GW in 2010!). We saw PV manufacturing becoming more a low-margin, commodity business. A decade of consolidation, wring out costs, more capacity, PV growth steepening. Yet 2021 and then 2022 also saw rising inflation – plus war.

In 2021, 9 of every 10 PV panels were being made in Asia. Our planet's biggest PV solar module factory in 2020 was in Anhui, China. Perhaps capacity for 60 GW modules by end 2023, each & every year. But given economics, it's going up in 4 phases, to $2.5 billion. From a standpoint of where we need to be on CO_2 in 2035, it's but a start. Just a beginning. Still, is wildly small, if we 'need' some 60% of global electricity demand to be met just from solar alone.

Without vastly ramping, on today's trends, current growth rates, global PV capacity may be just 400 GW/year ahead. That may 'seem' a lot – yet is only an incremental increase in global PV installed capacity. Growing too slowly. On that rather 'meh' rate, it will simply take too many decades to get to 60% of electricity from solar. Given where we need to be on CO_2 and so climate – and then on war/energy security 2023, 2024 etc - solar must soon become very, very cheap energy. Wind too. So arguably, we need Policy for faster ramping. It's a hand that CO_2 forces on us all. On carbon levels already over >420 ppm; in 2020s, nowhere near enough installed manufacturing capacity to ramp solar and wind fast enough to 2025. Hence policy changes are needed to speed matters. A growing China recently had world's greatest existing installed solar capacity; the European Union was 2nd and growing; the US was a sad poor third. As emphasized, none of them in early 2020s anywhere near where they needed to be.

Think then, of wind. Here, Europe may soon lead. And wind power can be crucial. Note too: Russia's invasion of Ukraine in 2022 may *Hasten* figures below (from just before war).

For US leadership in wind, take a Great State of Texas. Generally speaking, the US is not yet a clean energy Generation Incubator, nor an exceptional innovator. In oil & gas, yes, but Texas say is partly open to clean energy innovation – with its less regulations/more flexibility - and it's very vulnerable on climate. CO_2 *may* cause stratospheric heating, weakening a polar vortex usually bounding Arctic; so ironically global heating *may* mean bitter Arctic air reaches briefly down to Texas. Record cold snaps, once just every 100 years, may need to be regarded as every 20, even 10 years or less. Weather extremes hitting all fossils hard.

Texas' grid also intentionally lacked US interconnections, left antiquated. So, wind's growth shall be crucial ahead to eg, Texas. Outside Texas, wind is rising fast too as a percentage of US power in the Midwest. In 2022, Iowa (an EV hub a century ago) had made 60% of its power from wind; it's not hard to envision conservative Iowa going over 100% by 2030! Conservative Kansas (near 50%), Oklahoma (close behind) made >30% of power by wind in 2022. Like more Liberal states, Colorado, New Mexico, Nevada, Vermont. Offshore wind in the Great Lakes, US Gulf coast, Western US coast: maybe all soon offshore wind powerhouses ahead.

Or, to focus on say new solar in Europe, consider a 2020 Report (so pre-2022 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 important observations there, for some notable conclusions. Startling observations include that to move fast and soon, will cost less (than moving slower). 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 conventional wisdom, so are worth unpacking. Start with the idea that moving *more quickly* to decarbonize, will cost *Less,* than status-quo of incrementally adding solar & wind. In part thanks to renewables getting so cheaper, the 'Leaders' scenario shows greenhouse emissions can fall 60% (from 1990 base) to 2030 in 10 years – reaching zero 2040. All a decade ahead of 2050. By contrast, more conventional wisdom would have Europe reaching only 53% emissions cuts, by 2030. And this Solar Power Report assumes No (current generation) nuclear, not due to its risks, but rather due to its higher costs.

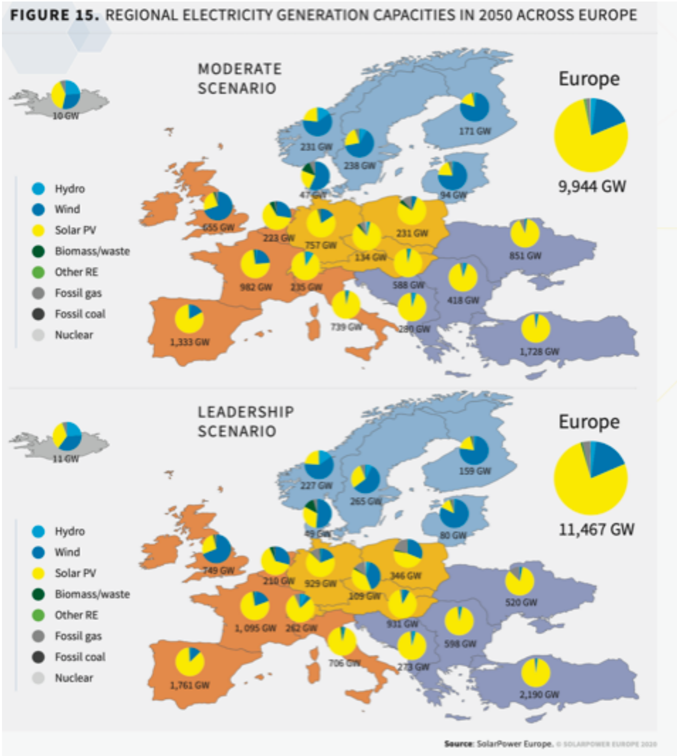
This Report recommends that policymakers should begin immediately creating a framework targeting installed 7 TW solar power – plus 1.7 TW of wind to be reached before 2040.

That assumes 2 factors: start upswing now as soon as possible – and grow PV manufacturing abilities harder and faster. With CO_2 a pressing issue, we may need to build up to 100 factories worldwide, each capable of making 60 GW PV like that factory going up in 4 stages in China. Ramping to around 7 TW extant solar in 2040. Clearly this is possible. Raw materials can ramp fast – we'd also doubtless find ways to make PV far more cheaply, efficiently. The US in World War II ramped its weapons & materiel productivity like never seen before. Only now, this time, it's the world coming to our own rescue. CO_2 was rising fast by 1 ppm/year at a first Earth Day. Lately scarily, by 2.5+ ppm/year. That number's only growing, accelerating.

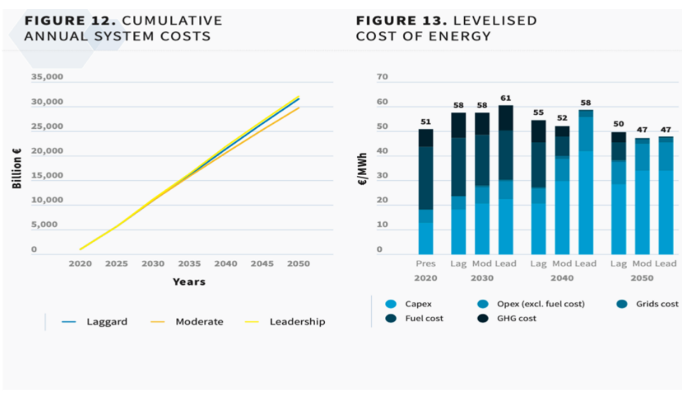
2 scenarios presented were Moderate approach – and Leadership one that's quicker. Former meets only 2 degrees C heating goal of Paris. Latter meets a more robust, better 1.5 degrees C goal. Again, it's a matter of when this ramp begins, so the angle of departure. But interestingly, the stronger and sooner 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. Northern & Western European regions mainly use wind, given natural resources of Denmark, Norway, Sweden, Finland, etc. Similar approaches under both Moderate and Leadership scenarios, just differing rates.

Seminally, Europe has enough renewables potential to meet its entire needs by 2040. Electrification of everything. About 63% solar, 30% wind on a Leadership path. As for costs, the Moderate path costs *less* over time - than a Laggard approach. Meanwhile a Leadership path starts harder, sooner, and beats Moderate path. Unlike child's game of rock, paper, scissors – in this Policy Framework, there's a winner: start now & go very hard, very fast.



