WilderShares, LLC

Q4 WilderHill® Quarterly Report: ECO, NEX, H2X, WNX Indexes, Dec. 31, 2024

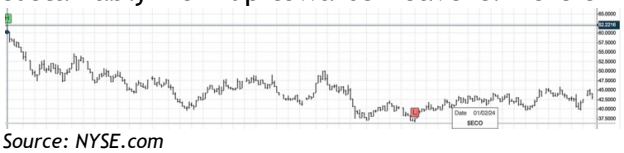
Clean Energy Index® (ECO) that began Q4 at 41.84, ended at 42.25, so up, yet near nil. Despite 2023's hopes inflation may slow, Fed pivot, it hit this interest-rate sensitive theme. When rate cuts didn't arrive, clean energy/ hence ECO Index® that had started out 2024 at 62, touched last year's low of 36. Yet, in the final 4 months of last year, ECO gained even with -- or *perhaps partly because of* the re-election of a president to their 2nd term -- we saw that in this president's prior 1st term 2017 to 2020, ECO rose dramatically. Or look back at the last few years and ECO gained +58% in 2019. Remarkably, it rose strongly +203% in 2020 for about best performance of any Index, or any Fund, anywhere. Unsurprising maybe after such strong gains 2019 & 2020, ECO fell -30% in 2021, -46% in 2022, -22% in 2023, and by -30% in 2024; that overshadowed any decarbonizing trends that might yet favor renewables ahead.

ECO's passive theme is risky & can fall hard. From in 270's in 2021, to down in 30's in 2024, clean energy's story hence ECO plummeted by over ~4/5ths. ECO Index®, Global NEX, Hydrogen H2X, Wind WNX can & do at times 'drop like a rock'. Jumps true, crashes too. Our mission is to capture & track a volatile story, so crashes must be expected. Strong moves down, or up, pervade here not only wind & solar, but across all the renewables; it's always been so.

Despite these falls, clean energy here is doing much 'better' than is natural gas, a competitor in generating electric power. From say start of 2023 with ECO at 80, to end of 2024 at 42, ECO was down near -50%. Yet same period, an independent tracker for natural gas (not ours, as we focus instead on clean) -- fell by more: it was down near -70%. Or past 10 years, a tracker for our own NEX live since 2006 so first for global clean energy was up a bit near nil -- still, far 'better' than a natural gas theme that was down -92% for the past 10 years!

As clean energy & so passive ECO Index fell into 30s in 2024, valuations discounted, some asked if this theme might, possibly, be troughing ahead? *Impossible to say!* Any inflection(?) would also only be after-a-long downturn. Note too a last 4 months of 2024, ECO didn't *fall* -- but instead it *rose* with re-election of president to 2nd term, under whom counterintuitively, clean energy gained sizably in their 1st term. Maybe on thoughts of AI demand, data centers, and 'all the above' energy strategies that could again be a rising tide lifting all boats including renewables on US energy abundance. Perhaps solar/wind gains, seen as cheap new energy -- rather than any climate aspects. We saw ECO was more volatile (upside) in that president's 1st term, than anything in a prior 20 years despite their antipathy to clean energy. That said, *past performance is no indication of future results*. And, to be sure, inflation changes may conceivably, be impactful ahead too -- volatility possibly heading other direction.

In sum new Hydrogen H2X & Wind WNX join respected ECO & NEX in tracking 4 facets of clean new energy. Meanwhile, energy that once was mainly fossil fuels taken from deep down underground & burned -- comes increasingly from renewables sunlight & wind, gifted to us all sustainably from up towards Heavens. Here's ECO over Q4 to end of Quarter/ 2024:



Source: NYSE.com

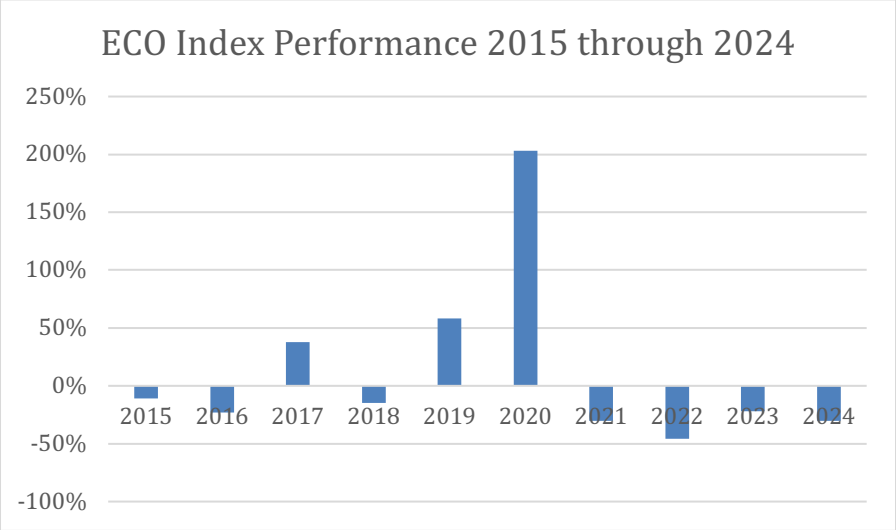
Nov. 2024 elections were impactful, so let's just glance first back at this chart for 2 months just prior to elections, through 2 months following. What changes if any, were seen in notable 4 months from Sept. -- to end Dec. 2024. This captures **ECO, top, black** with Sept. 2024 low. And ECO stands out here ending at top. After a shallow/ brief post-election dip mid-Nov., notably, ECO rises a bit afterwards. Thus, clean energy/ECO rebounded above pre-election-day peak. Some reasons perhaps, for this outcome will be discussed in pages ahead.

Sept. to end of Dec. 2024: here's trackers for 2 WilderHill (WH) themes, **ECO (black) at top** is up (near +4%), and NEX (red) second, down (about -13%). Included too, 3rd is an excellent (not ours) **solar-only** theme (yellow, down -17%. Last, 4th a global 'cleanish' (not so clean; it has brown themes -- so not our's) in blue, with many big caps (down near -19%). Thus:

Source: BigCharts

As we've seen, interestingly, clean new energy installations can grow worldwide, swiftly so – even as its equities fell over 4 years. Yet on re-electing a pro-fossil fuel/ nuclear president -- one not so favorable towards clean energy or climate action -- the green equities at 1st rose. Fascinating. Perhaps a bit understandable! In this president's 1st term 2017-20, long project-cycles in renewables meant they'd enjoyed it as interest rates *fell*. But as as rates rose, green equities plummeted. Oil & gas deriving value upfront, grew more valuable. In shale, one may see one's $ back in <5 years, so high rates had less impact, unlike renewables' carrying costs. Longer permitting times too in solar photovoltaics (PV), in wind, interconnection IX/TX etc -- were headwinds vs. when 'money was free'. Yes world is adding many gigawatts (GW) new PV in 2020s, much in China. More than all other energy combined, any year in history! Yet on overcapacity, a deflationary China, was hard to make profits. Yet gaze out. Look not just at US, or just equities -- and we see an amazing *Pace of Actual Solar Growth Worldwide*. Since 2005, the annual growth of new PV installations worldwide averaged +44% per year to 2024! More new solar capacity was installed globally every 3 days in late 2024 -- than had existed in a whole world in 2005. Hence yes, the pace of solar installations, is rocketing! Yet without corollary growth in profit margins, too, there'd not been heady rise of equity gains.

On now a 'new' president, & congress, it's maybe worth glancing back, to see if there's been past political correlation in this theme. Mid-decade, 2025 a look back at annual returns past 10 years is food for thought. As expected, we see clean energy/ hence the ECO Index is *very* volatile. That volatility is no surprise, in an emerging theme. Yet the annual moves below are *not* what one may have expected -- if one had sought a correlation of ECO with president and party then in power each one of these years. Below is ECO, in 2015 through end of 2024:



This 2nd point centers on the unexpected. Counterintuitive: Not what one may have expected perhaps, in each one of these 10 years. With a *conservative* president in office, clean energy's theme/ hence ECO *rose* very sizably. In 2017-2020, a conservative's 1st term, this clean theme very strongly *gained*. Tallying annual gains/losses in each of these 4 years, it was surprisingly *up* by a very large net +284%; that was up +38% in 2017, down -15% 2018, up +58% in 2019, up big +203 in 2020. Remarkable gains, under a conservative party & leader famously opposing a 'green new deal' or US action on climate risk & carbon. This same president was re-elected to a 2nd term for 2025 to 2028, and so let's watch what happens soon ahead.

Inversely, and maybe unexpected too, is that under a *liberal* president who'd supported climate action, this same clean energy theme captured by ECO *fell very sizably* 4 years 2021 through 2024 by a net total -128% (adding up -30%, -46%, -22%, -30%). Not what one might have predicted! Counter to conventional wisdom, yet in 10 years clean energy *rose* hard under the conservative president -- *fell hard* under the liberal -- opposite of assumptions. But then, looking at 'just' a past 10 years through 2024, perhaps was only a short-ish time horizon.

Supposing was maybe a fluke, on just 1 presidential term on each side, we note a prior ~10 years too from 2005. Here, we see annually 2005 to 2008, a conservative president's 2nd term ended near nil if summing those 4 years (+4% in 2005, +5% in 2006, +58% in 2007, big big -70% in 2008). Waters were muddied a bit by a Great Recession in 2008 that dropped all very hard; consider if it hadn't been for a 4th harsh final year 2008 all globally down, we see that previous and also conservative president would have shown (again also surprisingly) large net *gains* in clean energy's theme/so ECO in their own 2nd term in office. Lastly is a liberal president's 2 terms 2009 to 2016, saw a net -40% *loss* summing 8 years (+28% in 2009, -5% 2010, -51% 2011, -19% 2012, +57% 2013, -17% 2014, -11% 2015, -22% 2016). Hence these 20 years to end of 2024 do *Not* reflect expectations, if assuming losses under a conservative, gains under a liberal. Facts were quite opposite! Resists accurate, easy political predictions, *ex ante*.

As this president did have a full 4 year, 1st term 2017-2020, one can ask: Did decarbonization/ clean energy activity or equity trends decline, reverse then? No! In rhetoric & actions, this same president has *favored* fossil fuels, oil, natural gas, oil, carbon-laden coal, & nuclear -- and has strongly *opposed* renewables: solar, wind, decarbonization. Interestingly, however, we see despite all that, clean energy installations & equities both grew strongly 2017-2020. Solar installations were then up 32%, nascent power storage up 200%; wind installs up 69%, EV sales up 109%, EV charger installs up 129% (latter 3 off miniscule base). Only biofuels were down, and it owed much to overall demand destruction that punished all fuels in Covid-19:

Key Metrics for U.S. Decarbonization

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

Source: EIA, Energy Institute, Raymond James research

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

So importantly, decarbonization was Not halted in that president's 1st term, 2017-2020. Nor may it be 2025-2028(?): remaining critical too are innumerable state-level policies, private-sector goals etc all advancing green energy. More too, a better economics of green power. US States reflect this: rock-ribbed conservative Texas is outpacing liberal blue California on renewables; ruby-red conservative Iowa, Oklahoma, Kansas leading on wind. A liberal Oregon by contrast, failed to start up wind offshore. Globally, one expects a liberal Europe to lead; instead start/stop policies there hinder much. Anything-but liberal China, is a world leader -- even with its supply chains saturated, profits there squeezed. Yes, clean energy equities 2017-2020 jumped. And on an IRA roll-out, 2/3rds of dollars went 1st to conservative states so made it harder to terminate IRA wholesale, yet targeted scalpel cuts may mean hundreds of billions $$ taken off EV funding, DOE Loans, PTC/ITC credits phasing out sooner. That, is understood: Elections & 2024 Red Wave Have Consequences! Yet it's thin; 2 GOP Senators clean energy moderates; yet 53 seats may neutralize it some 2025 in Senate reconciliation. Moderated too by thin House-majority; 18 members in 2024 supported the IRA. Also too, oil & gas executives may Not want so much 'Drill Baby, Drill' bringing lower fossil fuel prices -- so much as to ensure ongoing demand for their products, few regulations, less taxes.

Control of Congress is vital; of House where spending bills originate, & of a Senate where tall 60 votes needed (or on reconciliation only 50). Much nitty-gritty is determined here. That said, regardless of a 2024 red wave, not all clean energy invokes partisan battles; good ideas can be agreed-on despite politics. For instance, more grid capacity is vital for adding in more solar, wind, battery storage -- just as it is for adding in more gas /coal power, and nuclear -- and grids can be bettered without just new poles and pylons. Note then extant cables are often made of heavy steel cores surrounded by thin aluminum conducting electrons. Replacing old wires with lighter carbon fiber core & thicker conductor wires carries more power: this is 'reconductoring'. In say California, a widespread switch to such new cables can hasten better transmission capacity up 4-fold to 2035. Or streamlining permitting is Big. Still, presidency/ control of executive means a lot. For example in 2024, US Treasury expanded a 25% Tax Credit on a CHIPS Act that could help US domestic firms re-shore, to make US solar PV (photovoltaic) ingots, wafers, modules. Hence the politics is complex. And control of the presidency, so the executive matters, albeit in ways that will resist making simple predictions.

So much too is controversial, political. Like say, should a US go faster now on domestic-PV, batteries, mining? Hasten US offshore wind, in face of a president opposing that? How big to go on US – and too in EU on tariffs on electric vehicles (EVs) & solar from China? Go fast on US/EU nuclear plants? Farther out, fights brew on a now-niche clean hydrogen. Europe 2020s was drafting rules so its green H_2 has a nexus to renewables, to guarantee green H_2 is made when sun shines, wind blowing on 'additional' green-electrons. Yet whether it's in Europe, or in a gas-abundant US in mid-2020s, H_2 from natural gas is much cheaper @ €1.50/ kilogram -- than is a green H_2 costing 3x that: no one wants H_2 at that cost! Late 2020s, cheap EVs, solar too *may* soon be made in EU/US. Green H_2 may get less-niche. But mid-2020s, most EVs, like the solar made outside-of-China -- or any green H_2, or e-methane made anyplace -- were all far too pricey. Costs are thus a huge issue. As big new tariff / trade wars perhaps loom

As some fossil-players may claim say, they're making 'green' H_2, on gas-fired electricity or non-renewable nuclear -- by 'trick' of buying RECs (renewable energy credits) separately from wind & solar generated distant places & times. Conservatives can support this. Combine RECs with electrolyzed H_2 -- call offspring clean H_2, no matter the power. Liberals insist H_2 only is 'clean' if directly made by wind or solar on US incentives like a Sec. 45V with electrolyzers in service within 3 years for 'additionality'; focus on climate, avoid CO_2, align H_2 production with actual renewables though hard to implement. Conservatives, on other hand, can favor All of The Above energy strategies thanks to abundant cheap US shale gas, worry far less about carbon or climate risk. Less-controversial, may be dairy RNG (renewable natural gas) made in America's agriculture states. Or, renewable natural gas from landfills or wastes. To avoid methane spills is indeed one good fast way to limit greenhouse gases. Or capture carbon permanently, say by mineralizing it as rock. Or unsurprising, France ahead may push for say, a turquoise 'low-carbon H_2' that's derived from its ample nuclear power fleet.

As fights brew, incentives matter, and US Treasury can partly help to decide what grows. For instance a 45X MPTC (Manufacturing Production Tax Credit) may possibly help US-made PV/wind to get globally-cheap! On politics in part, as it is oil & gas. Say, 5.25 cents Wdc solar tax credit on prevailing wages & apprentices possible for 60% cost reductions in US solar. Conceivably 4 million new US solar/wind jobs, yet we know the IRA will be cut back. In short uncertainty reigns in clean energy, so it's no surprise to see volatility in clean energy stocks. To surely predict what will happen ahead, is regardless of elections and like with equities in general, an Impossible task. Still, some review & analysis here can be useful.

Take say level & direction of Fed Rates that may influence clean energy's theme. Look at Federal Reserve's Economic Data (FRED) for US Fed Funds Effective Rates 2020-24. From low Fed Rates of 1.55% in Jan. 2020, it dropped to a (free money!!) just 0.09% in Dec. 2020. Low rates boosted longer-cycle renewables: Thanks, Central Banks + no inflation! But after, rates leapt from a 0.08% in Jan. 2022 -- to a once-normal yet high 5%+ in latter 2023. We saw then big equity falls here 2021-2024, perhaps not surprising on that spike. Central Banks had to head off inflation; just was that they'd responded late to gathering inflation. That resulted in several years of some of the fastest interest rate increases seen, in well, nearly-ever.