Source: Solar Power Europe 2020.



Source: Solar Power Europe 2020.

Certainly we can't plead ignorance. Brilliant Eunice Newton Foote born in 1819, in 1856 had published her paper 'Circumstances Affecting the Heat of the Sun's Rays', which predicted changing carbon dioxide & water vapor in air, could alter climate. In 1860s, John Tyndall added infrared radiation, methane. Arrhenius explained over a century ago, mechanisms of global cooling or heating via a carbon lever, predicted a massive 4 degrees C heating comes with each doubling of CO_2 – pretty much spot on estimates today (and note we've gone from 315 ppm to >425 ppm within this author's lifetime). Add in a whole suite of GHGs: methane too and it's like we've climbed over 500 ppm. Roger Revelle had alerted governments further to this in 1950s & 1960s (and he had great impact on this author at Scripps in 1980s!). Or, we could continue as is – let vagaries of oil & gas throw energy markets and so us all for loops - over & over. Take our time, delay on ignorance, make any eventual turn towards clean – tougher than was needed. Look at wicked oil dynamics seen just in say, 2020 and 2021.

Why a Major Oil Crash Happened in 2020 – followed by Oil Spike Up After

In early 2024, the US was producing more oil – 13.3 million barrels/day, than any country in history! Oil was fetching a high-ish, 'healthy' price. But it wasn't always thus. Let's look back, intriguingly, to 2020, to a remarkable world oil crash. Some called that crash illogical, yet it arguably unfolded with an explainable logic of its own. 4 years prior, it started as oil *Demand* collapsed with onslaught of Covid-19. Businesses froze globally. Very quickly, surplus oil began backing up worldwide, just as we'd forecasted here in a Q1 2020 Index Report. That Demand Destruction swiftly grew so large, that where to store all the 'excess' oil was a real question - especially when oil 'prices' in artificial sense & bit unsurprisingly, went briefly negative.

At start of 2020 the world had been producing 100 million barrels/day, well-matching needs. Demand & production were expected to (only) grow. Indeed, in only just 2 of a prior 35 years, had demand for oil to then, dipped – then only a brief bit. Yet suddenly in March 2020, a monster demand collapse from Covid loomed large; perhaps down some -25% or more. Normally on slightly slackening demand for whatever reason, supply can be slightly curtailed. Excess stored, soon mopped up. But instead Saudi Arabia & Russia had *ramped* production up in wrestling for market control. An important day March 9th, crude prices plummeted by -30%: greatest one-day 'fall off the cliff' in oil of roughly past 30 years. In that March, US benchmark West Texas Intermediate (WTI) crude had fallen -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 by the Ides of March 2020, was that America's crude price might yet drop well under $20/barrel absent intervention. There might then be 1.8 billion surplus barrels of crude, yet 'only' 1.6 billion of storage capacity.

Prices under $50 vex, under $30 threatens America's oil industry, both shale & conventional. Producers from tiny to huge are a diverse lot and all felt pain. Texas in 2020 had some 174,000 wells of most every imaginable kind – some so curious as to be hard to believe. Latter Q1 2020, the White House thus embarked on an unusual path for an 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, the indebted shale producers. But oil was near just $20 then, and was likely going lower due to demand destruction. It could go briefly near zero in theory some places maybe on volatile futures contracts trading. Storage was filling, was near tank tops, so fixes were badly needed as bridge until activity bounces back.

E.g., May 2020 front-month WTI contracts would expire late-April. So, if -25% less demand was not met by great production cuts, fears grew of 'tank tops' like in landlocked Cushing, Oklahoma US. 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 -$37 close. Contracts months out were less distorted. But WTI oil even near $20, still showed US/global oil markets were in distress. Even a better global benchmark, costlier North Sea Brent crude had briefly dropped down near $20 by late April. Not nearer zero, yet oil near $20 meant production cuts worldwide. Perhaps 1 million oil patch jobs & expertise might potentially disappear. Rig counts fast dropped, capacity tight, wells shut-in, bankruptcies – some wells perhaps might not be (expensively) re-started. Maybe will force some US shale producers to shut in, pain perhaps was an initial aim like in 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. By latter 2023 oil was again be near $100 – with the US the biggest oil producer in the world in early 2024! But that all of course unknown to the oil industry, back in a panicky 2020/2021.

Perhaps much was down to timing. In 2014-16, opening spigots failed in a thriving oil-hungry world; impacts were muted. Oil did drop near $50 briefly. Yet excesses soon were absorbed. Was not enough fall to kill 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, 2020, only lower-cost conventional producers can survive. Later on, raise prices, post-shale bankruptcies. It's long said a cure for cheap oil, is cheap oil – seen again & again. More market-share re-captured by those lifting oil from ground most cheaply, by conventional means. If competing shale capacity was gutted, 'too-low' prices near $20-$30 might disappear. (All very unlike clean energy where lower prices can go lower and lower, without that floor of oil. Also unlike clean energy, as choke points can hit oil hard: at a Strait of Hormuz as about 25% of all oil trade passes through it; Strait of Malaga as about 75% of China's energy imports pass through; the Suez Canal, Bab El-Mandeb strait; Taiwan Strait under obvious geopolitical threat, and Panama Canal facing drought and climate risk).

Thus in 2020 on a pandemic + on tank tops, oil went under <$20. Quickly reviving economies & getting oil demand back, was essential. Oil-rich nations may ideally want high crude prices nearer $70 - $100 like 2022-24. To let them better balance their own books, national budgets. But, regaining firmer demand was first. Proposed conventional new oil projects were anyways uneconomic, without oil at least well above $50. Plus for nations it's vital to realize, pump crude while its still richly valued. Vast underground reserves held too long, look increasingly like maybe stranded assets one day. As such, they might be of sharply diminishing value due to CO_2/ climate concerns – or electrification. The ascent of electric vehicles, or simply on changed economics. Meanwhile, US oil companies might want oil around $70-80.

Globally then, oil industry had faced pressing fears April 2020: Inland wells for instance without either Port or storage nearby, nor distribution pipelines - might have to sell crude for unthinkably low-prices. Lacking close by off-takers might mean dreaded tank tops. In Canada for instance, inland wells far from ports were lifting heavy crude that's then hard to move; suddenly, mounting product upended all, raised fears of a runaway cratering. Vast demand destruction further benighted industry's evaporating total storage, changing everything. This was the 'logic' behind the oil industry's 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 the US by only 'organically' cutting – that is, just by 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, long before OPEC) ordering rare cuts as 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 of 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, cutting 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 on landlocked Cushing fears, proved to be not as 'useful' as Indexes for Brent Sea Crude (stayed positive with $20 bottom then) – and even new Oil Indexes like in UAE.

It was about getting past an immediate crisis, re-starting oil demand in 2021. Crude might then rise organically – on demand rebirth or on 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 re-open 2021. If Covid is increasingly endemic, more like a 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 coal – long dirtiest and cheapest energy – although still dirtiest, in 2020 became relatively costly. Fracking had long ago pushed down natural gas prices strongly. Natural gas at -90% cheaper, became in 2020 very attractive for making power. Unsurprisingly one after another, US coal-fired power plants closed.

Thus, when a benchmark Brent crude fell Q1 2020 to $26/barrel, with Australian coal at $57/metric ton or roughly equivalent being by analysis 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. The levelized costs (+ fuel) for solar & wind had fallen too, they were relatively attractive vs old coal or gas. In sum, dirty energy was briefly getting both 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, eating up slack. Oil's crash had uncomfortably gotten near to upending more in the oil patch. Key hub Cushing's 4 huge tanks nervously had grown full-ish. Pipelines to forward crude, had slowed to closer to like storage that could have meant a kind of oil constipation backing-up to producer. Had 5,500 miles of pipes for refined product from Gulf Coast to mid-Atlantic, stopped accepting gasoline, no contracted-buy 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 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 began with oil tops on lips, gave way to a 2021 with tops largely unnoticed. Then to war in 2022, demand surging - or at least, prior oil/gas surpluses no longer any concern.

2022, much changed: oil, especially gas went new directions. Russia shut supply, changing a great deal. Before, renewables were rather unaffected by oil & gas crises. But with oil/gas very pricey, growing clean energy/storage/even H_2 was an aim. Storing electricity is simple, if little's needed; push water high, release it as power's needed; plus some batteries. But early 2020s much changed. Vastly more needed meant 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. Yet if Texas is a nation, that PV would have ranked it 5th - after China (30 GW), EU (16 GW), a whole US (13.3 GW), Japan (7 GW) – ahead of say, Vietnam at 4.8 GW of PV in 2019. Then in 2022 Texas' wind+solar fast made some >35% of its needed power at 27 GW, and it was growing faster in 2023/2024.

So, very generally, think of US needs as 20x more renewables capacity than existed 2022. More needed for industrial processes like green heat in steel & cement. Roughly a dozen-fold plus increase in solar capacity plus great new wind capacity. One 1,300 MW (1.3 GW) Texas solar farm going online 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 Clean Energy Index® Reports was on *Solutions*. Not on CO_2 - nor climate *per se* – but rather on solar, wind, EVs, storage etc as ecologically & economically better paths. Climate Crisis was a big driver - but that CO_2 itself wasn't a core theme in Index Reports. Lately however, global heating and weather extremes are coming in at worse ends of what models have foreseen. In short, CO_2 dearly matters, so let's address it directly.

For an acute sample of remarkable science here, a 2020 article in Proceedings of National Academy of Sciences warned that in a span of just a "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 current trends in particular, CO_2 & population, a narrow temperature niche that our species has long required is projected to change more in just 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

So, we're giving increasing pages in our Reports to climate & CO_2 in clean energy's story. Decarbonization and 'Environmental, Social & Governance/ESG' (just 'E'). First here note: CO_2 has been a hero to our species – in moderation. Earth without CO_2 might have had near 0 C surface temperatures. Instead, heating thanks to CO_2 in tiny concentrations well under 400 ppm, had long meant greenhouse gases naturally gifted us average temperatures near ideal for us 59 degrees F. We've habituated ourselves to that over ten thousand years plus.

Late 1950s as regular CO_2 monitoring began, modern readings were already rising from what had long prior was near 280 PPM, to 315 PPM. By 1988, scientists became alarmed as planetary warming due to increases in CO_2 had reached 350 ppm. Worried, a world conference held in that year called for reducing from a 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 at it, that nebulous agreement to try to act was a 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 by 2017 - to over 400 ppm in 2020s. That's higher than in at least last 3 million years. Maybe highest in last 12 million years. So mere aspirational words absent acceptance & robust action, has woefully not achieved what's needed on decarbonization for climate.

Yes, more specific cuts were laid out 5 years after, in a 1997 Kyoto Agreement on climate. Yet CO_2 went on rising, even more sharply. It's been a mockery of acting on CO_2. International agreements were again tried in 2009, but that Copenhagen event failed. CO_2 levels continued increasing, temperatures spiking up. A 2015 Paris Agreement was roughly more of the same. CO_2 was still on a fast uphill, scary climb. By 2020, only 3 countries had met early Paris terms: Marshall Islands, Suriname, & Norway which made up only 0.1% of emissions globally. In short there's been No cause for optimism. The gathering in Glasgow 2021 meant to take stock and speed progress – failed. The truth is despite flowery words, there's been woefully little.

In sum commitment Isn't there. That's why it's arguably crucial to see *clean energy even *unsubsidized,* can soon beat fossil fuels; *there's slight, but some recognition of science; and *since the Covid-19 crash the notion of big change – like decarbonizing away from dirty fossils – to cleaner paths while creating jobs – seems just a bit more approachable worldwide.

And nearer-term just to 2100, intercomparisons of some 56 climate models indicate some most awful possibilities *may* be a bit less likely. Barring say, methane feedbacks, underseas clathrates, water vapor, permafrost change, & hoping for no other mal-contributions, then models' scariest near 9 degrees F by 2100 *may be* less likely on recent understanding. (That would be less than 9 F from here, as there's been some warming). Those models assumed a high fertility, widespread global coal, and failure to strongly embrace renewables. Such models may be realistic, but their highest/worst-case predictions of an unlivable 9 degrees F warming so very soon, may be less likely. On the other hand, studies in 2021 showed 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 highest end Representative Concentration Pathway (RCP) 8.5 unlikely, heaviest CO_2 emissions of that band improbable – then we should also regard lowest RCP 2.6 even more unrealistic. It assumes widespread embrace of renewables already far greater than is seen, and No use of coal (ha). Neither one, especially latter, was close to accurate early 2020s.

And lower-end of that wide and 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 to concern nations & leaders, greatly. RCP 8.5 one basis for the prediction (above) of mass loss of the inhabitable niche of climate by 2100.

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 2080 or so, then decline. (CO_2 in atmosphere rises and 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 fast accelerate.

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

Next, very ambitious, is hoped-for RCP 4.5: emissions peak in about 20 years near 2040, then fall fast. CO_2 not long ago stable at 280, and now over 400 & rising fast, rises in this view to 'just' some 650 ppm – unlikely, but then stopping there. Strong decarbonization is assumed to be undertaken, from now, with CO_2 in time dropping. That *may* be possible, although it's a huge stretch to be sure. And arguably unlikely, on present CO_2 already some 50% greater than near 280 ppm pre-industrial era, rising fast. Perhaps 4.5 is very improbable, as hundreds of new coal plants are *being built, right now* early 2020s. Each with a life of 20 years or more. Hence in operations in 2040s and after, unless they are prematurely shuttered.

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

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

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

That moderately ambitious timeline is absolutely do-able. Unfortunately, mainstream science also implies the inertia in this CO_2 scenario destroys global low-lying lands & megacities from sea-level rise & climate crisis. It blows far past a 2 C Paris goal (to say nothing of likely-now-dead 1.5 C aspirations) and can put us unbearably ahead 5 C, even 6+ C degrees hotter.

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

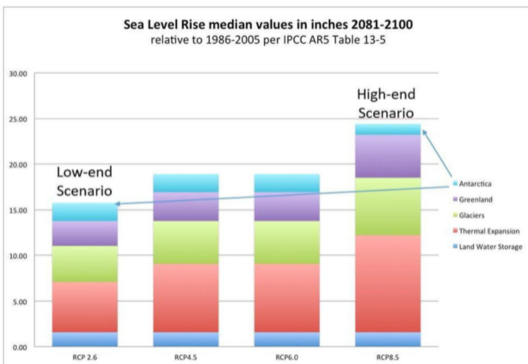
Imagine say, just ~80 years hence. Note then how projections by an Intergovernmental Panel on Climate Change (IPCC) for sea level rise in 2100, may be a bit misleading. For end of century rise may be unwinding at far more rapidly accelerating rates than what seemed to be projected by IPCC. Getting that so wrong, lax policy today allows for too much CO_2, methane, and inertia heat to build unduly. Which could neither be halted, nor unwound.

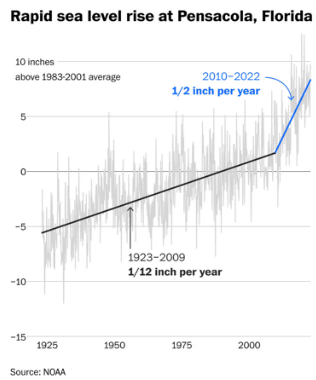
This notion actual sea levels seen in 2100, could be greater than IPCC projections is well laid out in 2020 piece, 'Twenty-first century sea-level rise could exceed IPCC projections for strong-warming futures' by M. Siegert et al., One Earth, 3 (Dec. 18, 2020). Their first paragraph nicely lays out cogently, clearly big ideas that scientists may now find mainstream – yet these same thoughts ought to be viewed by the public 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-10) 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.