Consider interest rates for these can mean a lot to clean energy's (& equities) theme. Rates as set by Fed/Federal Reserve, get headlines. But important too are 10-Year Treasuries that move differently, on market sentiments: they also mean a lot. In 2020, 10-years remarkably were <1.0%; when ECO jumped +203%. But from 2021, the 10-years rose next 4 years. As Fed finally eased a bit late 2024, 10-year Treasuries did *not* respond same: they at 1st rose! Past a psychologically key 4.50%. If goes past a >5.00%, ahead, that may make riskier clean energy equities harder to justify. But, if falls <4.0%, may help re-ignite animal spirits, renew interest in potential returns in a volatile theme. see eg, https://finance.yahoo.com/quote/%5ETNX

The year 2024 began with ECO sharply down, so it elongated big steady falls of 2021, '22, '23. Charts were ugly then in clean/ all energy. Yet looking back to try divine a bit what's ahead -- is of little weight if trying to see forward! All is just musing, playing with numbers. Finding coincidences by looking backwards, given joys of ample data over 20+ years. There's no way to surmise from just those past facts what may yet be ahead. One might only glance at such thin gruel bit of a past and then guess (and be typically wrong!) about the future.

Confounding above, is impressive pace by which actual new renewables are being installed, with records being set for new $$$ in wind, solar, grid, etc. Global low-carbon investing had hit $1.77 Trillion in 2023, up 17% from 2022. How then can this theme's stocks so plummet, go down for years, again 2024 -- as clean energy grew globally?! We look at that curious fact in pages ahead. Just a brief mention here is as margins compress, as new energy prices fall -- profits have been hit hard. Meanwhile, longer-planning China has 'ignored' overcapacity fears with unshaken policy support, aimed for ever greater market share, ever-lower prices + full employment. Unlike West, where near-term profits are prerequisite. As US & European projects got pushed out by interconnection & transmission (IX/TX) chokepoints. Though new interconnection approvals could grow ~5x in 2025; and in 2023/2024, the 5-year load growth forecasts grew 450%, from 23 GW to 128 GW. Other issues too vex the West like start/stop policies for inconsistent support (unlike in China), scarcity of high voltage transformers, poor grid capacity, lack of domestic lithium etc etc. We'll discuss such thorny factors ahead, as maybe some diverse reasons green energy stocks had dropped hard of late to 2024.

This new president 2025-2028 will bring changes. Perhaps 'All The Above' energy strategies – that embrace solar/wind as instead 'cheap energy', one tool in a portfolio. Here natural gas and soon nuclear 2030s grow as firm power, necessary on intermittency of renewables. Total US energy production expands fast to meet new demand from AI, data centers. Yet, notably with all renewables growing too. Let's briefly look next, at what components were *Most Down* from start of 2024 -- to near-end-year (Dec. 24, 2024). At all 4 volatile Indexes: in original ECO live since 2004 that's made of purer plays on major US exchanges; in global NEX since 2006 as 1st for *global* clean new energy so mainly components outside US; and in the 2 newest global themes of H2X for the hydrogen economy, and WNX for wind energy and grid.

First up is ECO. To near-end of 2024, 3 Components here most *down* included a: *Solar Inverter maker (-84%); a lithium explorer (-79%); and in *Solar services (-74%); most *up* included a longstanding name in wind/grid (+124%). ECO's tracker was down -28% for year (YTD) then, declining the most YTD of these 4 WilderHill themes. At global new energy NEX, 3 components most down to near-end 2024 included a: *European maker of grid equipment (-81%); a German solar inverter maker (-76%); and Finnish maker of EV fast chargers (-69%). Relative to a 1/3rd of ECO components up, a greater % here were Up at near 40% of this NEX theme. Year to date, the NEX tracker was down rather less too than ECO, yet still was well off by -23%.

At global hydrogen H2X, most down to near-end of 2024 had included a: *US fuel cells maker longstanding here (-78%); *S. Korean maker of separator polymers (-73%); *and a Norwegian electrolyzer firm making clean H_2 (-56%). Up most included a *US-based maker of high-temp fuel cells that may use less-clean hydrogen-rich fuels (+64%). Year to date to near-end 2024, H2X tracker was also down less than ECO, and down just slightly less too than NEX at -22%.

At global WNX for wind & grid, components most then down included a: *Swiss holding firm in electrical-measuring gear (-64%); *a longstanding wind manufacturer in Denmark (-54%); *French maker of brushes in electric generators (-42%). Of the 4 themes, a bigger percentage was up, over ½ this theme, and wind WNX was down least of 4 WilderHill themes, off by 'just' -6%. Hence WNX, did 'best' in 2024 followed by H2X, NEX; while ECO trailed. All that, even as global wind energy installations are growing: a record 117 GW new wind was installed 2023, up 50% over 2022. Cumulative global wind capacity hit 1,021 GW, a bit like, say ~1,000 nuclear reactors (though wind is intermittent). Yet on climate goals so heeding CO_2 budgets, for world to stay under <2.7 degrees F, or a 1.5 C max heating, it's far from enough new wind capacity. That said this Index basket Not having had in 2024 losing themes then of solar, or H_2 or EVs -- had meant WNX although down by -6%, was a relative 'winner' of these 4 here.

*A curious fact too for the year 2024 was that once again installations of clean energy grew -- even as equities sank. Note importantly, as clean energy capacity grows, it's also getting *Far cheaper* too by out-competing on low-price vs classic fossil fuels natural gas, oil & coal -- and although intermittent, it's far less costly than nuclear. In 2010, levelized cost of energy (LCOE) then for onshore wind had been a very pricey $0.11/kWh -- was 23% worse/higher than coal/gas @ $0.09. Yet by 2024 onshore wind's cost became 67% better/lower, at just $0.03 -- vs. fossil power @ $0.10. Utility-scale solar, fell even more in cost! from high $0.46 in 2010, or 400% costlier than traditional gas/coal -- to amazingly better $0.04 by 2024, so 56% *cheaper* than fossil average. Battery storage project costs fell hard too, by 89%: those dropped from $2,511/kWh back in 2010 -- to $273 by 2024. Storage shall be key ahead to solar/wind.

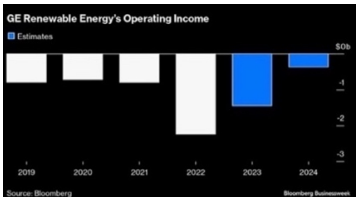
Clean energy hence ECO did touch a 30s nadir in 2024. Earlier in year this theme briefly rose a bit like on tariffs on China, on meme mania, possible Rotation from big caps to mid/smaller caps here. Still, on fears in tech generally, green energy specifically, ECO had touched that intraday low on Sept. 10th of 36(.48). Some asked then as noted with ECO down in 30s, if such low valuations may mean some troughing ahead, given deep-discounted levels? *It is impossible to say!* But at such levels -- past coincidences like steady declines over 3 years 2021-mid-2024, and being down a neat -50%/year, ceased. Plus new factors are in play. For instance late 2024 inflation fell some. A new president, under whom counter-intuitively clean energy rose hard 2017-2020 despite harshly bearish rhetoric and actions: that may be impactful. As can be lower renewables prices, a wave of energy production on AI voracious energy needs. China too may cut ahead some overcapacity in solar, lithium, accept a need for profits. On these & several other factors, clean energy's theme at times, briefly rose in 2024.

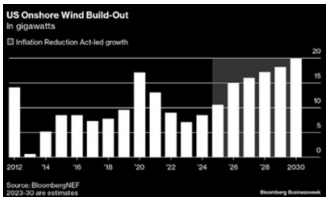
Broadly at least 15+ factors were perhaps at play in a clean energy bearishness 2021-2024. *Debts were sharply up in the US, and Europe, and China; *Inflation rose across the West; as *Interest rates & credit costs jumped, *Hopes for margin expansion/profits in solar, wind, EVs were dashed. *Funding & new Rules needed 'yesterday' were slow to come from US agencies. From *2023, 100+ US residential solar installers went bankrupt, 6-fold figure of prior 3 years as US residential solar installs fell ~15% in 2024, and California was down some 40%-50%. *China's big Overcapacity in solar, wind, EVs etc was sticky, so bubble fears; as *Some supply chains stayed clogged despite *Less demand for EVs, wind, PVs higher costs. *Big-Cap stocks did better than Mid and Smaller-caps here as *Speculative disruptors faced poor sentiments: *100+ SPACs since 2020 also diluted investing. *Ongoing China/vs Western Tensions threatened to decouple strategic green trade ahead. *New House Speaker's 1st bill, & president from 2025 are sure to mean IRA funding cuts. Finally, there's politically as well all sides, lately an *Exhaustion over scientists repeated alarm-bells regarding a (now here?) climate crisis.

Brief blips up at times, like late 2024. Earlier on Nov. 2023 saw a brief inflection up: ECO that month was up +8%. NEX +10%. Hydrogen H2X +10%. Wind WNX +13%. Yet October had dropped hard, so 4th Quarter 2023 ECO was down -5.8%. Not just ECO off hard 4 years in row: competing clean themes dropped too; ECO just presents the longest record, the most data. Against a flood of China's solar/wind & EVs, as its property bubble (inevitably) burst, Beijing has pushed since for more manufacturing capacity, but it lacks domestic demand to sop up all its green 'emerging future industries'. Overcapacity can kill earnings; by 2024 some 25% of mainland China listed firms were unprofitable -- vs. just a 7% the decade prior. All as China tries to ramp its Exports in search of demand, exporting a deflation that hit profits everywhere.

Let's look at wind, for just one facet here. In Oct. 2023 a big wind name made headlines as it abandoned its contracts to develop 2 wind farms off New Jersey. Why might such 'failure' have been bit 'positive'? Well, big wind manufacturers like GE, or Siemens -- were *losing* $$ on each enormous offshore turbine/tower delivered. GE's contract to supply turbines in that deal for a 1st New Jersey wind farm had been negotiated 3 years prior. GE was then stuck with delivering units, even after wind prices had jumped 40%. Thus, a $1.5 billion deal that was obligating GE for new turbines/towers, was putting it ever-deeper into a hole. Ending that contract, ironically, might notably help it to reduce a huge $6 billion backlog. Like (hopefully) in China, accepting the needs for businesses-to-realize profits rose undeniably.

GE was splitting into parts, seeking profitability. It's GE renewables had lost $5.6 billion from 2019 to Q3 2023 -- but its onshore wind was maybe near-profits tail end. Small profits in grid seen late 2023, were its 1st in years. So sour headlines of a cancelled project, maybe helped mitigate issues. First step, if digging oneself in a hole, is stop digging! As GE's renewables narrowed losses, a bottoming(?) ahead seemed, well maybe, at least possible. Q3 2023 losses had slowed -7.6%, off a scarier -26% year before. Better clarity hoped-for latter decade too on incentives in a 2022 IRA law for wind (discussed ahead), so in stocks captured & tracked by say WilderHill Wind Energy Index (WNX). An emblematic GE took 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. Its once-too-many tower designs at 40+ in 2021, had been lessened to 9 by 2025. Rotor options were cut from 15 to 4. In hopes profit margins might, just *possibly,* begin to emerge in years ahead. 2024 saw maybe a bit more maturing too in its onshore US wind. So rather optimistically, there were some hopes that just perhaps, later in this same decade, one might finally start to see an idea of global wind profits ahead. With a build out of US onshore wind possible latter 2020s decade:

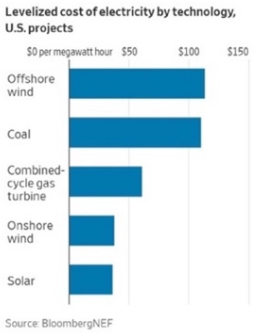


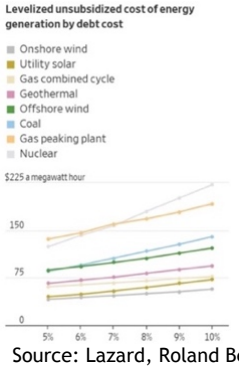


Source: Bloomberg Source: Bloomberg

Many green themed-baskets like ours – saw then an elongated 4 years of declines. Partly on wind: a firm in 2024 pulled out of 2 offshore wind contracts in Maryland, on low offtake offers. Or take a UK that's a leader, at times in offshore wind; in 2022, 13.8% of its electricity needs were met by wind & 2024 was 1st full year more from renewables @ 37% (wind/hydro/solar) -- than fossil fuels @ 35%, so UK knows about successful wind! As US just-started, baby steps from scratch, few supply chains, no wind installation vessels yet! Yet UK has had its own issues. Like a lack of support; just £44 per megawatt-hour (MWh) was offered for offshore wind in 2023 -- it got No takers, auction flopped. After 2024 elections, CfD budget was raised >50% to £1.5 Billion; far greater offshore wind offer of £73/GWh. So, after the 2023 failure -- offshore wind bids returned, 3,367 MW, a 9.6 GW total CfDs awarded latter 2024. Still, a lot is yet needed, if UK is to up offshore wind capacity 4-fold, go from 13 GW wind early 2020s -- to 50 GW targeted capacity 2030. Despite inconsistent support, stops/starts. Plus in mid-2020s on insufficient energy storage. For instance Dec. 10, 2024, a forecast of 2 windless days meant output would plummet from >7 GW, to 2.2 GW, so power prices rose to £175 megawatt-hour, steepest in 2 years, and meant more and costlier fossil fuels would have to be burned. Until there's far more storage capacity on UK grid, and a stronger grid, this is an issue.

And the EU too was also far from its own 2030 target of 30 GW/year. Cash-strapped Germany stepped up with billions of Euros support. Yet China, once again, led in its support by far. Its own wind makers growing to among the biggest; 16 GW commissioned at Xinjiang Goldwind in 2023, Envision 15 GW. In the EU, Vestas did get 13 GW, yet China's Windey, Mingyang grew wind fast. In Germany, PV support led to 124 solar projects, 1,600 GW new capacity that led solar prices 2024 falling to EUR 0.051 (USD $0.056) per kWh -- better/lower than a prior USD 7 cents. In a US, offshore wind supply chains were immature, and things sanguine. Its offshore wind costs had risen too 40%, so wind was pricier than gas 2023, near coal. Onshore wind & PV were the cheapest-options, considering energy costs vs. debt. Clearly better vs. 2 costlier options, nuclear & gas peaker plants. Coal, like offshore wind, sat then in middle on costs. Hence the 3 relative winners were *Baseload natural gas combined cycle, *Utility-scale solar, and *Onshore wind. In sum, these latter 3 were the very best on costs vs debt:





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

Hence for solar/green stocks down 2021-2024, China overcapacity was a real issue. Shorn of market guardrails, profit/loss signals in the West -- profit margins were decimated worldwide. Then once the West from 2025 resists buying/soaking up China overcapacity, maybe applying new tariffs, those results ahead could go in a variety of ways, many pretty impactful.

When PV poly prices did fall 2023 by -50%, panels by -40%, all that super-cheap PV was very tough on Europeans & Americans trying to compete. China's glut was thorny even in its own solar-firmament; its state-guided economy sought full employment, ever-lower prices, more market share. In 2022, China made up 90% of world spending on clean energy. A bewildering array of its firms sought to enter + sell PV, as China firms halted their own expansion plans. 70 listed firms there had gone into solar -- from dairy farming, fish feeds, jewelry, real estate, chemicals etc... (Bit of a story seen before; Toyota of Japan had started out with weaving looms). A Chinese poly leader defied oversupply fears; it aimed to *add* 575,000 tons more capacity, beyond 200,000 tons needed on market growth. After China's prior poly oversupply shakeout of 2010-13, again 2018-20, fears were of a 3rd wave; of China poly prices falling to maybe record lows well under <USD $6/kg. Of China's global poly share rising to 90%. Yes, non-China poly could command *somewhat* higher prices on the desires for domestic product. But at such very big and widening gap, the difference was getting 'ridiculous'...

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

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

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

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

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

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

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

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

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

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

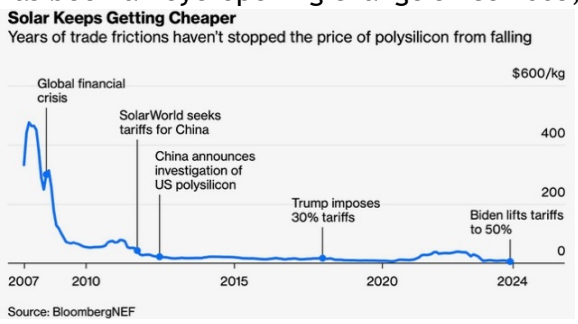
Moore's Law famously shows number of transistors placed on poly chip doubles every 2 years. Such is the room to advance on a silicon base. In China's case, it had faced around year 2000 many vulnerabilities with few oil reserves, and faced oil price spikes. Its government chose instead to target new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

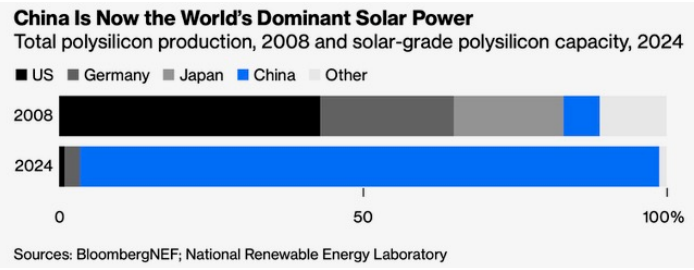
Early 2000s as global poly industry grew, the US PV poly producer invested to expand capacity. By 2005 it announced plans to invest $400 million, then later, another $1 billion. A lot. But consider too, that near 40% of costs in making poly, is the electricity costs. Michigan is industrialized and boasts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

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

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

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





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

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

Some tailwinds *may* yet help the US on Clean Energy: *Older Utility-power gets ever-costlier; as *45X US tax credits are helping build US solar, wind; *US electricity Demand rose in 2024 to 4,099 billion kWh, more in 2025 beating a record 4,003 billion kWh & growing; as *heating & transport are increasingly electrified; *Demand is growing as seen in AI & data centers, re-shoring US chip makers mean nuke plants/or GWs-worth of new demand. Consider too, a US which once had spent $400 billion annually on oil imports, in 2024 was the World's Biggest Producer of Oil (70% shale) & of Gas (80% from shale) -- thanks to shale fracking revolution! US nat. gas met a steady 42% of electricity demand 2023 & 2024; as nuclear is still costly in the West; US nukes met a static 19% of electricity '23, '24, '25. As coal's share fell from 20% in 2022, to 17% in '23, 15% in '24, 14% in '25. Coal's role in US electricity in 2023 was ½ vs. decade prior -- mostly replaced by gas. Meanwhile electricity from new wind, hydro, solar *rose* from 21% in 2023, to 23% in 2024, to 25% in 2025. But it was Not nearly fast enough.

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

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

A COP28 Climate Conference ended late in 2023 also choreographed a shiny (oily) veneer of success. It had highlighted Agreement for 3x global renewables capacity by end of decade: nothing wrong there! A petrostate heading it was smart to put 3x in front. But what they did Not highlight, was also worth considering. Fossil employees/ reps had dominated attendance at COP28 like never before: ~4 times that seen in Egypt a year before. 2,400 people, greater than any Country's Delegation (save Brazil). Quietly too, they'd made *Petro-states' interests a main 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 a "phase out" of fossils -- to softer "transition away from". Some silliness like "responsible yachting". Worse was wording to 'accelerate' [so-called] 'carbon capture and storage'. That COP 28 end-product was deemed 'devastating' and 'dangerous' by many climate scientists, who'd often used much saltier language. In sum the fossil-focused nations viewed this COP28's final result a significant success, indeed they'd Voted for its outcome.

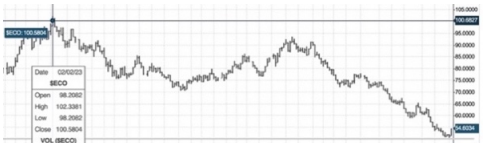
Next, for the data-lovers, are math parlor-tricks, a few coincidences discoverable in clean energy's story given much data. Of mild interest only thanks to ECO calculating live 20+ years. Take a volatile 3 down-years 2021, 2022, 2023. Clean energy's story, tracked by passive ECO saw steady declines. So steady that: 1) each year's high came early-on, in 2021, 2022, 2023 -- that was followed by a nadir low very late in each calendar year; and 2) coincidentally such steady falls meant each year's nadir low was near -½. Thus 2021 dropped by a nearly 'neat' -½ (-49.6%) in going from an early 286.89 intraday high seen on Feb. 10, 2021 -- to its nadir low of 142.39 as seen in an intraday low very late in that year, on December 29, 2021.

In 2022, green energy's story then fell a 2nd time, again from a high earlyish in that year -- to its low very late in year, by near -½ at nadir. From a 1st day 2022 year's high at 152.87 -- the nadir close that year was bit interestingly near -50% (-49.7%) to 76.02, on 3rd to last day 2022. Such -50% fall in this passive story again by chance only, seen looking *backwards* on rich data. Still 2 non-imprecise consecutive steady drops near -50%. Looking for coincidences say Q1 2022, it fell to near, say, a 100-resistance level 4 times. Or, early in 2023 it initially fell repeatedly to a 70; of course, later that year it obliterated that fully-random, 70 value.

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

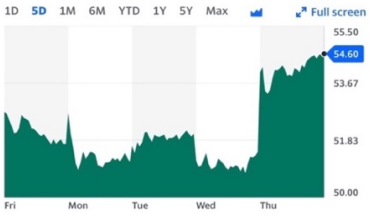
Thus, one mustn't read too much into it, other than to confirm a great volatility, oft down! Like Jan. 2022 this passive theme fell by near neat -30% in blow-out. Down -20% in Jan. 2024. Never predictive, it's ephemeral. Maybe points a bit to 'enter on dips, sell on rips'! One thing noticeable in zooming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

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


Source: NYSE.com

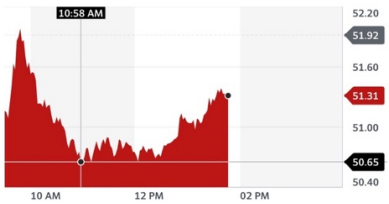
Yet in Oct. 2023 this theme was falling hard & fast towards (past??) a 'conjectured' 51 low: it hit 53 on Oct 23rd; again 25th/26th. Then hit 51(.62) hard on 27th. Plummeting, felt like a rounded 51 (end of year?) might be about to be decidedly breached -- proven quite-wrong in that 3rd year! And yet. End of October clean energy's theme fast bottomed, by a conjectured 51 (-50%) -- touched again Oct. 30th. On November 1st it notably touched (only) a tad lower, 3rd low so far: still rounded 51. If this low were to hold as nadir all 2023 -- then -50% conjecture might be born out, though Not Coming very End of Year. ECO is just a passive theme, yet curious coincidences may be discerned in a sea of data. Next left, this theme did hit a low on Nov. 1st for a 3rd time in 2023 barely at an intraday low of a rounded 51 (50.61). At right, we see the same 51 bottom on Nov. 1st -- in a more conventional 5-day chart:


Source: NYSE.com

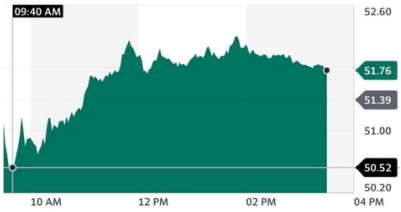


Source: YahooFinance.com

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



Source: YahooFinance.com



Source: YahooFinance.com

In sum, it held for all 2023. Did Not go below, into 40s, bust a 'just-for-fun' conjecture of story down by -½. In Dec. the Fed saw a lane for maybe Rate *Cuts in* 2024 -- reduced concerns weighing heavily on ECO. Theme leapt to low 60s. Big jump, yet premature on hopes for cuts. Hopes then early in 2024 went from say 4 cuts -- to maybe 3, to 2 -- all year! Looking back, 2023 saw the 3rd and last consecutive time a near -50% conjecture was fulfilled -- while a high near start/low at end of year was Lost. 2024's high literally did come 1st day of year at 62.38 (intraday); a bit interesting was to see if a nadir might be late in year -- and/or near 31.19. It did not: low came Sept. 10th so well before end of year -- and was at 36.49 so well above a conjectured -50% to 31. Moreover, notably, having fallen so much, looking forward an early-high/ late-in year low, & a -50% conjecture no longer apply. Especially as rates in 2024 started falling and on election results that ironically may be bullish. In sum, 3 years of coincidences like -50%, ended by mid-2024. For past data, see, https://www.nyse.com/quote/index/ECO

For 20+ years we've looked at how clean energy innovations *may* become better vis-à-vis old energy. At ways, disruptive new solar, wind, EVs, storage, hydrogen (H_2) could potentially, make sense in their own right. We've emphasized too clean energy stocks shall be *volatile; that they can & will 'drop like a rock'*. We're proud as Originals in Benchmark ECO since 2004 -- and Global NEX too as zero-carbon energy to help avoid climate risk in a first place. As solutions that can appeal regardless of climate risk. And yet, climate maybe unsurprisingly is fast now rising to fore of late. Our heating planet seems to shout, along with robust scientific consensus, that tipping points & threats now loom ahead or may be already at hand.

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

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

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

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

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

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

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

In Summer 2023, an extreme heat became too much. Aug. 6th power prices skyrocketed 800% from $275, to $2,500/MWh. Just 1.6 GW spare capacity left 6 pm sunset, as demand peaked at 84.4 GW -- new State record. Emergency cooling centers were set up. Renewables propped up its fossils-grid, kept prices lower thanks to sun/wind -- but could only do so much. Sept. emergency saw just 500 MW left! Or, Derecho winds in Spring may bring 100+ MPH winds. 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 now, unalterably. Normally, a rise of ocean temps of 10ths of a degree is notable: seas require far more heat to rise, than air. Yet in North Atlantic off Newfoundland, Summer 2023, sea surface temps reached 9-18 degrees Fahrenheit (5–10 degrees C) above normal: beyond even many of the most extreme climate models.

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

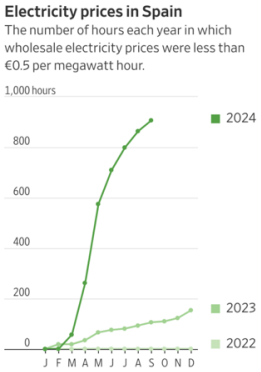
Bloomberg New Energy Finance (and NEF partnered with us early on in creating the NEX) has noted that end of 2020s so just in a few years, the US may build 600 gigawatts (GW) new *solar, *wind, *energy storage capacity. BNEF points as new impetus to Inflation Reduction Act (IRA) discussed ahead: may go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

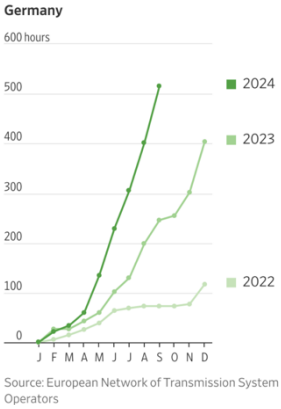
Looked at another way, on 3 big Federal laws since 2022, US may double its recent pace of decarbonizing – to hit 4%/per year *fewer* emissions by 2030. That 4%/year of cuts, brings down emissions by 40% to 2030 -- but that rate still falls short of 50% emission cut called for by the White House. A 50%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

For example, contrary to politically-driven claims, clean energy *can reduce* energy costs. Like in Texas, in Iowa, or Europe -- *renewables can be Deflationary*. In an Australia that once clung to coal, resisted new energy -- on new leaders renewables surged. Output far up year/year. With less need for costlier gas, wholesale power prices went to zero or negative, 12% of time; 9 am-5 pm in populous Victoria & in S. Australia, negative 55% of time. Yet, negative prices disrupt all; old-energy supplier incentives too. Power prices are set in day ahead markets for next 24 hours, so if there's an excess ahead, they'll bid 'negative' prices, harming themselves (harder still on nuclear & coal plants that can't easily shut down). By 2025 over >40% of freestanding Australian homes had PV, >18% of electricity & began to make sense to heat water in day on excess PV to match supply/demand. Just as wrong too, have been critics who've claimed EVs must-forever-be-too-costly: China <$10k EVs have 200+ mile range. Other criticisms perplex, like skeptics who claim that since climate has always changed in Earth's history, curiously then any pro-renewables policies must be bad: perhaps that's on badly mis-understanding the science. Such skeptics' arguments may be retreating just a bit -- but for certain, the skeptics and the climate deniers remain so vocal in so many ways.

3 recent Charts below, using newer data are a bit startling on what they imply, one may infer. The 1st two show how consumers in Europe mid-2020s, lately can take advantage of negative electricity dynamic pricing. In most of US (unlike in EU) retail consumers cannot so access dynamic pricing. (Texas had option nearer it but a 2021 freeze sent electricity prices soaring as gas shut down discussed ahead; yet on these new aspects to renewables'-dropping costs, some US states may rethink it & may allow retail access to dynamic negative pricing too).

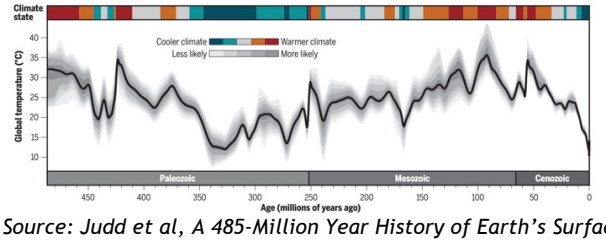
In Europe, prices in 2022 were below zero, only a tiny 0.3% of time. Rose to 2.2% in 2023. In 2024 to a bigger 6%. Places with lots of renewables, can get higher/ 'better' (for consumers): was 8% in Netherlands, 11% in Finland, 12% in Spain. Also shows what may come to US if Rules are relaxed. In US in 2023, just 21% of its electricity generation was made by renewables -- EU was clearly ahead then at 44% in 2023 -- yet some US regions may see changes, if negative dynamic pricing is allowed. Southern California wholesale prices were <zero only 5% of time 2023; but a boom utility-scale solar meant they went negative ~20% of time 2024. (A downside was the 3 million megawatt hours curtailed 2024 could have powered ½ a million of its homes for a year -- but that loss was on a lack of energy storage, and RECs trading). In windy Midwest, like say Iowa in US may see 'too cheap' wind power at times as a boon for its consumers on windier days & nights. The 2 Charts below for Spain at left about to go over 1,000 hours -- and for a Germany at right about to go over 600 hours -- show remarkable growth in their negative pricing that came about in just the three years to late 2024:





Source for both: Wall Street Journal

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



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

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

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

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

Utterly different, was shifts in 2022/2023 from La Nina that held global temperatures down -- to instead twin El Nino, for hotter oceans many places -- maybe going back in 2025 etc. Or further out, heat likely soon that directly impacts us humans. While we simply don't see stunning ocean heat now happening being as consequential, as foreboding as it deeply is, a hot oceans & Mediterranean Sea may have great impacts for even we air-breathing, fine-less bipedal, land-based humans. More than just turning up air conditioning needed in response. Potentially new ocean regimes may be existential threats we can't yet conceive of. Like slowing of key Antarctic overturning current that drives much. All that, right now is right in front of us. May be big near-term risks, yet that we humans seem unable to fathom.

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

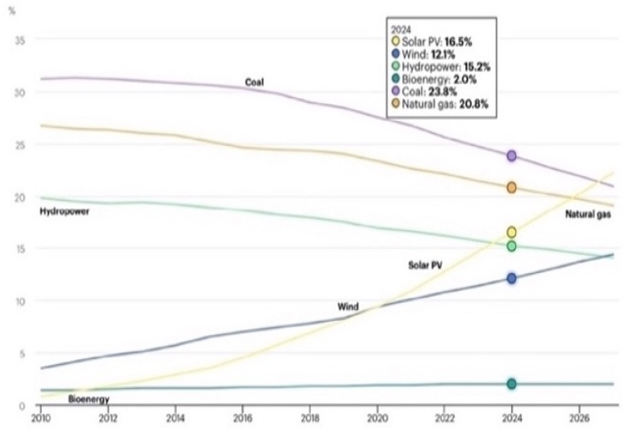
Still, via a climate lens it's scary: nowhere is clean energy going fast enough! Everywhere, sees decarbonizing setbacks. On unending human CO_2 it won't be 'just' 1.5 C hotter ahead; not-realistic. In 2023, China & Saudis refused to raise 2025 targets at G-20 ministers meeting. China was 196% of increased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

Take UK that once had led on wind, but in 2023 chose oil & gas. It sought even if 'net-zero' in 2050, to get 25% of energy from oil & gas. Hoped-for UK offshore wind deals were cancelled in 2023 as Party then in power, felt wind won't pencil on capital costs. Underlying all was a belief putting off climate was 'pragmatic'. But, *that was wrong;* renewables *can be tangibly cheaper*. Spain's new solar July 2023 met 24% of demand -- up from 16% in 2022. In Sicily, ½ excess demand hot summer days was met by new solar. In 2024 a new UK Party took power; a 1st move was to end de facto ban on new onshore wind since 2015. It faces though de-industrializing threat, if new wind turbines & blades kit is from China. A German/Spanish wind giant had giant losses -- thus announced a €2.2 billion charge on wind turbine troubles, a net fiscal year Loss 3x that expected. Earlier, markets had valued its wind unit at €5.5 billion; after gave it near-zero valuation. Wind was pared back worldwide early-2020s; fell 20% 2022 from prior year; saw 32% less growth than a record 2020. Oil & gas though, were different. In 2023, 20% of oil & gas projects slated to start in 2023-28 were at a Final Investment Decision stage (FID). Far better than an 8% seen in offshore wind; a meagre % for H_2 projects. Things after improved: a record 12.3 GW offshore wind reached FID in 2023; vs. just 0.8 GW 2022; later, 8 Euro wind projects for 9.3 GW hit FID stage 2023. Clean H_2 saw just $10 Billion at FID stage in 2020, 102 projects worldwide -- after, projects at FID rose 7-fold in value to $75 Billion, with 434 projects latter 2024; 90% greater FID numbers that October 2023. For sure clean H_2 costs are still much, much, much too costly in 2025, but the progress is real.