Near-term, end of century on strong warming, seas in 2100 may be quite higher than usually accepted IPCC range of 0.61m -1.10m, what the public calls roughly 1-3 feet of rise. In particular, upper end projections are unduly taken by laypersons as maxing about 1.1 meters (~3 feet) higher – yet that's in fact **not** the true ceiling at all. It could be much higher.

Uncertainty now cloaks Antarctica's immense, oft hidden, dynamics. Computer models may thus exclude mechanisms – if machinations are hazy. So shorn of major details, the data suggest global rise is possible *well over* 1.1 meters to 2100, far above 3 ft. Difficulty modeling ice sheet/glacier dynamics in short, potentially left out greater Antarctic contributions. It removed complex & cascading effects. Especially in higher heat scenarios where we seem to be trending - comparing models to reality. So IPCC high-end curiously had indicated *least* rise from Antarctica, even in RCP8.5, high heat scenario in IPCC AR5 (left)! While regionally the Gulf of Mexico saw a recent spike of 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 must be huge concern. Scientists understand a crucial fraction of airborne carbon already emitted from industrial revolution, plus this century (and perhaps next) can persist for thousands of years. In short, CO_2 released in relatively brief window from just 150 years ago to a mere 1-2 centuries ahead even if emissions are mainly halted in a few decades, may have committed the world to a great inertia in oceans. Impacts from unstoppable rising seas, going on for maybe centuries, perhaps on for many millennia.

Science suggests many tens of feet of rise is possible on CO_2. Accelerating rise, maybe locked-in perhaps going on and growing for thousands of years. Past rises seem to have happened in non-linear ways, at times quickly. A meltwater pulse due to CO_2 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' in releasing CO_2, methane and greenhouse gases at rates not seen before. Global reshaping is what we're talking about. So put aside for a moment, noisy political debate. Ignore too impacts say of new diseases, heat, storms, famines, droughts, tornadoes, collapsing ecosystems. Follow-on impacts spreading out like ripples on a pond, like earthquakes following unburdening melting glaciers above land that affect distant tectonic plates. Just impacts of seas rising, is enough.

Climate & ocean inertia is something that we've written about (such as in Scientific American, Oct. 19, 2016): observing for example how problematically, models projecting scenarios of climate change forecast only out to year 2100. At times just to 2050. As a result public discussions have been mostly framed as a lesser "X degrees warming", & "Y feet sea level rise" just to end of century, only. We've accidentally but notably limited our thinking, causing us to miss striking impacts that may go on, beyond an artificial, near time horizon. https://blogs.scientificamerican.com/guest-blog/exposed-the-climate-fallacy-of-2100/

Politicians from Miami, and the State of Florida no doubt want their home to exist centuries ahead. Same, New York City, Boston, Washington DC, London, Shanghai, Amsterdam, Mumbai and so on. Yet their leaders are still discounting staggering losses these places *may* face ahead. That's due in part, to relying on a near-term and distorting 2100 horizon.

Anything like sea level rise going potentially for centuries, or thousands of years, essentially means "forever" on 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 very ground upon which innumerable buildings sit, first as sinkholes then more dissolving all.

And so, we do ourselves a dread disservice by consistently framing just very near-term 2100 as essentially last, final year of impacts. We're thinking in blinkered way decades out, while our foot presses hard on warming 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 and from a scientific perspective.

These data show that in 'recent' past rising CO2/warming starting from 20 millennia ago, had crucially brought Earth out of its last ice age. Air temperatures then rose over a period from that last ice age, to roughly a modern climate that began some 11 millennia ago. From that point, onward, both CO_2 levels and air temperatures then sharply leveled off.

Sea levels, which were at that time still 400 feet lower than today, did not stop rising, however. They *continued rising long past air temperatures reaching their plateau*, rising for another 8,000 years, climbing another 150 feet to today's height. Oceans thud did not achieve near-current state we all know as modern coasts in maps, until roughly 3,000 years ago.

This mere sliver (in geological time) of climate stability lasting last 10 or so millennia, dearly helped human societies, cultures to flourish. But a lesson ought to be, seas are acutely sensitive to CO_2, and temperatures. They can have inertia lagging carbon cycle and 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 rising CO_2 worldwide, and to decrease emissions. This thorny fact is not widely appreciated.

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

Opportunity for us to go on ignoring this plausible dynamic, according to accepted science, is growing vanishingly small. There's already been an-accepted near 1.5 degrees C increase in global temperatures of late. That rate of change alone, seems to come close to what were the greatest natural variations to have occurred over the past 10,000 years.

So current rates of change are very concerning. It took a long period from 21 millennia ago, to 12 millennia ago, for atmospheric CO_2 levels to jump by 80 parts per million - from about 190 to 270 ppm. And in that span, global temperatures rose on average a huge 7 degrees F. We're on track to maybe repeat that increase (or more) - over a far, far briefer period.

For where we're going on CO_2 already now 425+ ppm & rising fast, think first: the Pliocene. A hot Earth then 3-5 million years ago had a forested arctic. We might reach such climate soon. Of course, it'll take a lot longer for equilibrium. For flora & fauna to react, vast changes to come in time with mass-extinctions. But those temps existed a couple million years before we humans later evolved in more comfortable world nearer 230 ppm. Can get hotter still, like a Miocene of 400-600 ppm. Coasts far submerged. Interestingly at 'just' a 400 ppm Pliocene, much of Greenland's ice sheet was gone; the glaciers may be sensitive to 'modest' warming. Millions of years ago, CO_2 changes occurring naturally, took thousands of years to unwind. Maybe tens of thousands of years+ to slowly rise or fall. By contrast, in a human lifetime now, we're exploding CO_2 by astounding 100 ppm+ (!!), so flora & fauna only beginning to react. Cascading exterminations, extinctions seem unavoidable. It's not just the Fact of this Change – but rather is the Extreme Pace of such Change/s, that's bound to be deadly.

In post-Pliocene 3-5 million years ago - or a Miocene from 5-23 million years ago, there were long periods - millions of years of hot Earth before humans appeared, for PPMs/temps to fall. Down from earlier Miocene 400-600 ppm, at times 2,000 ppm perhaps on extreme volcanism. That eventually gave way to hospitable carbon levels, temps we've evolved at, nearer to 230 ppm. Key then, was our planet's ability to pull CO_2 out of atmosphere over very, very, very long periods of time, via Earth's natural 'rock thermostat'. Specifically CO_2 was absorbed for example as by rocks over millions of years. Taken up as by calcium carbonate in oceans.

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

So, pulling extant CO_2 from air & oceans may soon be touted by some as a necessity. Different from clean renewables in first place to prevent pollution, there's a variety of potential (some not so awful) ways to do this – and if done right – sadly may make sense. Of course, it mustn't be done in ways extending fossil fuels. And mustn't be done say, by treating deep oceans too like as an open sewer, injecting carbon there we've been treated the air for centuries.

Rather as noted, any direct capture or sequestration should *Remove CO_2 from air & seas *Permanently, *in Practical, Economic Ways Scalable to Gigatons, with Carbon made *Benign & Stable, and done in ways *Carbon Negative – not merely carbon neutral. If meeting those criteria such technologies *might* conceivably be included say, in Indexes. But in 2021, no such technologies existed. None so ecologically benign yet, nor scalable: a basic requirement.

Conceivably, innovations might arise. New Prizes for cleverer ways to pull that CO_2 from air, incentivizing better albeit bitter action ahead. Perhaps CO_2 may become carbonates, benign solids such as building materials and 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 making shells on CO_2 in dissolved mineral ions in seawater. But this would have to be far faster, must require very little energy, be ecologically benign, no easy task! Or in a single step non-thermal plasma conversion of CO_2 at room temps and say, 15 PSI pressure, rather than requiring 500 degrees F and over 150 PSI. This is a riddle that may not soon be solved. And it's likely then climate impacts may be baked in.