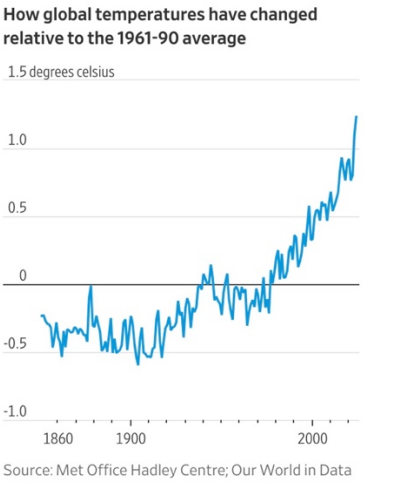
Again, a big Texas in US is a case in point. Its gas plants *will* struggle in cold/heat extremes -- and fuel costs will soar at times. Its Grid is far more prone to breaking down, than leaders knew 2024. One issue is 'firm' fossils & nuke plants will Fail: like in Texas when gas froze off 2021 as some tried to blame renewables: PR efforts scrambled to call only fossils reliable -- despite the facts. 2023 again had shown gas strained in hot/cold beyond that expected when thermal plants were built. *It shall happen again!* As weather extremes grow in frequency they'll challenge thermals struggling in new-typical temps. Greatly adding PV, wind, storage, better grid will help lift teetering lines from failure; keep prices from skyrocketing. Still on climate, without tremendous growth in solar/wind, storage, transmission, robust grid, a resiliency to help keep renewables firm & dispatchable, *that will not be near enough*.

There's bits of good news. Global solar capacity growing 2x every 3 years, expands 10-fold /per decade! 10 years ago, mid 2010s, solar was 1/10th that of mid-2020s. 10 years of growth later, it was up 10-fold. Like growing planet's nuclear plants 8-fold -- faster than building one nuclear plant in the West! Globally, nuclear divides by geography; 2024-2030 may see 55 new nuke reactors as 61 GW, or ½ in China (26) -- rest in Asia & Middle East; 0 in US, 4 in Europe. Newer, safer nuclear reactors may suddenly grow in US, given needs of AI from latter 2020s. However via a lens of what's needed to hold heating to 1.5 degrees C, this decade ends scarily Bust. New temperature records, eg, Sept. 2023 was the hottest Sept. then on record not by a usual 1/10th of a degree -- but by 0.83 F! Yet latter 2020s natural gas is still slated to make huge gobs of power -- despite its CO_2. Global coal still abundant 2027. Some green growth, but spending projected Nowhere near $4.5 Trillion early 2030s. Instead, all overshadowed by inertia of big dirty energy; it made huge 45% of electricity in 2024; coal was 23%, natural gas 22%. Fossils to be still core in 2027. So on climate science, CO_2 /greenhouse gases, the 2020s end as a Bust for all -- with world temps going well over 1.5 C degrees heating:

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

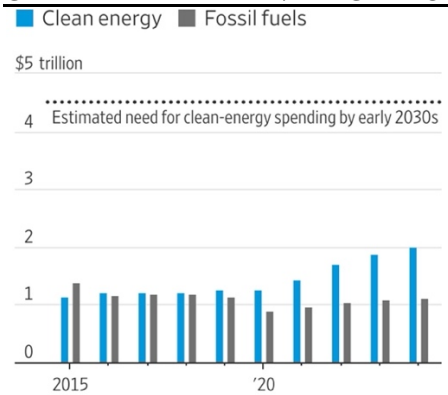


Source, left: IEA, *Share of cumulative power capacity by technology, 2010-2027.*



Right, Wall Street Journal; Met Office; OWID.

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



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

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

Green shoots like in windy North Sea 2020s, may hint at what's ahead. Bit like how in 19th century, newly-cheap hydro power once led to 2,500 mills: they made ½ of the world cotton in Lancashire UK 1860s. Or how cheap hydropower led to aluminum smelters, to airplanes in Seattle last century. After all industry follows cheap energy. Ruhr Valley dirty coal once had led to (dirty) steel-industries. But this time, better *clean* economies *possibly may* grow ahead. For zero CO_2 steel. Or new green hydrogen (H_2), ammonia (NH_3), e-methane and other low-CO_2 derivatives -- possibly made from clean (& prerequisite, cheap) renewable energy.

But again, green H_2 now is still *Much too costly,* so renewables *will have to get much* cheaper, first. Europe's offshore wind *might* be able to scale. Turbines at sea can work at 60% capacity -- vs 30%-40% for wind on land. 9 North Sea countries lately aim to install 260 gigawatts offshore wind in <30 years to 2050, 5x the world's wind capacity of 2022. Bit like 24,000 biggish turbines. Enough to make electricity for say, 200 million European households. Some firms kitting out for oil & gas, may shift to offshore wind, like say Esbjerg Denmark. This town of just 72,000 souls could boast in 2023 of having helped on 2/3 of region's offshore turbines, enough to run 40 million homes. It aims to grow its capacity ahead, maybe as 3x to 2026.

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

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

Wow, green energy has grown. 3 decades ago, 11 now-tiny turbines made up the world's 1st offshore wind farm: 5 MW total in Vindeby, Denmark. Now just 1 offshore turbine can be 15 MW -- *per turbine!* Bigger 18 MW models unveiled. Just imagine 100 say, of the 15 MW offshore behemoths -- or why not say, 1,000, or even more(!?). Wind ahead can make TWs, more than most all. Indeed China has huge ambitions for its own wind/solar ahead, plus nuclear. That nation has the sheer ability to make thousands of new GWs happen, along with less coal.

Coal, once, was very big in the US; it still is in China. Now, as a Harvard economist has said of US coal, "We can't shutter all these plants tomorrow; we need to do it in an orderly fashion to support grid reliability but we should be able to do it in fairly fast order. Coal has been natural decline due to economics: those economics are going to continue, this is a transition that's just going to happen. We built a lot of coal plants in US around 50 years ago because we were worried about energy security in the world. That made sense at the time and made an important contribution. But we know a lot more now about climate change, so now we need to make different decisions." Coal's future in US is inauspicious. Interestingly however, some conservatives who normally venerate free markets -- look to *Require* coal be kept going(!) -- even if the coal plant owner wants to shut it down! In West Virginia, Kentucky, Montana, Utah, Wyoming, they've lately claimed that it is a fight about 'culture'.

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

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

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

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

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

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

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

Other side of coin, juxtaposed, are many reasons for bearishness in clean energy. True, $1.2 Trillion+ in total may go to US solar/wind/EVs thanks to an ***uncapped*** IRA. But many renewable projects were recently slowed, or even killed. Supply chains in solar, wind, EVs, still full of pitfalls. For instance, in US, approval to connect to grid takes far too many years, sometimes a decade+! Local regulations and protests vex. In US, big wind farm starts fell by a dramatic 77.5% in Q3 of 2022 -- vs 3rd Quarter of 2021. New utility-scale solar projects fell by 40% in 2022 -- vs in 2021 -- despite big ongoing demand for green electrons and green projects.

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

And troubling self-goals. California once led in solar; it cut back home solar value in 2023. Three public Utilities seriously pushed to end incentives for home solar -- to instead charge based on users' income, rather than electricity use. In Q1 2023, Florida installed 70% more new solar capacity than California. In other matters wind turbines have grown fast in size, but unreliability has made some wind maker's warranty costs double. That industry needs to improve reliability of its huge turbines -- before turbines grow further. The 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. Europe more accustomed to sticks -- than to carrots -- (rightly) feared it was driving Euro-firms to US. They called for a European Green Deal Industrial Plan, mimicking America's IRA, for carrots to draw firms to old-world in a race to top. Largely due to IRA of 2022 -- the US in just Q4 of 2022 saw $40 billion in new US solar, wind, storage; as much as in all 2021. Private companies & public entities contracted for a record 36 GW clean power in 2022, up 18% over 2021. Many firms clamored to invest. Whether wanting to decarbonize -- or merely, just virtue signaling. Either way, the demand to contract for clean electrons (if affordable) in early and mid 2020s was enormous.

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

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

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

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

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

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

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

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

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

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

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

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

Green theme equities were down hard 2022, 2023, 2024 -- yet not so much July of 2022. That July's rise was on 1 Senator's Yes, that begat an Inflation Reduction Act (IRA) of 2022. Its formal spending was $369 Billion -- yet uncapped aspects could lead to $1.2+ Trillion in federal outlays, $3 Trillion investments by business. War, energy insecurity had spiked prices at first, then bit of glut, drops in oil/gas. Despite CO_2's weather whiplash, fossils had lost no lustre -- vs. intermittent, yet in-ways better renewables. But look closer, and there's wrinkles. For instance natural gas prices dropped hard late in 2022, then 2023 & 2024. Vessels carrying US liquified petroleum gas & propane exports to Asia -- were hit by drought at Panama Canal. That had reduced transits from 40/day -- to 30 in Oct. 2023, to 25 in Dec. 2023. Long alternate sailing routes to Asia on climate crisis/drought, raised propane prices in Asia, even as LPG prices fell elsewhere. And Red Sea transits were hit by threat of attacks mid-2020s.

In an energy transition begun badly, gas & weather weaponized, weather mimicking extremes once-felt decades out, it seemed possible in this century, the 'center might not hold'. Society used to stabler climes, may be rent asunder. Climate collapse *possible*, shortages of power, food, water. Attacks on grid. Climate ironies of droughts, & floods, big hot, & cold snaps -- *might* cast sustainable energy in new light. India, may see heat in extremis. Global rich & poor alike may be forced some places to blackouts, sometimes to burning simple 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 incentives too. A gas pipeline was promised in debt default showdown 2023. More tries even by some liberals to streamline (fossils too) Permitting. Revenues-side, big US corporations saw a 15% tax. Some Deficit Reduction, somewhat reducing inflation; Senator so named the Act. And the Senate's majority leader got a desired Chips Bill that 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 of labor. Delivered, hot weather in extremis. Kept alive after attacks in 2023.

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

That carrots-only IRA was far short of what the science says, is needed on climate: CO_2 is rising fast. And its $360 billion only felt big, as it barely got the 1 needed vote. In comparison on extant greenhouse gases, over $100 *Trillion in Climate investments* may be needed, globally! Yes, that uncapped IRA *is* rather a tailwind. Compared to the last decade when just 1 renewable, hydropower -- once met 10% of demand. Big dams can't grow; in the IRA we've turned to wind & solar, which are growing vastly faster. End of last decade wind had met just 7% of US demand but was growing, solar was 3% but was growing. That 10% by both wind + solar, plus another 10% from hydro -- then had met 20% of US demand at end of last decade. Another 20% was met by nuclear -- thus 40% was zero-carbon sources. But other side of ledger, gas & coal were meeting most all other US electricity demand. Gas & coal firm & dispatchable, took care of ~60% of US needs end of last decade. As transportation & heat were met by oil, diesel, gas, coal last decade: thus electrifying all will take years. A long-ways to go! That's why 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 recent US electric generating capacity 1st six-months 2022: it helps show where US electricity may be heading mid-2020s. My, it's changing! 2/3rds new US power capacity built 1H 2022 was then solar/wind. Wind had led at ~6 gigawatts (5,722 megawatts) of newly-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 big picture alarms, as 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 of that was still natural gas. Of new generating capacity placed in service a year later, in 1st half 2023, 34% was solar, and 16% was wind -- but 47% was nat. gas. Geothermal 'should' now be a big, dispatchable renewable. Its steam could run relic thermal gas/coal plants. But for now, it's too costly, so puny 26 MW capacity built. Biomass can be dirty, albeit renewable; just 2 MW. In US, just 2 MWs hydro built. And no 2nd generation costly US nuclear fission was being built (though latter 2020s nuclear was seeing a comeback on new demands of power-hungry AI and data centers). Nor was there new US coal, unlike some other nations in 2022 when India, China, even rich Europe went back to burning some coal.

As we still burn gas widely in the US, a flip side is the fast-coming new solar & wind pipeline. The US Federal Energy Regulatory Commission had estimated 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. And solar's not going to be hit by retirements for some time, unlike coal, oil, gas, nuclear hit too by fuel costs, breakdowns, maintenance, shorter lives. Just on solar's most-likely projects, these can double 2022's US utility-scale solar capacity, take it 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. The IRA law will no doubt stimulate more new US solar building ahead, even faster.

New US wind capacity to be built to June 2025 may be 70 GW (70,393 MW). 2025's high-probability new US wind & solar capacity may pass 2.3 GW built/per month, not including distributed solar on homes, or geothermal. Watch geothermal later this decade: for years the geothermal most anywhere, was stuck at just 0.4% of total electricity mix: but new, deeper wells could expand that. So 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, is far from enough. New US clean energy capacity in 1st half 2022 had brought total wind/ solar/ hydro to meet 26.74% of US electricity demand. Was better, true, than 5 years prior in 2017 when US solar, wind, hydro then together had met just 19.7%. Or 10 years before 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 wind, just a single digit 1 to 2 percent came from solar.

Natural gas spiked to $8 in 2022 -- before falling hard to $2 in 2024 (boom and bust). Yet due to that spike, nations had turned to burn coal, devastatingly. Busted global carbon budgets. No chance of seeing a ceiling of 'just' 1.5 C degrees heating. The physics & chemistry are well known, CO_2 well-understood by science. Look ahead, on present trends we're rushing to past 2 and 3+ degrees C of heating. Hotter still, unprecedented gigatons of CO_2. With globally blazing temps nearly-certain, we may flee to cool climes in a new 'Cold Rush'. Nearer-term vanishingly-short Winters + hotter/longer Summers may = despair. It is known; 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 a geological record for an idea as to what's maybe ahead. Drilling 2 miles below Antarctic ice, science looks back in time. To past climates, when 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 in looking far longer back in the Past – than seen in Financial Reports! CO_2 had dropped hard in a past Ice Age to 160 ppm (parts per million). Natural cold at times, natural hot other times -- long before we humans. Explained by the fact Earth moves in predictable ways around the sun, non-round not-perfectly elliptical orbits. Over tens of thousands of years our Planet moves via 'precession' and 'axial tilt' like a top spinning on a table. 3 predictable moves explained by Milankovitch cycles, variable/cyclic cold or warming. Meanwhile continents drift too changing Earth's surface, impacting big ocean currents. How much land is in Northern vs. Southern hemispheres affects how much heat is absorbed by -- or reflects sun's heat. Ice sheets near poles reflect sun (cooler) -- dark oceans at poles facing the sun, absorb heat. Net result of variable 26,000 years precession, 41,000 year cycles in axial-tilt, plus continents drifting is cooling, warming. It can & does change climate by a few degrees C at poles (that's a Lot!). Over time, naturally. Once renewed heating re-starts via many factors, like CO_2 released naturally by volcanism, or CO_2 from decomposing vegetation, or methane under permafrost etc, they can 'kick-start' more rapid heating via water vapor naturally in air. Water vapor is a very potent greenhouse gas in just thousands of years.

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

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

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

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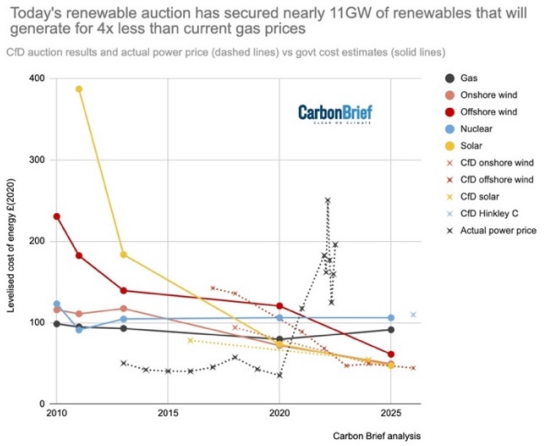
2 UK power generation auctions in 2022, 2023 did point out how fast things can change. Even though much infrastructure for gas-fired power resists a power revolution. Auction results in 2022 had shown wind (& solar) can start to displace UK gas-power, as record 11 gigawatts/GW of green electricity won bidding -- @ 1/4th cost of gas! Could power 12 million UK homes. Put another way wind handily can beat gas on price. In UK Contract for Difference (CfD) bidding, offshore wind saw prices 70% lower than had been seen in a 2015 Round. Offshore wind thus had gotten far cheaper in ~7 years to 2022. But costs did after that, rise. In 2023, under a de facto UK onshore wind ban, plus due to a poor offshore wind support and inflation in wind -- things turned bad. Before, wind/solar saw year over year cost *decreases*. Yet green energy/ wind costs rose 2023. True, rose also at fossils, nukes. But offshore wind bids 2022 were nicely in £GBP/MWh at just £37.35; onshore wind £42.47; solar £45.99. Frankly those turned out to be much lower costs, than what would be seen in offshore wind just a year later in 2023. So, when UK government in 2023 kept CfD about a same £44 for offshore wind -- that wasn't good enough. It killed 2023's wind auction. Inflation, supply chains all meant wind's costs then were some 40% higher. So 2023's 1st auction was a flop! Later on in 2023 they later raised support to £73. But to make up for lost time, and given aims to raise wind 4x from 13 GW -- to 50 GW, more was needed. On the new government there in 2024, things did improve.

Was bit indicative of happenings globally in green energy then. Of the UK projects bid in 2022, a largest share or 7 GW with 93 winners was offshore wind. With notably low-bidding at €37.35/MWh, offshore wind was nicely in 2022 about the cheapest electricity of all in UK. But 2023 needed a higher CfD floor. Nearby too, European Ports were also ready to ramp wind on EU-side too. To increase offshore wind to a targeted 150 GW by 2050. On 2 Nov. 2022, UK sent a then-record 20 GW (20,896 MW) wind energy to grid: met 53% of UK electricity demand. Wind/solar/nukes/hydro/storage together met 70% that day. Despite war, was a spot of happy news. UK consumers could pay less, get abundant secure domestic electricity, new jobs too. All thanks to welcome growth this decade in *deflationary* wind & green energy:



Source: CarbonBrief

It's startling to see above how swiftly wind & solar costs plunged those 12 years. Natural gas went from relatively 'lowish' cost 2010 -- to ghastly costly mid-2022 (before falling hard once US and Europe reacted swiftly to Russia turning off supplies). Gas just after this Chart, dropped back sizably in costs late 2023/24 -- as solar and offshore wind too lost near-term attraction due to inflation hitting clean energy in 2021-23. That's a tale told in pages ahead. Not so much about the volatility in fossil fuels, and nuclear -- as lovely cost-reductions. Yet potholes too in renewables, as wind & solar became the most affordable electricity.

It's not been a straight line. Nor the same, all places. Europe, for instance in 2022 enjoyed relatively better/lower costs installing solar vs. a US. Why? For starters, Europeans didn't pay solar tariffs like US buyers have to for energy kit from China. Didn't have America's state by state added net metering (NEM) costs. Nor, same restrictions on China. Plus, natural gas is a core competing fuel in Europe -- and the natural gas there has been very expensive. Mid-2022 was $40+ per Mcf. So, a gas option there was oft 3x than in US -- that has 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 $0.69/watt. Italy to $0.79, UK $0.85. Meanwhile, US was more costly 2021: $1.09/watt. Europe shaved $0.10/watt off install PV costs relative to US. Surely in a world facing unending climate crises, one may think decarbonizing fast is a priority. But No. US champions less regulatory burdens, but it lately has had higher soft costs for solar -- for design, permitting, installation -- vs. Europe's lesser burdens. If comparing like, for like, say 2 systems of similar sizes even putting aside the costs of PV hardware (lower as well in Europe), America in 2023 was much less efficient.

Step back and cost *trends* to install renewables 2020 to 2021 worldwide, had as one hopes to see: Declined. More recent inflation, 2022 & 2023, hadn't shown up in those data yet. We'll see that inflation later. Yet looking 2020 to 2021 here, levelized costs of energy (LCOE) for new utility-scale solar, show electricity cost *fell* 13% in 2020/2021 to $0.048/kWh. Onshore wind, fell 15% y/over/y to $0.033 per kWh. Offshore wind, fell 13% year over year to $0.075/kWh. This is significant. Take say, Germany. It has a *potential* to raise offshore wind generating capacity to 81 GW. For rather like 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 the 7.8 GW its operating offshore wind had then made in 1H 2022. Put in perspective 139 billion kWhs of clean energy was made by all of Germany's renewables 1H 2022, and that met nearly 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 then 12 Bn kWhs.

In 2022/2023 renewables costs rose in solar/wind. Still, fossil prices rose inordinately, so renewables' changes were rather moderated. And clean can beat fossils in unprecedented ways. Look at average fuel-only costs for gas-fired electricity (no CO_2 Fees) mid-2022: these rose to $0.23/kWh: so 23 cents per kilowatt hour was wholesale cost ***for just fuel alone***. Built gas plants in Europe were pricier to run -- than to build new onshore wind, or solar due to free fuel. When gas fuel costs 2022 jumped briefly 540% vs. 2020, was no contest. 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 in 2022. No wonder renewables if competing on even-playing field, were obvious choice. Thermals coal, gas, nukes struggled to stay work in Summers. That said, big hydropower struggled too, given droughts at dams worldwide 2022. Big hydro may have already peaked at ~15%, to never again be a global growth driver.

In a dozen years, 2010 to 2022, LCOE figure pretty much had said it all. For electricity made from natural gas, costs had briefly hit 23 cents/kWh for fuel-alone, 27 cents with carbon Fees like Europe. By comparison, best-case onshore wind was down near just 3 cents(!) thanks to free fuel -- and 68% cost drops since 2010! Solar PV best cost was down near 5 cents on declines of 88%!. Offshore wind, best case just 7 cents, on falls of 60%. Renewables enjoy 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/unwanted. A security risk. Russian gas suddenly a liability, weakness. Energy Security hawks wanted all (non-Russia) gas they could get asap, even if LNG vessels meant more fossil infrastructure. On other hand, Climate hawks wanted immediately to get off all that. To go directly to zero-carbon infrastructure exclusively, now. So keeping with any LNG or natural gas, was seen by latter as a mutual suicide pact.

Both sides concurred: Germany & Europe could Not use Russian gas. Emphasizing new need, agreed on by all, for vastly more electricity Storage. (Electricity storage can be measured as Power, so in watts -- or as Energy, so in watts over time -- like megawatt/hours. And 95% of electricity once had been stored as pumped hydro: moving water between 2 elevations: seen as power by turbine size & elevation difference. Globally 165 GW could then be stored. As energy, by how much water in reservoirs, in 2021 it was 9,000 GW/hrs or 9 TW/hrs. Anyways pumped hydro storage capacity was capped: dams can't grow, best sites taken. Electricity storage capacity if once mainly pumped hydro -- wasn't now near enough given intermittency & diversity of renewables. Electricity must be used immediately when made -- or be stored. So intermittent sun & wind demanded much storage. Maybe green hydrogen, useful in storage too. Storage & better grid were keys to unlocking magnitudes of clean energy growth.

Batteries offer just short-term storage, to say 4 hours. Long-term storage options can hold electricity for days, weeks, months. Yet achieving huge-enough zero-emissions global Storage by 2040, meant new capacity, some 2.5 terawatts (TW) power, 150 TW/hrs of energy. Thus, Herculean efforts needed, fast. But outside pumped hydro, 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 sought was quite an ask!

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

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

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

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

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

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

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

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

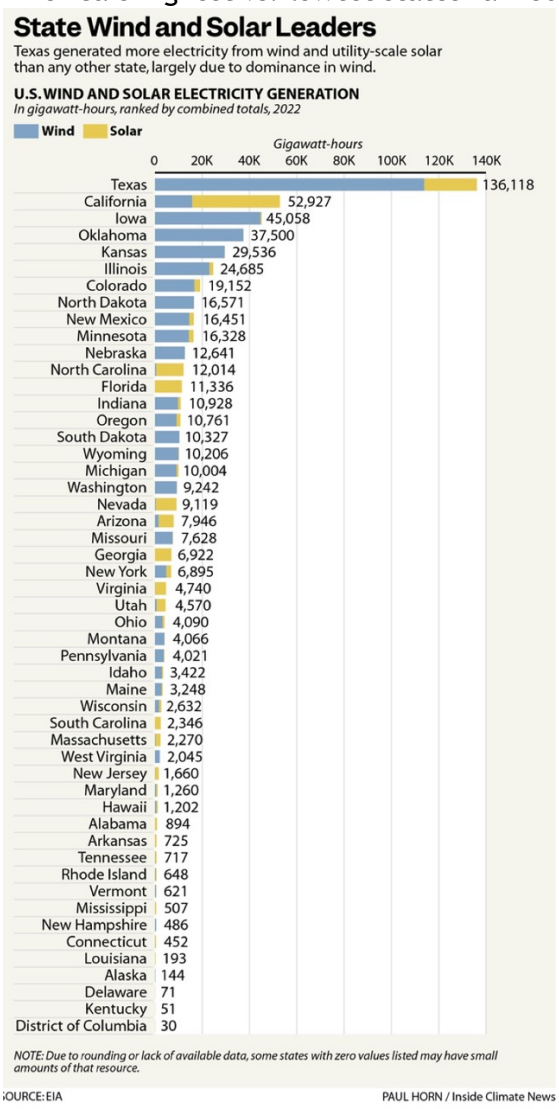
First good news: global investments had hit $1,000 Bn ($1 Trillion) 2022, a then-record. A breakdown from 2021 showed renewables wind/solar investments had grown just modestly 5 years before to $361 billion. What really took off, was electrifying transport: it leapt to $273 billion in 2021, up +77% from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

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

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

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

Folks are all excused if they've assumed California is America's #1 State for renewables; in fact, it's Texas. Many Texas business & local leaders embrace renewables. Yet some Texas political leaders curiously make much of their allegiance to fossils, antipathy to renewables. Maybe as cheaper renewables became a threat to gas, oil, coal, nukes; in 2022 wind & solar made 25%+ of State's power -- at times it had 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 had curiously been introduced in 2023/2024 -- trying to reverse clean energy growth. Here below one sees America's highest vs. lowest states ranked for their 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, utility-scale solar (above). Yet its electric power needs were so huge, renewables still had only met 34% of the Texas total electricity demand. Adding nuclear, & hydropower, Texas led nation by making a big 180,000 gigawatt-hours of zero-carbon electricity. That's all nice, but its coal & natural gas still are very big there -- yet feeling threatened. In 2023 a raft of Bills were introduced in Texas' Legislature to stop/slow renewables. Nationally for how big renewables & nuclear had gotten in all US, of total demand in 2022, ~40% of US electricity was met by zero-carbon sources. That was some ~22% met by renewables, and ~18% met by nuclear power.

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

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

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

Blackouts may lead to conservatives wanting a 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 had opposed renewables stimulus in IRA, though they increasingly benefit from wind. Later on in 2024 the IRA funds rolled out at first went in large part to a few, key red Swing States in the '24 elections. Conceivable a GOP Senator, House Members, may tear away from past partisan GOP opposition to green energy. Maybe on new weather extremes, quakes from fracking, unpalatable Russian gas. Catalysts to bring back elements stricken from IRA; sticks that can nudge CO_2 heavy plants to retire. Once-heretical ideas like a carbon-tax, might be re-considered. Or $ Trillions spent on fossil troubles, climate disasters, or war/s fought again and again over oil & gas, might be rethought - reframing thinking.

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

Bill Gates in 2022 had emphasized to Senator an IRA can help innovation. China after all had nurtured its own nascent battery industry; by 2022 had strategic rare Earths, other minerals, processing, refining, production. When Senator & spouse dined with Gates, they discussed how IRA could benefit West Virginia workers who'd lost coal & power plants jobs. White House reps too, and 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 crunch time. AFL-CIO, UMW noted how IRA could at last fund 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 -- so allowing 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, and 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 -- all huge!

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 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 needing rare Earths: Neodymium, Dysprosium, Terbium -- on China's dominance.

Also points to two WilderHill Indexes that launched in 2022, for Hydrogen Economy (H2X) -- and for Wind Energy (WNX). These H2X & WNX Indexes are green & cognizant of European SFDR, '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 they 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 had first 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 consequential 2022 drew to an end, much was changed. An option some hoped to see shine -- nuclear (Not in our Indexes) -- was then hard hit by problems. One may have thought France's current-generation nuclear tech could 'ride to rescue' 2022 on Ukraine war. That French nuclear fleet know-how would grow output full tilt. Send added electrons to Europe, sit back pretty, unvexed by slowing or 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 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 ~30 years ago. Taxpayer subsidized, yet high electricity costs seemed to vex in perpetuity. Power cuts in 2022 had taken La Belle France to under <300 terawatt/hours. All with consequences for Europe, which struggled at first then to find enough fossil fuels-fired electric power.

Not yet well-known, then, was France's nuclear plants had been acutely hit by unexpectedly bad corrosion issues, maintenance needing time to sort. Only could hope 30 GW is back online fast. And that focus on nuclear 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 biggest modern nuclear plant going up then in the West. In the words of The Economist (June 25, 2022):

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

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

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

Factors in equity declines 2021-2024 included, Inflation, High Interest Rates, green energy costs *rising* as not oft seen here; *War thus turmoil; and a *Supply chain chaos that hit all renewables. Fossil & nuclear costs rose yes too -- oft by more. Inflation though was tormenting a green energy theme long used to price *Declines*, cost *drops* -- instead it found No safe port. Green stocks got hammered 2021 to 2024 as costs surged for all: labor, capital, materials, shipping etc. Usually-falling wind & solar prices – rose hard. And green equities fell hard, many stocks here were down by -50% in 2022, and in 2023, then fell down again in 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 presciently a huge $80 billion 10-year supply deal with China counterpart CNPC. India's refiners signed for heavy crude. Europe looked instead for alternate supplies fast, for oil & critical diesel, especially natural gas, mindful of cold winters, hot summers. China 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, gas -- climate crisis -- which will likely be much worse than people yet recognize.

Destructive warfare wasn't just kinetic, some were attacks not so 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. 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 small US solar maker asked US Commerce Dept to investigate 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 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. Was re-raised too in 2024.

Clarity was 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 a lesser IRA, a mountain valley pipeline, some questions went away. But not all. Sorely needed too on ever-rising CO_2 was renewables capacity growth, green incentives, looser supply chains, better efficiency, more EVs, carbon pricing. In Europe too. Plans had indeed arisen 2022 for a 5-fold increase in UK solar capacity from 14 GW -- to 70 GW by 2035. Germany began to plan for solar to grow 22 GW -- to 215 GW by 2030. Europe, US, China, and more pushed renewables. Sensibly so as these are a great foil against dependency on fossils. For certain too some prior political naysayers were now attentive to new climate risks. But certainly not all -- and opposition remaining rock-rigid in conservative party in the US -- even as the 2024 rollout of early IRA funding went strongly into normally conservative, red Swing States key for the 2024 elections. Clean energy went from growth, a spurt of margin expansions and jumping stock prices in 2019 & 2020 – to instead margin compression and drops in 2021-2024.

In, 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 -- moving fast to 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 …?

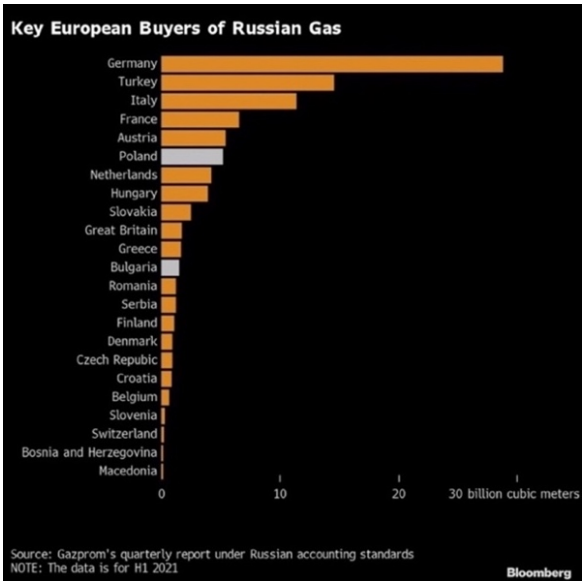
Shell-games like 'carbon offsets', or 'renewable energy certificates' had let firms pretend to use little natural gas. Claim say trees left on slopes so steep they can't be cut, 'reduced' fossil-use via carbon credits. Surplus, non-transparent, European hydro certificates somehow incentivized renewables.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

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

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

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

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



Source: Gazprom's Quarterly Reports; Bloomberg.