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

An international panel in 2013 gave scenarios for rise this century, straightforwardly on expansion due to warming oceans. But they'd only allowed then for small influence say from runoff from marine ice-sheet instability, MISI, primarily on the 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. 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 of current trends continuing, little action this century to reduce CO_2, led to about 3.5 feet of rise by 2100, rate increasing rapidly to between one third to over half an inch (8 to 16 mm)/year last 2 decades this century. Such a rate under a century hence, could be up to 10 times the 20th century average rise, and it might possibly 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, or 5 inches from 2010-2022 in Pensacola Florida; that may be due to thermal expansion in a hotter Gulf, or slowing, maybe even dying Gulf Stream. And globally, newer papers on ice-sheet dynamics show prior understanding was incomplete, that MISI mechanisms may be much more extensive across 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 may be starting perhaps at Thwaites Glacier now. Unexpected collapse of say Antarctic marine ice sheets could cause previous upper estimates of sea rise to be exceeded, not long after (even before?) end of this century. Although timescales are profoundly uncertain, rapid rises *may* occur in relatively short, say, two to nine centuries. Or as Gulf of Mexico 2010-2022 indicates, with rises of half an inch per year although due to different mechanisms, like ocean currents, far faster.

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

Consider: its likely CO_2 makes a complete failure of pouring $ billions, $ Trillions into armoring coastlines. One can imagine enormously long expensive walls, say 10 feet high topped in just a couple centuries. One can't even imagine bigger seawalls able to handle what could become oceans going 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 but a year in an artefact human calendar: the world's seas will not suddenly halt rising then. Things may get a wee bit better – or wee bit worse due to heating next centuries; maybe more likely a whole lot worse threatening very survival of human civilizations: but it's certain that they won't get a whole lot better.

Scientists are natural skeptics, not prone to dramatize their findings. But cause for abundant hope is fading. That ought to stretch our thinking. Listening to the sea, and to science, ought to adjust our thinking about what's wise. Paleoclimate records indicate 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. Or rise by yet much faster rates to a 220 ft max height ahead. Given aggressive CO_2 trends, that must be considered.

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

Just imagine then, another 7 degrees F change – but instead – of global *heating*. Certainly, that will alter land, seas, & ecology in scales and ways hard to fathom. Looking back to Earth's record it's conceivable on a temperature rise of "only" 2 to 5 degrees F warmer, seas could rise fast in non-linear ways, say going 15 to 65 feet higher. Drowning so much today, like 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 ever stop that. It renders the shapes of whole countries as we know them, today, a distant memory.

Mechanisms by which this happens are easy to fathom. Greenland's ice sheet stores 'only' 22 feet of potential sea level rise, going say, some 10 millennia. However, Antarctic ice sheets store much more: 150 ft. of potential rise. In past years, the East Antarctic ice sheet annually gained some 175 trillion pounds of thin new ice (precipitation). But West Antarctic annually lost much more, some 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 plus inertia, we're heading to conditions unknown in human history. Earth exhibiting changed states that now can only be guessed at. For instance, melting is making Earth slightly alter movements on its polar axis. Length of days changing, as ice melt redistributes mass of water towards bulging equator. Small changes in Earth's spin, may not seem troubling, yet it shows magnitude of change possible from tiny CO_2 molecules. The Gulf Stream keeping Northern Europe far warmer than 'it should be' may already be slowing significantly.

A century, even just decades from now, science strongly implies people may look back on recent year 2021 with a 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 2 inches per decade (considerably faster in 2021, than 50 years prior), were *so much less*. If there's irreversible collapse in Greenland, or Antarctic, far more rapid rises will happen – making a memory of a better past. One where a jet stream & gulf stream existed. It's impossible to say just when things might occur. But given fast rising heat and CO_2, it's sure that change will happen.

Yes, an Inflation Reduction Act had 'felt' like good progress, for it was more than many were then prepared to give. Maybe felt too like clean energy was replacing fossils 'fast enough' – though it wasn't: not given science, physical CO_2 budget, world burning fossils. The dollars in IRA seemed huge – yet were dwarfed by the scale of Global efforts needed: now over $100 Trillion of spending worldwide. So we're likely all in for unbearably hot future. Killing Most Life. Maybe lasting less than say, a million+ years, or even under a hundred thousand years – yet ending us, our cultures, our societies, maybe our species. All on silly reasons, really. On no good reason, we've chosen not to go clean fast enough. Of course, no doubt it's uncertain. Yet, climate risk may mean catastrophic change. Maybe in most everything, everywhere, all at once. Our rampage of burning oil, gas, coal has become a mutual suicide pact, given we know probable outcomes. It's as if we humans are determined to wage an intended war on other life on this planet – making it very hard to cheer our own species on.

Conclusion:

The Clean Energy Index® (ECO) began Q2 at 48, and ended Q2 at 42, down about -12%. Despite hopes last year that inflation might slow and Fed pivot – it hammered this volatile theme all 2023 as ECO ranged from 100 to 70; then in October of '23 it plunged to last year's low of 51. In this capital-intensive interest-rate sensitive story, fears pressed down – vs some eagerness for capital costs to moderate, supply chains loosen. As it grew clear in 2024 rate cuts *weren't* coming early, pessimism again struck; clean energy touched a 1st half low of 40. Year to Date (YTD) 2024, ECO was down in 1H by some -32%. Or last few years, ECO rose +58% in 2019. Remarkably it then rose strongly +203% in 2020 for about the very best performance by any Index or any Fund anywhere. Unsurprising maybe after such gains in 2019 & 2020, ECO fell by -30% in 2021, was off hard -46% in 2022, dropped -22% in 2023 as high rates, supply chaos, perhaps recession - beat out decarbonization that may favor renewables ahead.

Take say since a start of 2023, when ECO was at 80; clean energy benchmark ECO is here down some -44% to mid-June 2024. Yet same period an independent tracker for natural gas (it is not ours, as we focus on clean themes) and gas is key in generating electricity, fell more: natural gas is here *down by* -64%. And while 1st *Global* clean energy Index NEX was down too -22% since 2023 and up only by +7% over the last 10 years – so barely above water – that's still far 'better' this latter period than natural gas which was down by -95% last 10 years!

ECO Deletions for the start of Q3 2024 were: Eos, FuelCell Energy, Lion, Naas, Polestar – and the ECO Additions for Q3 were: Arcadium, Darling, Rex, SolarMax. At NEX for Latter Q2 the Deletions were: Encavis, Fisker (from intra Q1), Gevo, Iljin, Novozymes, OX2, Powercell – and NEX Additions were: Allis, Blue Bird, Darling, Energia, Eurogroup, Hyundai Electric, Tamura, Wasion. At Hydrogen Economy H2X, Deletes were: Gevo, Iljin, OX2, Powercell – and the Adds were: Dae Myoung, Eurogroup, Kaori, SungEel, Voltalia. At Wind Energy WNX the Deletions were: Encavis, OX2 – the the Adds were: Allis, Eurogroup, Taihan, Voltalia, Wasion.

As always, we welcome your thoughts and suggestions.
Sincerely,

Robert Wilder

Rob Wilder
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Appendix I: ECO Index (via independent tracker PBW) components in descending % order infra-Q2 on 4/25/2024, about ~8 weeks before rebalance to start Q3 2024. 71 Stocks*:

First Solar Inc	2.20	SolarEdge Technologies Inc	1.43
Solid Power Inc	1.89	Canadian Solar Inc	1.42
MP Materials Corp	1.89	NEXTracker Inc	1.42
Sigma Lithium Corp	1.87	Brookfield Renewable Corp	1.41
Ormat Technologies Inc	1.82	Tesla Inc	1.39
Fluence Energy Inc	1.82	Blink Charging Co	1.38
Freyr Battery Inc	1.74	ReNew Energy Global PLC	1.36
ESCO Technologies Inc	1.70	SES AI Corp	1.35
JinkoSolar Holding Co Ltd ADR	1.69	Rivian Automotive Inc	1.34
Itron Inc	1.69	NIO Inc ADR	1.32
Bloom Energy Corp	1.69	NaaS Technology Inc ADR	1.32
Bel Fuse Inc	1.68	Lithium Americas Corp	1.31
Lithium Americas Argentina Corp	1.67	FuelCell Energy Inc	1.31
Lifezone Metals Ltd	1.66	Wolfspeed Inc	1.31
Array Technologies Inc	1.65	Archer Aviation Inc	1.30
Ameresco Inc	1.64	Sunrun Inc	1.29
Enphase Energy Inc	1.64	Navitas Semiconductor Corp	1.28
Advanced Energy Industries Inc	1.60	Stem Inc	1.27
Quanta Services Inc	1.60	XPeng Inc ADR	1.27
Piedmont Lithium Inc	1.58	Polestar Automotive	1.25
MYR Group Inc	1.58	Plug Power Inc	1.21
QuantumScape Corp	1.58	Enovix Corp	1.21
Wallbox NV	1.57	Lion Electric Co/The	1.20
OPAL Fuels Inc	1.56	Sunnova Energy International	1.19
Joby Aviation Inc	1.55	ChargePoint Holdings Inc	1.16
Albemarle Corp	1.54	EVgo Inc	1.13
Gentherm Inc	1.54	Shoals Technologies Group Inc	1.09
Preformed Line Products Co	1.53	Eos Energy Enterprises Inc	1.08
LanzaTech Global Inc	1.53	Energy Vault Holdings Inc	1.08
Standard Lithium Ltd	1.52	Amprius Technologies Inc	1.01
Universal Display Corp	1.51	SunPower Corp	0.95
Ballard Power Systems Inc	1.51	Atlas Lithium Corp	0.54
Altus Power Inc	1.49	TPI Composites Inc	0.50
Sociedad Quimica y Minera	1.49	Emeren Group Ltd ADR	0.49
American Superconductor Corp	1.46	Maxeon Solar Technologies Ltd	0.33
Gogoro Inc	1.43		

Some strong representation above from *Thin film Solar, *Batteries, *Storage, *Lithium, and *Geothermal.

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

INDEX (ECO) SECTOR & STOCK WEIGHTS FOR START OF Q3 2024. 70 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 - 12% weight (8 stocks @1.37% each + 2 *banded)
Altus Power, AMPS. Large utility-scale & rooftop solar PV, community solar.
Array Technologies, ARRY. Solar, tracker mounts follow sun through the day
Canadian Solar, CSIQ. Solar, vertically integrated solar manufacturer, China.
**Emeren,* SOL. Solar development, Europe, US, plus 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.
**Maxeon,* MAXN. Solar, efficient PV panel manufacturer after spinoff.
Nextracker, NXT. Solar trackers, optimizing PV daily performance yield.
Ormat, ORA. Geothermal, also in areas of recovering heat energy.
TPI Composites, TPIC. Wind Blades; also light-weighting transportation.

Energy Storage - 28% sector weight (17 stocks @1.55 each + 3 *banded)
Albermarle, ALB. Lithium, specialty materials in batteries for energy storage.
**Amprius Technologies,* AMPX. Silicon anode batteries, greater energy density.
Arcadium Lithium, ALTM. Lithium, producer/processor post-merger.
**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.
Fluence, FLNC. Battery storage, for renewables and digital applications.
Freyr, FREY. Greener batteries, after IRA credits moved from Nordics to US.
Lithium Americas, LAC. Lithium, deposits in the State of Nevada in US.
Lithium Americas Argentina, LAAC. Lithium deposits Argentina; China nexus.
Nio Inc, NIO. EVs, China-based maker of premium vehicles, battery as service.
**Piedmont Lithium*, PLL. Lithium, US domestic source battery-grade lithium.
Quantumscape, QS. Battery, solid state lithium-metal energy dense fast charge.
Rivian, RIVN. Electric vehicles, trucks and commercial fleets, charging
SES AI Corp, SES. Li-metal anode battery, may be safer, faster-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.
Tesla, TSLA. Electric vehicles, pure-play across EVs, advanced energy storage.
Xpeng, XPEV. Electric vehicles, advanced mobility, swappable batteries, China.

Power Delivery & Conservation - 24% sector (15 stocks @1.60% each)
Ameresco, AMRC. Energy saving efficiencies, net zero CO_2, decarbonization.
American Superconductor, AMSC. Wind, grid conditioning; superconductors.
Blink Charging, BLNK. EV Charging, among bigger EV charging networks.
Chargepoint, CHPT. EV Charging, global including for fleets and businesses.
EVgo, EVGO. EV Charging, DC fast-charging Networks, renewable power.
Gogoro, GGR. Electric scooters, swappable battery stations, Taiwan-based.
Itron, ITRI. Meters, utility energy monitoring, measurement & 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.

Quanta Services, PWR. Infrastructure, modernize grid, power transmission.
Shoals, SHLS. Solar, for electric balance of system, wiring, combiners.
Universal Display, OLED. Organic light emitting diodes, efficient displays.
Wallbox, WBX. EV Charging, allows bi-directional vehicle to grid, V2G.
Wolfspeed, WOLF. Electrifying power, Silicon Carbide SiC, converters.

Energy Conversion - 20% sector weight (13 stocks @1.50% each +1 *banded)
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.
**Energy Vault,* NRGV. Gravity energy storage; can repurpose old wind blades.
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 – 10% sector weight (5 stocks @1.80% each +2 *banded)
Brookfield Renewable, BEPC. Renewables hydro, wind, solar; energy storage.
ReNew Energy, RNW. India renewables, among largest there in solar & wind.
**SolarMax,* SMXT. Solar rooftops & batteries installer, homes, commercial.
**Stem,* STEM. Microgrids, smart new energy storage via machine learning.
Sunnova, NOVA. Solar provider, operating fleet for residential, plus storage.
SunPower, SPWR. Solar system provider, storage and distributed generation.
Sunrun, RUN. Residential solar systems, PPA, lease or purchase rooftop PV.

Cleaner Fuels – 6% sector weight (4 stocks @1.50% each)
Darling Ingredients, DAR. Renewable biodiesel, sustainable aviation fuels.
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.

Appendix III: **WilderHill New Energy Global Innovation** (NEX) via independent tracker (PBD) on April 24, 2024 – or about 5 weeks before next Rebalance in Latter Q2 2024. 110 stocks:

Shihlin Electric & Engineering Corp	2.30	Rexel SA	0.97
LS Electric Co Ltd	2.11	Kingspan Group PLC	0.97
Ta Ya Electric Wire & Cable	1.52	Samsung SDI Co Ltd	0.96
Chung-Hsin Electric & Machinery	1.40	Motech Industries Inc	0.96
Fugro NV	1.31	Xinyi Energy Holdings Ltd	0.96
Encavis AG	1.31	Tianneng Power International Ltd	0.96
Xinyi Solar Holdings Ltd	1.27	Landis+Gyr Group AG	0.95
Toyo Tanso Co Ltd	1.27	Ormat Technologies Inc	0.94
Lotte Energy Materials Corp	1.22	Acciona SA	0.93
Core & Main Inc	1.21	Vestas Wind Systems A/S	0.93
Itron Inc	1.18	China Datang Corp Renewable	0.91
Atkore Inc	1.17	Orsted AS	0.91
RENOVA Inc	1.17	Scatec ASA	0.91
Prysmian SpA	1.15	Enlight Renewable Energy Ltd	0.91
Flat Glass Group Co Ltd	1.15	Verbio SE	0.90
Subsea 7 SA	1.14	Sino-American Silicon Products Inc	0.89
Teco Electric and Machinery Co Ltd	1.14	Brookfield Renewable Corp	0.88
Nordex SE	1.13	NFI Group Inc	0.88
Neoen SA	1.12	Ecopro BM Co Ltd	0.88
NKT A/S	1.11	NEL ASA	0.88
Yadea Group Holdings Ltd	1.08	EDP Renovaveis SA	0.87
First Solar Inc	1.08	Mercury NZ Ltd	0.87
Ganfeng Lithium Group Co Ltd	1.07	Corp ACCIONA Energias Renovables	0.87
Nexans SA	1.07	United Renewable Energy	0.86
Verbund AG	1.06	REC Silicon ASA	0.85
Wacker Chemie AG	1.06	AcBel Polytech Inc	0.85
GS Yuasa Corp	1.05	Boralex Inc	0.85
Sociedad Quimica y Minera de Chile	1.05	SMA Solar Technology AG	0.84
Signify NV	1.05	Ameresco Inc	0.83
Hubbell Inc	1.04	Elia Group SA/NV	0.83
Voltronic Power Technology Corp	1.04	West Holdings Corp	0.83
SPIE SA	1.03	OX2 AB	0.83
Innergex Renewable Energy Inc	1.02	Phihong Technology Co Ltd	0.83
Energix-Renewable Energies Ltd	1.02	Enphase Energy Inc	0.81
Novonesis (Novozymes) B	1.00	Iljin Hysolus Co ltd	0.81
Hannon Armstrong Sustainable Infra.	0.99	CS Wind Corp	0.80
Takaoka Toko Co Ltd	0.99	Universal Display Corp	0.79
Terna - Rete Elettrica Nazionale	0.97	Bloom Energy Corp	0.79