As seen above, Germany, Italy, France etc were in bind at first, on Russia. A worry early 2022 was over natural gas rationing in Europe. Fast moves off Russian oil especially off gas was 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 & attention to clean energy, it seems counter-intuitive -- yet it did not & does not -- equate to persistent equity gains for clean energy. Not in ECO, NEX, H2X, WNX. Often months, eg April of 2022, January of 2024, that ECO drops hard near -20%. 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 world's best-watched themes, NASDAQ/Dow/S&P500 drops were no small-potatoes. As noted ECO briefly jumped July 2022, 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 the ARKK -- then ECO & NEX Indexes 5 years to late 2023 presented then rather comparable finish. That ARKK which is younger, is also innovation heavy; it had begun a decade *after* our own ECO -- yet also in disruptive (but different) themes. Below chart begins roughly similarly. ARKK started later, ARKK in 2014 -- vs ECO in 2004/ tracker in 2005; and our 1st Global clean energy NEX (lighter blue) was born 2006 / tracker 2007. All 3 themes center on innovation; in 5 years since Sept. 2018, chart here to end of 2023, **ECO** (dark blue), NEX (light blue) and **ARKK** (red) all jumped fast about same time, March 2020 -- then they all three after fell hard.

As we see ECO first jumped higher, went farther up, than 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 here about nil -- vs. the NEX that's then the up at +15% -- both versus ARKK here at the end of 2023 about -8% underwater:

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

Source: finance.yahoo.com

For all our warnings of ECO, NEX re: their acute risk, those 2 here went up more, down a bit less than did ARKK. Yes, we see periods too where ECO/NEX drop more than ARKK; there is no doubt but that all 3 themes are highly volatile! As always too, innovation/tech are volatile, hugely risky areas -- whether it's active like ARKK, or passive like here. Clean energy in wind, solar, EVs, H2 never have been havens of calm. And these 2020s look to be a time, when all energy may see acute volatility, shortages, rationing, perhaps too calamitous blackouts.

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

Clearly, bearish troubles overshadowed clean energy equities 2021, 2022, 2023, 2024. One worry at first, was 'only' a bipartisan $1.2 Trillion(!) infrastructure would pass 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 theme and so ECO Index -- were hard down hard on inflation & supply chains all 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 too 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.

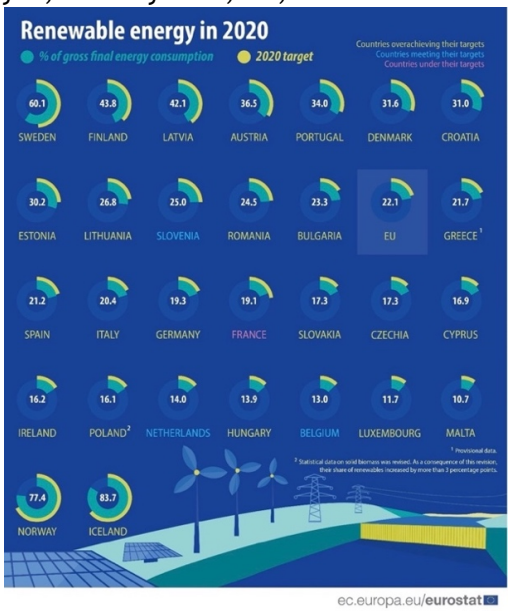
Wind's growth had meant in 2020, 25% of UK power was from wind over a year. And UK wanted wind to account for more, over 1/3rd+ of its power by 2030. In Europe, wind power made on average 16% of electric power 2020 and growing. Pair that green resource with energy storage, and wind/solar together may 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.

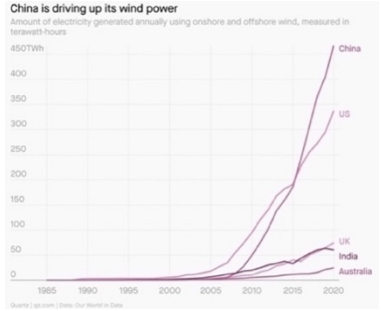
UK famously had left 27 member European Union in 2020, so isn't seen above. But, the UK did in 2020 source 42% of its energy needs from renewables, thanks to a big wind push. Expect offshore wind to fast rise in UK & Europe. Yet curiously if renewable costs in UK, like elsewhere fell -- why did UK average home energy bills in 2021 *jump* to GBP £1,200/or USD $1,630? And go *higher* 2022 as UK wind power was made @ just 5p per kilowatt hour (kWh) -- under ¼ what a homeowner pays?! That, was due to the 4x jumps in natural gas prices 2021 -- for energy markets were set by a *costliest*, yet most needed (still fossil!) fuel. In an energy transition, it made no intuitive sense to see energy bills spike -- as renewables got cheaper! Yet, Ireland showed what can be; in Feb. 2022 its wind supplied 53% of needed electricity. Less windy hours there, its wholesale electricity had cost EUR €229/MWh; in windier hours it dropped to €134/MWh. And even in bit less-windy Nov. 2022, wind made up 48% of its power generated. Average wholesale electricity then had cost €143.12 MWh -- windier days it cost just €106.99 per MWh, Even counting non-windy days, weeks, that wind power had met 1/3rd 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, far ahead of US. Of roughly 20% US renewables in 2020, 13% or 2/3rds was solar/wind; 7% or 1/3 big hydro. $105 billion got invested 2021 in renewables, EVs, batteries, etc -- 37 GW solar & wind. Yet natural gas was generating twice that, 20%, or a key 2x or 40% of power. As Europe pulled ahead big picture was neither Europe, nor US made near enough clean power (India too was just 22%). Each must grow 2x or 3x faster, given decarbonization's goals. War did change much early 2020s; Europe grew its renewables, EVs faster. European light duty EV sales were 19% of vehicles 2021, double 8% world average. Then, 1 of 6 cars sold in Europe (more China) were soon EVs -- growing faster. Vastly beat US at just 1 EV out of every 20 cars. For a Europe where 1/3rd of oil, more gas had in 2021 come from Russia, war served to turbocharge green energy growth. Yet, with also a nightmarish rush to then burn more domestic coal.

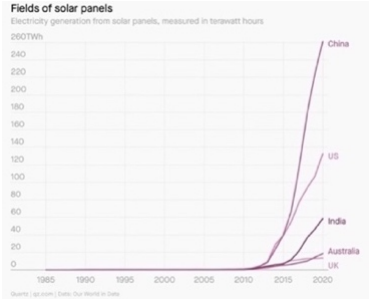
What of China? As arguably the most important bloc for renewables? China in 2020 was world leader in its absolute energy generating capacity. Yet its 342 gigawatts (GW) green capacity still meant (only) 14% of power was from renewables. 14% not far off figures for the US. Still, figures can deceive.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

Wind & Solar Growth in China surpassing all:



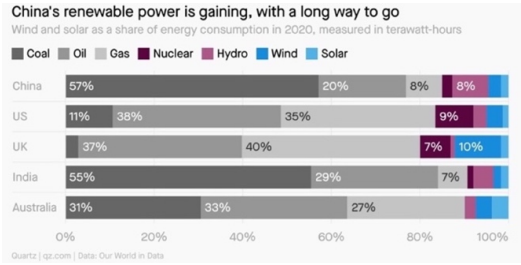
Source: Quartz / Our World in Data.



Source: Quartz / Our World in Data.

Yet China's voracious demand puts it into perspective. In 2020 China had needed 40,170 TWh of energy - only 15% was met by 'renewables' (which in China includes current-gen nuclear). In US, 23,927 TWh was needed, a similar 17%-20% was met by renewables. Europe's green % figure was only a bit ahead of both in 2020, so is much room for improvement at all 3 major blocs. Especially for coal -- where China is undisputedly the pejorative 'king of coal'. But before a rich US, or Germany etc can climb up to crow on their 'uses-less-coal' grandstand -- note they are all burning immense amounts of coal too. Plus, oil in transport. Natural gas for power. With war 2022, coal-use jumped globally on spiking natural gas costs. Thus, fossils oil/diesel, gas and still far-too-often coal -- go on overshadowing our world energy mix.

How 5 big countries had fared in 2020 is seen here as fossils in charcoals, browns & grays dominate, left. At right, blues & pinks, solar, wind, hydro + nuclear have mild penetration, near 20% in 2020 -- and growing. Left way too much room to improve, while Rome burns:



Source: Quartz / Our World in Data

Then coal-loving Australia was bottom here, coal 60% of electric generation back in 2021. Though renewables' 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: one test in America shut down late 2023. Much preferable would be distributed 'SMR's but of another kind, clean & greener too, 'Small Modular Renewables'.

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

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

An expert in Net Energy Metering (NEM) called 2022's draft NEM 3.0 decision, 'dystopian'. Without roof PV, few will install batteries in first place. Noted payback was not a short 3-4 years (as PD claimed) -- but ~7 years [born out by our own experience]. Installed PV doesn't cost a low $2.38/watt as proffered in PD, but nearer $4/watt. To put huge costs on PV -- *retroactively* -- can kill distributed home solar. And, adding storage -- costs much $$$.

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

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

Utilities are accustomed to big, centralized thermal-plants -- that they alone own/control. They may support big solar farms which they do own -- but those haven't much lowered retail power costs yet, at some 25+ cents per kilowatt hour (kWh). By contrast decentralized rooftop home solar like in California could 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 gasser car -- to instead have solar roof & EV. The 1st PD would quash this option, even in progressive California, even in 2022. Pushback was swift & vocal. Notably when California pushed that off to after the 2022 Elections -- it piled on more uncertainty. Pushed down a solar sector already hit by anti-circumvention, further. Only the very costliest solar + storage might then make sense.

Not just in California either: sunny Florida had its factions trying to halt rise of roof solar in 2022. A bill introduced in Florida's State legislature, backed by its huge electric utility, could decimate home rooftop solar. Well, the legislation wasn't just 'backed' by that utility. It was later uncovered that the Florida legislator who'd introduced the bill to slash home solar, had this draft bill delivered to them by State's largest public utility. While they may simply hold similar views of 'what's good for the State', that close nexus was notable.

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

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

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

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

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

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

Storage & grid will take time to be built. So, what of big parts to this puzzle: natural gas & current gen II nuclear near-term? Early 2020s California needed all its 25 GW of renewables -- and soon 50+ GW more green power. 17 GW utility solar should have been added 'yesterday' -- even utilities support it. More offshore wind. Were gen IV/V nukes safe, affordable now, no wastes, it would be wonderful! The State has one gen II nuke, its life extended from 2025 -- to 2030 closure, but it was none of that -- yet is needed. California's grid in 2032 *might* be 70% renewables, & 85% greenhouse-gases free. But the latter 2020s is scary.

It's easy, thinking of politics, to forget that CO_2/ climate actually have THE final say. Politics ignores that, though science indicates this error may revisit us many-fold. Work's happening in future-gazing science, getting ever-more right models that help better see what may be ahead. For instance, how the clouds, water vapor may contribute to heating -- or not -- like other greenhouse gases (GHGs) is vital. Potentially, clouds *may* mean Earth gets much hotter still. Or, reflective clouds might instead mean we're in less blazing cauldron than predicted. A newer National Center for Atmospheric Research (NCAR) Community Earth System Model 2 (CESM2) has implied more impactful heating *may* come, sooner than was forecast by 20 prior models. So, scientists re-looked at that CESM2. More granular, sophisticated than in prior models, this bigger amplification seen as *possible* from clouds, should be worrying. Clouds may reduce heating (yay) -- or may instead supercharge it -- so getting clouds' complicated impacts right, is of the essence. Like impacts of short-lived methane, or GHGs besides carbon dioxide (CO_2) -- consequences can be planetary-scale. Clearly, water vapor is crucial.

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

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

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

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

Back in 2019, there'd been some 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 records. Still, operating margins hit a 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, was another 13 years for S&P to again reach prior levels.

By 2022, a big headwind was rising interest rates hurting equites. Not long-ago, investors had gotten nearly Zero % from bonds. So, demand grew for higher-risk themes, for better-returns at times in volatile themes. But if low-risk alternatives could soon boast respectable rates -- then Treasuries, bonds etc might re-see capital return for smart place to call home. Real rates in 2014-18, had meant inflation-adjusted 10-year Treasury yields expected just a +1.0%. On Covid, fell to eyebrow-raising *negative -1%*. As PEs rose from a 'common' 21 -- to a high 27, CAPE went from normal 20s -- to (yikes!) 40. On rate hikes, return to mean may be bearish for stocks. As rates tighten. All fundamental points 2021-2024. In Oct. 2024, CAPE would hit the 37s -- that was 3rd highest point while in a bull market, since 1871. Only 6 times had CAPE gone over 30 in 153 years; in 5 of those times, the Dow, S&P 500, and/or Nasdaq subsequently had declined between 20% and 89%. So a heightened CAPE = was some reason for concern!

If a threat then 2023/2024 wasn't of 'Unprecedented' inflation -- as it had been even higher in 1981 -- maybe it was that inflation may take root, grows hard to kill, rates higher for longer. Inflation is partly a state of mind, psychological. If expectations take root, both higher rates + stagnant / sluggish economy can mean stagflation; Fed Rates tools are wickedly un-useful in recession. No central bank wishes to hike rates going into a recession, economy cooling. Equity-risk premiums of holding to riskier stocks (vs. safer bonds) makes equities decidedly an unhappy place to be. CD rates over 5% can mean a new world, vs. 2020. Higher rates of 1970s are something a younger generation can't so 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 high interest rates, 2021, 2022, 2023, 2024 were all decidedly not great times for risky, volatile, high PE green themes. Makes prognosticating tough; it's impossible to consistently time markets. To foresee in advance, the best = and ahead of time lowest entry points.

Raised too a dilemma for China from 2024. The US late 2024 saw its high rates begin to subside -- from an elevated place -- after 4 tough years. But in China, deflation & debt became a big issue. Local, municipal governments had pursued spending, lending, full employment, and overcapacity. Specter of deflationary pressure there -- was a new and real concern.

Past few Quarters

If volatile pure-plays in WilderHill (WH) Indexes at times may jump up faster & higher than some competing energy themes in the Up times -- a flip-side is volatile WH themes can/do **plummet harder too** in Down times. Recent Quarters embody this. Jan. 2023 ECO jumped high/er, say, as 1 CPI Report 1-day showed maybe less inflation: ECO rose +10.1% that day; ECO's jump was more than other (all younger) green-energy themes. Yet big drops in ECO, maybe bit less in global NEX -- *are Not the worst in all energy,* Not, even close! For example, ECO has far out-performed vs. natural gas. Past 10 years clean energy/so ECO repeatedly did 'better' over long periods, than natural gas tracker theme below. Not just in long periods; on some single days the spread between clean theme -- vs. natural gas may be big; for instance Oct. 28, 2024 the ECO tracker was up +3.94% when a natural gas tracker on that day was down -7.68%, the spread/difference near 10%. Though ECO had dropped down over 2023 / 2024 -- nonetheless, clean energy ECO, and more so global NEX still did 'far better' here vs. natural gas. This Chart for 2023 to end of 2024 shows NEX is 'least down' at -37%; ECO is down -48%. Compare that to a natural gas theme via its ETF: we note while gas is very big for electricity generation – that the **natural gas tracker was down here by much more at -70%:**

Start of 2023 to end of 2024: ECO & NEX plus Natural Gas tracker are all Far Down!); here NEX, light blue is 'least down' -37%, ECO is down -48%; and Natural Gas is down by -70%:

Source: finance.yahoo.com

Early 2025 it was expected on a conservative and very-pro-fossil fuels president, that natural gas will be again even more favored ahead -- while renewables may be attacked on a variety of fronts next few years at least. Think of a Paris Climate Treaty; the US had been a member; it called for pro-renewables policies. Then, in their 1st term this president had fast pulled out of that in 2017 by executive orders and actions. Starting 2025, this same president could do so again. Or, say, formally submit it to Senate where over 60 votes are required so it would immediately & knowingly fail. Plus maybe move to strike down the EPAs basis for regulating CO_2, greenhouse gases, via like 2009 'endangerment finding'. Aim for legislation that pulls back on the in-scope pollutants under the Clean Air Act. It is expected from 2025 they may work hard to reverse decarbonization, net-zero goals. Yet at a same time, they can also streamline permitting, improve grid, and so also enable more renewables -- that are after all, often cheapest domestic energy. May be a rising tide that lifts all boats across energy. The next quarters should prove very interesting, with active Oval, executive & congress!