JinkoSolar Holding Co Ltd ADR	0.79	Aker Horizons ASA	0.67
TPI Composites Inc	0.79	SolarEdge Technologies Inc	0.65
Doosan Fuel Cell Co Ltd	0.79	NIO Inc ADR	0.63
Ceres Power Holdings PLC	0.77	EVgo Inc	0.63
Ballard Power Systems Inc	0.77	FuelCell Energy Inc	0.62
ITM Power PLC	0.76	Canadian Solar Inc	0.61
XPeng Inc ADR	0.75	Plug Power Inc	0.58
Kempower Oyj	0.75	Sunrun Inc	0.58
Array Technologies Inc	0.75	Rivian Automotive Inc	0.55
Wolfspeed Inc	0.75	ChargePoint Holdings Inc	0.55
Solaria Energia y Medio Ambiente SA	0.73	Meyer Burger Technology AG	0.54
PowerCell Sweden AB	0.73	Alfen N.V.	0.53
Nibe Industrier AB	0.72	Shoals Technologies Group Inc	0.49
Gevo Inc	0.70	Stem Inc	0.48
Archer Aviation Inc	0.69	SunPower Corp	0.43
Lucid Group Inc	0.69	Sunnova Energy International Inc	0.32
QuantumScape Corp	0.69		

There's strong representation above from *Heavy electric products and switches (Taiwan), *Power Transmission and distribution (S. Korea), and *Electric wires and cables (Taiwan). In short, grid infrastructure (esp. Asia) generally outperformed new energy generation in period above.

**Trading in Fisker was halted in late March 2024 and it was removed from NEX effective date 01 April 2024.

Appendix IV:
WilderHill New Energy Global Innovation (NEX) - for Latter Q2 2024. 111 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 Horizons ASA	Green hydrogen & ammonia, wind, CO2 capture.	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
Ameresco	Energy savings, performance contracts, renewables.	EEF	USD	US
Archer Aviation	Electric aircraft, eVTOL maker, for short hops.	ECV	USD	US
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
Brookfield Renewable	Hydropower, wind, solar, energy storage, H2.	ROH	USD	US

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
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
Energia Innovacion	Solar farm development, vertical integration.	RSR	EUR	SPAIN
Energix Renewable En.	Wind & solar, producer Poland, US, Israel, 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
Eurogroup Laminations	Electric motors, generators, in EVs, pumps, efficiency.	EEF	EUR	ITALY
EVgo	EV charging, an early leader in fast charging.	EEF	USD	US
First Solar	Thin film solar, CdTe low-cost alternate to polysilicon.	RSR	USD	US
Flat Glass Group	PV panel glass, solar engineering & construction	RSR	HKD	CHINA
FuelCell Energy	Fuel cells, high temperature and hydrogen.	ECV	USD	US
Fugro NV	Geo-data, subsea offshore wind construction, cables.	ROH	EUR	NETHER.
Ganfeng Lithium	Lithium, produces compounds, metals, for batteries.	ENS	HKD	CHINA
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.
Lotte Energy Materials	Rechargeable battery materials, elecfoils in batteries.	ENS	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.
Meyer Burger	Solar, modules, heterojunction high efficiency.	RSR	CHF	SWITZER.

Motech	Solar, cells and modules manufacturing.	RSR	TWD	TAIWAN
Nel ASA	Hydrogen, in fuel cell vehicles, renewably, Norway.	ECV	NOK	NORWAY
Neoen SA	Renewable energy, mainly in solar, some wind.	RSR	EUR	FRANCE
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
REC Silicon ASA	Solar, greater high-purity silicon focus PV, Norway.	RSR	NOK	NORWAY
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
Scatec ASA	Solar, hydro, wind, storage, green methanol, global.	RSR	NOK	NORWAY
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
Stem	Smart battery storage, AI energy management.	ENS	USD	US
Subsea 7 SA	Offshore wind, and power cables; has Seaway 7.	RWD	NOK	UK
Sunnova	Residential solar and energy storage installation.	RSR	USD	US
SunPower	Solar, efficient PV panels with rear-contact cells.	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
Takaoka Toko	Wind power on grid, EV charging, manufacturer.	ECV	JPY	JAPAN
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
TPI Composites	Wind Blades; also light-weighting in transportation.	RWD	USD	US
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 Energy Holdings	Solar Farms, a spin-off from Xinyi solar glass, China.	RSR	HKD	CHINA
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

111 stocks = % Weights **<u>% WEIGHT EACH COMPONENT = 0.900900</u>**

Additions for Latter Q2 2024: Allis, Blue Bird, Darling, Energia, Eurogroup, Hyundai, Tamura, Wasion

Deletions for Latter Q2 2024: Encavis, Fisker (removed intra-Q1), Gevo, Iljin, OX2. Novozymes, Powercell

111 Stocks for Latter Q2 2024.		**#**
Energy Conversion	**ECV**	**24**
Energy Efficiency	**EEF**	**27**
Energy Storage	**ENS**	**12**
Renewables - Biofuels & Biomass	**RBB**	**2**
Renewables - Other	**ROH**	**7**
Renewable - Solar	**RSR**	**26**
Renewable - Wind	**RWD**	**13**
		111

Appendix V: Comparison of 4 leading WilderHill Indexes for clean & green themes:

Index	**WilderHill Clean Energy (ECO)**	**WilderHill New Energy Global Innovation (NEX)**	**WilderHill Hydrogen Economy (H2X)**	**WilderHill Wind Energy (WNX)**
Theme / Year went Live:	1st Clean Energy Index – live since 2004	1st *Global* Clean Energy Index – live since 2006	New for Hydrogen – went live 2022	New for Wind Energy – went live 2022
Index Components can be on:	U.S. Exchanges: the NYSE, NASDAQ	Global, Solactive developed nations[i] plus Taiwan, S. Korea; most outside U.S.	Global, Solactive developed nations[i] plus Taiwan, S. Korea	Global, Solactive developed nations[i] plus Taiwan, S. Korea
Weighting Method:	Modified-equal weighting gives role to all components; no overweight top	Straight-equal weight gives role to all components; no overweight at top	Straight-equal weight gives role to all components; no overweight at top	Straight-equal weight gives role to all components; no overweight at top
Component minimum floor requirements:	Over >$50m market cap. Share price over >$1.00. Any companies under <$200m market cap at rebalance, are *Banded at 0.50% weighting each Calculations by New York Stock Exchange (NYSE)	Over >$100m market cap. Over >$750k ADTV existing components; Over >$1 million ADTV for new components. No breach of UN Global Compact principles. No ESG severe controversies on categories and thresholds provided[ii]	Over >$100m market cap. Over >$750k ADTV existing components; Over >$1 million ADTV for new components. No breach of UN Global Compact principles. No ESG severe controversies on categories and thresholds provided[ii]	Over >$100m market cap. Over >$750k ADTV existing components; Over >$1 million ADTV for new components. No breach of UN Global Compact principles. No ESG severe controversies on categories and thresholds provided[ii]
Independent Tracker ETF Fund	Yes: PBW in U.S.	Yes: PBD in U.S. Yes: GCLX Europe	Yes: HYSE in Europe	Yes: WNDE in Europe
Clean – avoids fossil fuels & nuclear power:	Yes, volatile with smaller cleaner pure-plays	Yes, volatile with smaller cleaner pure-plays	Yes, volatile with smaller cleaner pure-plays	Yes, volatile with smaller cleaner pure-plays
Cognizant of SFDR, BMR in Europe:	n/a	Yes, coming	Yes, article 9 deep green	Yes, article 9 deep green

[i] See the latest Solactive List of Developed Countries, https://www.solactive.com/documents
[ii] For details on fields and thresholds applied for exclusion, please refer to individual Index at, Methodology
ECO Index® is owned by WilderShares. NEX, H2X, WNX Indexes are owned by WilderHill New Energy Finance.
ECO Index is calculated by NYSE. The NEX, H2X, WNX are calculated by Solactive AG in Germany.
March 2023.

Appendix VI:
WilderHill Hydrogen Economy Index (H2X) for Latter Q2 2024 (60 components):

NAME	Description	Sector	Activity
Aker Horizons ASA	Green hydrogen & ammonia, wind, CO2 capture.	HI	NORWAY
Alfa Laval	Heat exchangers for green H2 production, electrolyzers.	HS	SWEDEN
Arcadis NV	H2 network, Netherlands, Europe, in planning.	HI	NETHER.
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, SOFC high temps can use variety of fuel sources.	FC	USA
Brookfield Renewable Energy	Teaming to produce green hydrogen from hydroelectricity.	HI	USA
Ceres Power Holdings PLC	Fuel cells, high SOFC temperature allows variety of fuels.	FC	UK
Chart Industries	Liquid hydrogen, storage and transport expertise.	HS	USA
China Datang Renewables Corp	Wind & hydro in China, that's developing H2 projects.	HG	CHINA
Chung-Hsin Electric	Fuel cells. Hydrogen, methanol reformers.	HG	TAIWAN
Compagnie Plastic Omnium	H2 storage, high pressure tanks, vehicles, fuel cells.	HT	FRANCE
Corp. Acciona Energias Renov.	Green H2, new GreenH2Chain to ensure green H2 origins.	HI	SPAIN
Dae Myoung	Wind, solar, H2, virtual power plants, sell RECs/CERs.	HG	S. KOREA
Doosan Fuel Cell	Fuel cells, high temperature for a variety of fuels.	FC	S. KOREA
Eurogroup Laminations	Motors, E-traction motors in EVs, trains; generators.	HT	ITALY
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
Greenvolt Energias	Biomass to hydrogen without need for combustion.	HG	PORTUGAL
Hanwha Solutions	H2 storage, refueling vehicles, drones, aerospace.	HS	S. KOREA
Hyosung Advanced Materials	Advanced composite materials for hydrogen tanks.	HS	S. KOREA
Hyster-Yale	Lift trucks, powered cleanly by hydrogen fuel cells.	HT	USA
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
Neoen SA	Water Electrolysis and renewable energy for green H2.	HG	FRANCE
Neste Oyj	Renewable hydrogen and diesel, SAF, but some fossils.	HG	FINLAND
Nexans SA	Cables, can carry both H2 + electricity, H2 pipelines.	HT	FRANCE
NFI Group	Hydrogen fuel cell electric power in buses,	HT	CANADA
OCI N.V.	Green Ammonia, building up from biogas, hydrogen.	HG	NETHER.

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
SKF AB	Advanced bearings, for H2 by compressed transmission.	HS	SWEDEN
SMA Solar Technology	Electrolyzer converters, green H2 from renewables.	GH	GERMANY
SungEel HiTech	Recycling platinum from fuel cell spent catalysts.	HI	S. KOREA
Spie SA	Hydrogen in mobility, H2 production, distribution.	HT	FRANCE
Takaoka Toko	Stabilizing the power grid, use of green H2 on grid.	HS	JAPAN
TE Connectivity	Hydrogen pressure sensors, fuel cell connectors.	FC	SWITZER.
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
Varta AG	Hydrogen gas generating cells, ultrapure.	HG	GERMANY
Verbio Vereinigte Bioen. AG	H2 from biomethane, biofuels, agriculture.	HG	GERMANY
Voltalia SA	Renewables generation for green H2 internationally.	GH	FRANCE
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

5 H2X Additions for Latter Q2 2024: Dae Myoung, Eurogroup, Kaori, SungEel, Voltalia
4 H2X Deletions for Latter Q2 2024: Gevo, Iljin, OX2, Powercell

% Weight each component:
60 Components = % each = 1.66666

Hydrogen Index H2X Sector	
FUEL CELLS (FC)	10
GREEN HYDROGEN (GH)	11
HYDROGEN GENERATION (HG)	11
HYDROGEN INNOVATION (HI)	10
HYDROGEN STORAGE (HS)	9
HYDROGEN in TRANSPORTATION (HT)	9
	60

*Cavendish Hydrogen was briefly spun-off into the Index in Q2, but had insufficient ESG, ADTV threshold to remain.

Appendix VII:
WilderHill Wind Energy Index (WNX) for Latter Q2 2024 (70 components):

Name	Description	Sector	Activity
Acciona	Sustainability infrastructure, engineering.	SG	SPAIN
Aker Horizons ASA	Offshore and floating wind, green H2, grid.	WI	NORWAY
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
Brookfield Renewable Corp.	Pure plays renewables wind, hydro, solar.	WF	USA
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
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
ERG SpA	Wind, going from fossils to clean renewables.	WF	ITALY
Eurogroup Laminations	Smart cores, wind generation, EC motors.	WI	ITALY
Fluence	Energy storage, using intermittent wind in grid.	SG	USA
Fugro NV	Marine geoconsulting, subsea offshore wind.	WI	NETHER.
Greenvolt Energias	Wind, residual biomass & urban demo waste.	WF	PORTUGAL
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
Littelfuse	Wind controls, sensors, circuit protection.	WM	USA
LS Electric	Offshore wind power, transformers & grid.	WI	S. KOREA
Neoen SA	Wind, a lead French independent producer.	WF	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
SBM Offshore NV	Offshore wind energy installations, wave too.	WF	NETHER.
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
Stem	Software, optimizes wind + battery + grid.	SG	USA
Subsea 7 SA	Offshore wind installations, also Seaway 7.	WI	UK
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
Takaoka Toko	Wind power use on the grid, transformers.	SG	JAPAN
Tatsuta Electric Wire	Electric wire and cable, power distribution.	WM	JAPAN
TE Connectivity	On+Offshore wind connectivity, sensors, cable.	WM	SWITZER.
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
Toray Industries	Carbon fiber for wind turbine blades.	WI	JAPAN
Toyo Tanso	Graphite, nanotubes, in wind, H2 storage.	WM	JAPAN
TPI Composites Inc	Wind blade manufacturer, assemblies.	WM	USA
Vestas Wind Systems A/S	One of first, largest, wind turbine makers.	WI	DENMARK
Voltalia	Wind to green hydrogen (H2), ammonia.	WF	FRANCE
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

5 WNX Additions for Latter Q2 2024: Allis, Eurogroup, Taihan, Voltalia, Wasion
2 WNX Deletions for Latter Q2 2024: Encavis, OX2

70 components = 1.4285% Weight each

4 WilderHill Wind (WNX) Sectors **#**

SMARTER GRID (SG)	21
WIND FARMS (WF)	16
WIND INNOVATION (WI)	17
WIND MATERIALS (WM)	16
Total =	70

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.

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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