Back in 1st month of 2023, green themes had briefly jumped 20% on narrative -- a hope really, inflation might slow. That Fed may pivot off high rates to soft landing. Yet as 2023 went on, talk fast shifted from a soft landing/strong employment -- to instead even-higher rates 'until things break'. Amidst that fears lingered of maybe bank crisis. Or of recession, a government shutdown, or debt bomb. Rate hikes were needed yes due to inflation, but at a cost say, of stagflation, or 'slugflation'. All 4 themes fell hard in 2021 through 2024 on that picture. ECO in 2024 fell farther, into the 30s. To be sure across these years, much negative volatility.

Another volatility factor was the outbreak of war. Big equity changes in valuations, if down -- or up, are oft associated with surprise. And 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 here. And a new need for energy security: 13 European nations had in 2022 relied on Russia for >1/3rd their oil. Yet ECO soon after fell back -- first to <90 in May 2022 -- then into 30s in 2024. As the US fast grew its natural gas LNG exports 3 fold, from start of war, huge! Still, arguably, Russia's invasion shouldn't have been such a huge surprise, if one had been watching closely early-in-2022. There were then small hints.

To global intelligence assets watching a run-up, there'd been warning signs. To wit, months before invasion, Russia had moved 3 LNG ships to its geopolitically-vital, stranded Kaliningrad Oblast on Baltic Sea. Natural gas piped there from Belarus, went via Lithuania to Kaliningrad; this 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 may let Russia try to alter NATO power in its own backyard, as may Suwalki Gap link to Belarus. So was notable Gazprom sent its ships Energy Integrity, Velikiy Novgorod & Marshal Vasilevskiy regasser in Jan 2022. Before, that first ship had carried its LNG from Russia's Far North, to Asia. To re-position Integrity, it weirdly went long distance, Cameroon to Kaliningrad. It had carried gas prior to China, only 2 of 58 shipments to Europe -- so all unusual. Having moved LNG ships meant if conflict began, went past Ukraine -- Russia with gas as a weapon might keep its strategic Kaliningrad outpost, 4x size of Manhattan and militarily significant, energized for weeks. Perhaps Russia at first envisioned a possible quick run into Ukraine, then Kyiv falls … 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. Notable too is that what's today Estonia, much of Latvia, once was captured by Russia's Peter the Great back in the Northern War from 1700 to 1721.

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

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

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

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

What's Past is Prologue. In 2021 an oil price spike, came only *after* fossils plunged 2020. Only *after* US coal production hit 50-year lows, after 151 mines were closed or idled. Only *after* oil hit historic lows back in 2020 on Demand Collapse, fears of 'tank tops' so little storage. Meanwhile, much oil industry in early 2020s sought oil >$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 with big supply cuts, some output shut + renewed demand after Covid, discussed ahead -- did oil roar back to $70s-$90s/barrel on supply curtailments 2023, 2024. From 2025, new US production including in Alaska may bring prices back down, so painful for Russia, Saudis. At any rate, if there's again high/ dear oil & gas prices, then that too may yet again make renewables more attractive in years ahead.

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

Said another way, were a prior 100m+ barrels/day of oil drilled 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. (Gas spiked on war in 2022). In US, coal's economics are dismal, hence miners look to where it's burned, Asia, Europe. Today, the fact that America's own domestic coal supplies had once been last century's cheapest, dirtiest, most stable source of US electricity, suddenly is no longer much in its favor.

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

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

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

On CO_2 levels over 425+ ppm & rising fast, there's no true possibility of holding global heating to less than 2.0 C. Let alone to <1.5 degrees C -- a threshold already being breached at times 2020s. Hence a worse climate-induced weather whiplash is forbiddingly looming just ahead. Agricultural crises too, so shortages of food, and of water/ on drought -- as well as ironically flooding too given hotter air holds more moisture. Action is necessary -- yet what's now being contemplated is nowhere fast enough. Other ironies too: Russia's war in Ukraine stoked new European energy fears, yes, pushed rich Europe to move faster past Russian gas -- yet the world is burning *more* coal. Talk, maybe dreams of a newer 'Marshall Plan' for green, yet still it's just dreams. Shorter term, LNG is a compromise that's embraced; one that Germany's Greens grimly accepted, with reason: before war in 2022, fully 40% of Europe's piped natural gas had come from Russia; after was just 8%. Yet 3 landlocked countries in that bloc still had had to rely in mid-2020s on piped gas sent from East (Russia) to West -- unable to simply import LNG like sent from the US; thus rich Austria in 2024 was still relying on Russian gas for 97% of its piped gas imports. Likewise, Slovakia was at 89%. Hungary was at 47%.

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

Data have since have made clear too, there never had been a 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 >5%. Got worse 2021, worse still mid-2020s. On climate, we're losing badly. Facts so far no cause for optimism. Not in this decade, nor this century.

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

Other was an omnibus, huge, 'Build Back Better' (BBB) reconciliation bill. One-third or $550 Billion of it was for climate/clean energy. It needed No votes from conservative party: but could pass 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 *growing* clean energy 4%/year in early BBB draft, may get $150 per megawatt/ hour. Draft limits were <0.10 tons CO_2 per mW/hr -- as coal Utilities spewing 10x that by by *not* cleaning up, could be hit by fees. Nuclear might benefit too, as would solar, wind, hydro: each might win being 'zero-carbon' under this initial proposed legislation.

The politics were that 1 key, oft self-described moderate Senator from a fossils-state, could not support BBB reconciliation as conceived. Both on substance, saying a transition from fossils to clean was 'already happening', so why spend taxpayer dollars to speed up -- and $3.5 Trillion stating cost 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 traditional spending on roads, bridges etc. New $$ for infrastructure of classic kind. Perhaps some for so-called 'carbon sequestration' to try to add years more to dirty fossils, by pretending they're cleaner. That might then 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, on the $3.5 Trillion reconciliation size. For them new taxes on the wealthy worked fine, or deficit-spending like as done by the conservatives to cut taxes. They 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 they might go for the small $1.2 Trillion bipartisan bill only. When moderates won a vote deadline extension on a smaller-sized bill, tension rose in late Q3 2021 on the BBB bill. Liberals aimed to hold onto the $3.5 Trillion top line dollar figure -- not wanting a lesser $1.5 - $2 Trillion as hinted at by that coal state Senator, who'd resisted naming a $ figure. US Debt default also grew possible. Late 2021 it grew self-evident any BBB amount 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 a narrow lane to resurrect parts, for a smaller clean energy & tax credits bill done in more piecemeal fashion in 2022. Were just the $1 Tn bipartisan fossils-heavy bill being all that could pass, that was worse than nothing to many progressives; several wouldn't support it. Progressives' leverage was linking both.

They knew many moderates did seek the $1T roads & bridges, maybe ‘carbon sequestration’, ‘advanced nuclear’ too. Some 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, that $3.5 Trillion was already a compromise. But such (small) leverage was challenged late 2021 by a real possibility of perhaps No Deal, on either bill.

Meanwhile, conservatives had no-doubt enjoyed the 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 down to, who would blink? All sides would likely get less than what they’d wanted.

While infrastructure in that moderate Senator’s home state was poor, their willingness to wait, or to move goal posts, meant the BBB’s window would soon close. Finding a sweet spot soon on $$ size was key. All agreed: Infrastructure can = jobs. That Senator, a Committee Chair helped sculpt a bipartisan bill, desired it. And goodies make much possible (recall Bob Byrd?) to bring moderates off the fence. But, could a big $1.5T reconciliation BBB happen? Or, far smaller bill only? Might internal dissension liberal side sink both bills/all!?? Progressive members did try to hold on to all or nothing -- given ‘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, then a global COP26 Climate Conference in Scotland.

It boiled down to: could reconciliation with some teeth, some climate action, but ‘just’ $2T -- then ‘just’ $1.5 Trillion, then less -- 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, 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 well later. To agree on the $1T Bipartisan now with more compromises -- or if not, lose $1.5T BBB (it maybe falling lower or apart) was 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 clean power -- could have saved money. And also have made clean electricity, *much less-costly, sooner too,* 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 to COP26 Scotland. Yet COP26 had failed going in: little was sought, less than needed, some nations didn’t step up, or didn’t attend. US President’s party needed to show it could govern: elections were to be held and conservative party was favored. Seeking resolution, trying to reach a deal over suspenseful days, a potential path came into focus. A smaller $1.2T bipartisan Infrastructure bill already had passed in Senate and was less controversial. Several progressives in the House though wouldn’t support it, for to do so would imperil BBB by giving away leverage before it was taken up -- it would grow more old-school fossil emissions without assurances. As a result, a Bipartisan Problem Solvers Caucus that had worked for months on bill, was called on to supply a dozen or so ‘Aye’ votes needed from the conservative Party. Partly to notch some victory, partly to build trust across the aisle, the Speaker brought this ‘smaller’ $1.2 Trillion bipartisan bill up for a Vote. Having now votes needed, before even taking up the BBB for vote, so de-linking the two.

Several liberal House members didn't support that, consistent with concerns they'd long voiced on climate. Thus, a dozen or so members in 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 had some $ for electric buses, EV charging. Direct climate action instead was mired, stuck in a big BBB bill along with big-social-spending programs. No breakthrough likely there at all.

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

Shorn of restrictions, no sticks to cut coal, oil, or gas, the dirties could instead go on being burned, pretty freely under a much-slimmed bill, utilities Not having to scale back. Gone was $150 billion in clean energy performance goals, penalties on carbon; removed. Bulk of plans to clean up US emissions were shorn off, a 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 'sequestration' actually, cheaply reducing carbon from coal, oil or gas -- hence 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 was 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. A few Senator/s may one day, break from other side of aisle, support climate action. In other words, the future likely belongs, if only eventually, to acting on climate at some point. But then may be too late -- as wilder weather, the escalating costs of climate *inaction* -- is made-bitingly-clear.

From one viewpoint, that 1 Senator had 'won': they'd kept the coal, oil & gas fires burning – but the big loser was our climate future. Given far stronger action was needed, things may indeed get worse. That 1 Senator saw themselves as lone moderate in deeply divided country. As a realist, one who'd cared for US energy reliability vs. multiplying crises. But it may reflect too deep misunderstanding. There's no redemption found in the science, with pushing off action to later years. No good simple 'compromise' here, like is often seen in politics.

So, 1 Senator watered down a proposed new rule that would have tamped down methane -- a greenhouse gas (GHG) released to air like an open sewer. Methane is a far more potent GHG than CO_2, so controlling it could better prevent millions of tons equivalent of carbon dioxide. Would have been like pulling millions of cars off roads. Scarily, methane concentrations in 2020 and 2021 of 15 and 18 ppb, were then largest since monitoring began in 1983. (As for CO_2 we refer ahead interchangeably to 'carbon' -- or to 'CO_2' – the latter atomic weight is 12 atomic mass units (AMU) and oxygen is 16 AMU; so mass ratio of a CO_2 molecule to one carbon atom is roughly 3.67). But the point is just 1 person was able to dicker, to dilute, and to knock down a proposed methane rule from the final 2022 IRA law. Plus, they had killed all draft GHG sticks. Research has shown that carrots/ like tax benefits have little impact in reducing carbon; to do that, one needs sticks -- those would have been very impactful.

Trying to keep hope alive, new revenue pay-fors were suggested to cover a $1.5 Tn BBB cost. Instead of eg raising taxes, or capital gains rates, novel tax scenarios were discussed. One idea was 15% minimum corporate tax for American companies, as some avoided any taxes. That could help get to revenue-neutrality moderates demanded. Also raised -- and rejected -- was an unprecedented tax on unrealized gains of very wealthy (could one deduct their unrealized losses?); that might be unconstitutional given 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 a 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 in 2022, 2023 or 2024 calendar. Maybe just a narrow lane for lesser, smaller bits of tax-credits, just before spotlight goes over to the 2024 elections. Bigger green omnibus actions -- might thus be put off to 2025 or after at the very soonest.

Fury on how reconciliation BBB was eviscerated in 2021 was immediate. Hyperbolic-sounding criticisms fast sprung up, like 1 person had forced impacts to Earth so profound, they might be visible thousands of years hence looking back at geologic record. To suppose a single person could have so visible an influence, as in the geologic record normally is laughed at, no chance, just hyperbole. But climate is unique, singularly different. Worryingly the critique *might even have had* a non-zero-chance of being right. Terrifyingly there's perhaps non-negligible, non-zero risk that it might indeed turn out to be true. Similarly, for changes wrought in 2025.

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

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

Anyway most all nations were, & are carbon-addicted, despite flowery words to contrary. Not just a usual China, India, Russia, Saudi Arabia, Qatar -- but rich G-20 polluters too who self-proclaim virtue: US, Japan, Germany, UK, others. Whose addictions were at odds with prettier promises at G-20 events, Climate Conferences. As HRM the Queen of England so wisely, aptly remarked in a lead up to COP26, it's irritating how global leaders "talk" but "don't do." Private industry, gave more of same. Like state-owned fossil firms, offered vague promises, glossy blue hydrogen ads, talk of distant 'carbon neutrality' in say distant 2050. All conflicted with more pressing CO_2 reality. COP26 that came only days after G-20, failed regardless, and that was apart in 2021's merely in-draft, fast-dying 'sticks' in the US BBB legislation.

On 3 reasons, 2021's COP goals were small beer. 1) Rich nations big 'commitments' of $100 Billion/year for developing nations were easier to mouth in a Paris Agreement -- than actually to mobilize at COP; 2) Global carbon rules as mere talk, was seen in a flailing US Congress and a disintegrating BBB; and 3) Most blatant, cuts big enough to keep to 2 degrees C heating -- let alone 1.5 C -- were obviously far deeper than what nations were prepared to offer. Commitments on offer were far short of a 2 degrees C ceiling; to say nothing of 1.5 C via 45% *fewer* emissions, a bridge too far. Simply adding up all 2021 commitments, meant emissions if followed, would drop by oh … umm, ahem, *Nothing!* Instead, they'd go Up +14% *higher* on best commitments of 2021. Canada increased ambitions at COP26, yet its new 'tougher' goals were so lax, that they'd still be in line with 4 degrees C of further heating.

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

As for that draft BBB, 2021/2022 had brought it to head: either compromise -- or failure. The Senate Parliamentarian needed to see all items 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 was re-written pared from 10 years -- to 3-years sunset (or 1 year) hoping a future Congress renews. That reduced top line costs but weren't the real cost reductions that Senator demanded. Fears were of stoking inflation, that sticks would hurt fossils dear to that 1 Senator's heart; it looked like only already passed Bill, might be all done. To some, $550 billion would go farther than ever on climate -- so, great. Partly (although arguably not fully) paid for, revenue raisers needn't rely on raising regular taxes, as feared by moderates and conservatives. Yet death of a bigger BBB was also likely a missed chance. A huge loss, given what that Bill might have been. It might have started taking seriously at last overlooked GHGs including methane, and clathrates etc, as sleeping giants, risks besides the CO_2.

In sum a 'smaller' IRA signed in 2022 was bit of a 'win'. But not an end-point to 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." Perhaps electrolyzer makers may invent better catalysts; low-CO_2 hydrogen tax credits help carbon avoided; even carbon taxes. Because a wee IRA of 2022 was negotiated quietly, between Majority Leader and 1 Senator, a narrow lane probably was all that had existed then. That 'smaller' 2022 IRA was defanged of all text penalizing fossils -- so became just carrots/no sticks, aiding fossils & nukes too. Perhaps a 'best' that was then possible. Yet earlier BBB text, thinned-out, may show which way the wind was then blowing. It may be re-raised, if climate is regarded seriously.

Bits of BBB Bill were kept in; the parts cut were oft anti-fossils 'sticks'. Those are Unlikely to be re-raised anytime soon -- especially as a 2022 IRA was being drastically cut back 2025. Maybe still favored: a better ITC if 40% US-manufactured content. More if US steel in trackers. Inverters aided if robust US content. In draft, that ITC could grow if projects are sited near former coal mines, or coal power sites; this could well stay on. Maybe a 45Q tax credit for better 'carbon capture & utilization' robustly stored, or for direct air capture to aid fossils. Proposed too were needed strong Federal methane Rules; any fees on methane are important, although what was proposed on this matter got diluted some in a final IRA of 2022.

That US Senator repeatedly declared a $2 Trillion+ BBB, 'Dead'. Was not surprising as that 1 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 targeted Bill was possible. Like in a 'Princess Bride' movie, hopes lingered it wasn't 'all dead' -- just 'mostly dead'. A slimmed bill *could* get to 'Yes'. In that movie, Inigo Montoya had hoped to bring Buttercup's True Love back to life. Miracle Max noted he was 'mostly dead' -- slightly alive. The slimmed down bill wasn't yet 'all dead' and in Washington DC, the joke was 1 Senator may allow something that will help fossil fuels too: thus no longer BBB -- but rather 'Build Back Manchin.'

Then, in July 2022, the Senator did 'surprise' with the one needed Yes vote. Thus, was the Inflation Reduction Act of 2022 born. With notables like tighter $7,500 EV tax credits + income limits; that Senator felt giving tax credits to wealthy would be 'ludicrous' -- though eg $7,500 credit may apply if 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 long captured strategic minerals supplies, so something needed to be done, though China built an enormous lead). In 2025 the IRA was dramatically reworked, one eye firmly on addressing China. Think of carbon linchpin, China. So wedded to coal it hadn't talked 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. And yet.

Consider what's possible there high end. In theory if all China's areas that could easily have solar, had it, mainly sparse-populated northwest (most people 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 (or 2x then-Total demand all energy with heat). By 2060 as solar efficiencies improve, its solar potential might rise +50% more to 150 PW/hr, when China plans for net-zero emissions. ½ its potential solar-areas were already capable of PV as cheaper there, 2020, than coal. 80% of its solar areas could be cheaper than coal in 2022. As solar improves more, 2030, solar could be cheaper than coal -- across all China!

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

By 2060 solar+storage could make 7.2 petawatt-hours, so meet 1/2 of China's electricity demand. Compliment its huge wind, geothermal etc to meet all needs -- alongside maybe nuclear (fusion? -- better than fission)! Yet put aside unknown fusion -- think of challenges in ramping proven renewables. Especially as material costs pinch. Battery designs if needing say cobalt, may hoover 36% of world known cobalt reserves -- 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. Materials availability, tech maturity, cost, efficiency impact choices. Look back a few years: it may have been propitious to have 'gone into **Photons**' then -- like into solar as one 'P' (like China did). Look ahead and another P here, **Protons** is riskier; energy storage & energy conversion with electrons in H_2, fuel cells etc; that *may be* propitious ahead. But it was unknowable in 2020s, with huge volatility. What is certain, is this 'protons' theme in 2020s *is still hugely risky*. More so, than surer-solar.

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

A wilder hair in 2020s was a *potential for* nuclear fusion. Put aside attention to H_2, fuel cells, PV, batteries a moment. Instead, focus on neutrons: fuse 2 isotopes of hydrogen, deuterium (^2H in seawater at 2 Neutrons) -- with tritium (^3H with 3 neutrons, bred as by lithium) -- and it creates a 2 neutrons helium (^4HE). Critically the 3rd neutron is 'gone'; so on Mr. Einstein's famous $E=MC^2$ this is mass imbalance, immense kinetic energy, 17.59 MeV mass 'disappears'! Immense energy, no wastes! But practical issues like overcoming Coulomb barrier in positive ways, inertial confinement at temps & pressures mimicking sun's core, mean it's latter half century at soonest before significant applied fusion is on grid. It's been lately called energy-positive -- but in fact, 100x the ignition power was used by lasers -- so 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, in 2020s, 2030s, 2040s.

All as the input costs to grow clean energy 2022/23/24 had soared. Supply chains were stretched. Inflation more than a 'transitory' curiously said 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 just physical of $^2H/^3H$ DT fusion ignition -- but of price rises like 2021 as Europe's wholesale PV prices inflated +19%. Panel prices in 2021 were up 50% euro cents/kW vs. 2020, poly prices spiked 4x from 2020 to 2021. Rose again 2022, 23. If US is to grow its own 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 with costlier, thorniest inputs. Take pricey silver in making PV panels, ripe for change as conductor in PV. How better to reduce, or better yet to replace dear silver with plentiful copper. Panels in 2021 had devoured 20% of global industrial, silver supply. In inflationary times, silver can be 15% total costs of a solar cell. *May* be worse on 'slugflation' (sluggish growth + inflation), or stagflation! So, to grow solar even more swiftly, think then of displacing that silver, since it's such vexing $$ constraint.

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

Or take buses, likely to move towards electrifying. A typical dirty, smelly diesel school bus in 2021 cost $150,000. A quiet, electric school bus, by contrast 2021 had cost dearer $350,000. So only 1,000 buses, pilot projects on grants were electric in US fleet of 480,000 school buses. Think of a passed 'small' bipartisan infrastructure bill: $5 Billion, ½ was for electric, ½ for low-emission (CNG) buses. Could mean schools even buying thousands of electric buses ahead. Driving costs down, too, for future EV buses that may offer Vehicle to Grid (V2G) to boot.

One big school bus manufacturer is Blue Bird; half its 11,000/year buses back in 2021 were dirty diesel. Other half had burned alternatives: eg propane or compressed gas, so polluting & awful for kids and climate. It only sold a tiny number of clean electric buses: 775 in 3 years to 2021. Understandably, 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 as Vehicle to Grid, selling back power, earning schools' money. Or as emergency community backup power. And $7 Billion for EV chargers. $ for H_2 demonstration buses (those are electric too in a way) in a passed in 2021 Infrastructure Bill – which means they could improve faster as well.

There'll be many obstacles ahead, to clean. Arrows slung, rocks doubtless thrown at green energy. Some claims contrived by opponents who blame clean (wrong) for power outages. Like Texas in 2021, as blackouts were first then blamed on wind energy (wrongly!!). There'll be times renewables rightly may be criticized in this decade -- but mainly that is because they aren't yet big enough! 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 mid-2020s -- yet.

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

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

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

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

In past simmering European fears re: Russian gas were waved off by how bloody cheap it was; at 40% of Europe's gas, Germany used more. Until that 'blew up'. Literally. To win approval for Nord 2 or soften targets, was maybe behind Russia's cuts; divide Europe, prepare for war. Paradigms shifted on fears Russia may invade Ukraine -- as it did. All that as China, Japan, and S. Korea too wanting LNG, pushed prices >$15/per million BTUs. US gas rose too as all is interconnected, from $2 mm/BTUs -- to over $5 briefly -- unheard of in US fracked-shale era. Europe Winter gas demand competes vs JKM (Japan-Korea Market) -- geopolitics meant Europe had to fill storage fast. That + a a mild 2022/23/24 helped. But all became scary on reality of war. Europe's storage reached >95%; but would have to refill quickly after hot Summers, maybe freezing Winters coming say in 2025 and through the latter 2020's etc.

2022 had thrust Europe's debilitating over-reliance on Russia gas, in sobering light. LNG was stepped up swiftly, yet underscored an immediate need for more renewables, fast. GWs *more* solar/wind quickly -- plus battery storage for firm power. LNG infrastructure and gas storage did shoot up – but better, clean power wasn't yet big or firm enough. As Europe tried to wean off coal, some places too off of current-gen nukes -- other places expanded nukes; was little breathing room for renewables to grow. Wind & solar early 2020s was in an awkward stage. Growing yes, but not yet near-big-enough to be Hero. In 2020, renewables had met only 20% of Europe's electricity demand, was nowhere near enough to overcome gas troubles … yet.

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

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

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

What is each 1 GW like? For comparison, 1 GW can power 750,000 US homes; roughly like a mid-sized (albeit there firm, always on) 2nd gen nuclear fission reactor. With proper support, solar & wind, yes, can grow very fast -- along with battery/storage to make that firm power. Or may stumble & fall, if future big bills like BBB with draft $ Trillions, fail. Partly too shows why there's such huge volatility here. And why across the Atlantic, small modular reactors are being looked at in a UK for low-carbon nuclear -- if its 7 big nuclear plants are cut back. Though its big reactors had made 17% of UK's costly power 2021, new 'smaller' gen IV small modular reactors (SMRs) may be seen in a standardized design in China, or France. But can they also be made 100% safe? Less costly sure -- but how about also less risky?!? In mid-2020s nuclear state of art, that answer is murky, dubious at best. Hence questions do swirl around current 2nd generation fission nukes 2020s, SMRs for 2030s too. Yet China, Germany, S. Korea, UK, US & others search for needed baseload power. Next let's consider broadened themes, hence ECO & global NEX Indexes along with H2X/WNX benchmarks -- and oil & gas too. We'll begin by re-noting a great volatility that ever-dominates across all energy themes.

After ECO gain in 2019 up 58%, then 2020 up +203%, it was maybe unsurprising as noted to see big falls 2021 through 2024. From a peaky Feb. 2021, was unknown of course if clean energy so ECO might fall in a harsh backslash shaped "\" down lasting several years or more? Or perhaps an "L" sharply down, then years sideways. Mid-2020s *might* see headwinds due say, 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, *Global tensions, *War, … or… ?? All was despite strong hopeful words at the global COP Conferences (blah, blah, blah) about undertaking climate action within this decade.

A few worries then were: *Green stocks had hit 'high' P/E multiples in 2021; so with *Inflation/Quantitative Tightening; *War, perhaps 2021's high was to be 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 1st half 2020s was also maybe fated as interregnum, a pause between Q4 2020 hopes for clean energy -- & clarity on "E" Earnings. Plus maybe -- as came to pass -- rates would long rise as Fed had let things run too hot -- for years of high rates. Thus, stocks here shifted to low valuations, poor expectations. On discounted values, capital unsurprisingly went reflexively mid-2021 from growth -- to value: so not towards clean energy! Markets may in future get re-accustomed to seeing higher yet historically typical non-zero rates near 5%, as seen in the past. But none of that, could lend comfort here early/mid-2020s.

Valuations at 25x EBITDA (Earnings Before Interest, Taxes etc) may be seen again. Yet risky, green themes with few dividends, little positive "E" earnings -- went bearish hard. In global NEX like ECO, components fell hard as one may expect on this macro-picture. Big, long sell-off followed Q1 2021 peak -- for years. Yes maybe that was a bit due: NEX/ECO had just spiked upwards by 4-fold/ & by 6-fold in just two years from 2019 to Q1 2021.

Recall too how early in 2020 year, ECO had 1st fallen by -50%. To see it plummet again a neat -50% in 2021 thus maybe wasn't so surprising. Or, note NEX was in low 600s early 2021. We saw NEX later near 400 in Aug. 2022; a further -50% drop could & did take NEX down Aug. 2024 to 200. Big possible drops in ECO/NEX are reality. In late 2024, ECO was in the 30s. And NEX was in the 180s. After all, ECO in 2020 had seen a -50% fall, went from 90 to 45, so -50%; it rebounded up big, then fell for years. We saw a -50% fall from top to nadir in 2021, *coincidentally*, curiously a 2nd neat -50% decline to late 2022 nadir. Then a 3rd near -50% fall to nadir in late 2023. Further falls can be envisioned, but given lower levels of 2024 down in the 30s, such prior steadiness in falls and -50% decline no longer applies.

In sum 2021 to 2024 have been a rough patch; interregnum; it may well continue. After this theme had spiked so 2019 to early 2021 on high hopes after a big Presidential win, plus surprise 2 seats gain by liberal party win fueled by hopes of maybe a huge $3+ Trillion BBB -- it was then fast weighted down by high P/Es, steep inflation. New fears & uncertainty over if a big Bill like BBB can ever-pass -- then came overcapacity troubles. Also, an air pocket as to elections. Frankly, even more skepticism might have been then warranted. For instance, whether maybe $$ Trillions+ of new funding for clean energy is truly feasible mid-2020s. We emphasize, without a doubt, passive ECO/NEX like newer H2X/WNX may fall more ahead. ECO falling hard 2021 to 2024 was understandable after huge gains. If P/Es are a useful metric -- & P/Es in 2021 were 'much too steep' -- maybe far lower P/E levels now are of use -- share prices better explainable. Odds of green energy again soon justifying nosebleed P/Es, pretty daunting, but there's always surprises. And, anyways the future is always unknowable.

Much was happening in early/mid-2020s. Some was hopeful; in 2021 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 were not enough for a 45% CO_2 cut. IRA of 2022 got us closer. Solar & wind capable of it, but on current trends we'll Not hit 45% CO_2/GHG reductions -- 'til later. Broadly, on 2 factors: 1) Renewables not growing fast enough to displace coal, oil, gas. And inversely 2) Global inertia in coal, gas are not yet letting up. On war, burning coal has *increased* -- it wasn't being shut-down anywhere near quickly enough in early/mid-2020s.

Solar & wind clearly are capable as solutions; *the 2 have potential to power the entire world* -- many-fold over. On today's technology & available locations, they alone could power the Planet 100x over! They could generate 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 had only captured 0.7 PWh of solar power, 1.4 PWh of wind. Though wind & sunlight if scaled up, could meet all our global power needs. Forever.

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

US offshore wind starting from zero 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 15% electrics 2021, more 2022, '23, '24 etc rising fast to EV dominant. Global EV sales far outshadowed a US. China had sold 1.1 million EVs in early 2021 more '22, '23, etc. In EU 1 million EVs were sold -- far better than US. Full-battery EVs made up 12% of cars registered in EU in 2022 -- vs 9% in 2021, 1.9% in 2019. EVs & hydrids were over half the EU car market late 2022; the first time, more than gas/diesel powered cars. Europe led the US in clean power generation by wind/solar -- & in EVs too. Meanwhile, China was rising much faster from near nil, and it clear will be beating all soon ahead. All this while US lags.

In Western Europe, coal-use 2019 was falling -- until war from 2022 revived coal! Natural gas use may be cut ahead -- but again, not yet! Instead, gas needs made Europe's energy prices jump 2021. Fell after on big ramp in US LNG. Gas, portrayed as '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 mid-2020s. Replacing boilers with heat pumps is costly -- has begun, can happen faster than expected. Renewable natural gas (RNG) blended with green H_2 to say 15% is another mid-term way. As is running ships & aircraft on green H_2, or hydrogen derivatives like ammonia (toxic so careful), methanol if green ahead. Maybe: transport hydrogen via benzyltoluene for a H_2 that's released more efficiently from big Liquid Organic Hydrogen Carriers (LOHC) at lower temps. All but one-side of climate coin. Other side must be big moves especially by China to cut its coal/CO_2/GHGs. To address the ample methane that's released to air. Clean energy gains are for naught, if coal & GHGs don't drop to near nothing. Yet huge populations in India & Africa with their understandable economic aims, seeking their own development ahead, may look towards cheap coal.

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

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

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

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

IRA of 2022 helps reduce CO_2 some in the US, one of worst offenders. And Paris Agreement won curious fanfare 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, far more* enormously: by some ½ to 2030. Actions worldwide may point to a plateau -- first of coal burning, next of gas, 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 did accelerate 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 in 2050 aren't worth discussing.

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

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

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

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

Lately, market forces help renewables. But according to best climate science, the carbon budget says a clean energy transition isn't happening nearly fast enough. A shift from coal -- to oil & gas -- had once taken half-a-century. We don't have half-a-century now, as science tells us. This transition isn't just to flop new energy -- atop lingering fuels. Instead, it's a full flip to new energies only; solar, wind, storage, maybe green H_2. Policies could hasten that. Especially as clean gets cheaper, better; they are for sure healthier. We saw attempts from 2022 to use fossil gas as cudgel in wartime, freeze Ukraine. But that cudgel 'broke' -- it failed. Capital markets responded fast & matter. Here now, pace of change in 2020s is of the essence. It's simple. Listening to what the science and once healthy 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 in volatile 2020. Given these 2 Indexes/ETFs stood out then as very top performers that year worldwide, ECO notably up +203%: why did the two do so well? Several factors enumerated next, may help to add a bit of colour. They imply too that down years -- these 2 volatile Indexes (as we've seen) drop harder/faster than most!

One big factor perhaps, is our using *decarbonization* as an organizing principle stood out. Another is: *Market Inefficiencies: our Indexes hold smaller & mid-caps not as known to mainstream analysts; fewer analysts in cutting-edge innovations like in electric cars, Li-ion, green hydrogen, fuel cells, solar etc -- may add sizable pricing inefficiencies. Few analysts in zero-CO_2 (and those that are here, 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 shorts -- vs +12,000% gains in one equity is impactful. 4th 'ESG' baskets may be steeped in greenwash, for example they may have natural gas! As our's has had a true clean focus was very unique & it's been consistent for over 20+ years; that it came into favor maybe was good fortune.

We'd seen similar in ECO in 2004–2007 as green energy, once-unknown, grabbed a spotlight. Sharp rises in tiny solar firms, electric car startups, li-ion batteries, storage, H_2 fuel cells. Stubborn-held (dis)beliefs maybe broke a bit -- or not. Views oft heard in 2004 had included that electric cars could *never* be fast as 'real cars', nor see 200 miles range, nor be as pretty, nor as fun to drive. Views then were often that 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 seeming promise, in 2004-2007. Clean energy back then was itself thought of (and was) much too costly*. And true, after a 2007- crash on overcapacity, high relative costs -- clean was 'promise only' back in 2007-2014 or so.

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

Or think financial sphere. Melt-ups redux. In ECO Index® there were 10 components all up over +1,000% from their own past 52-weeks lows then, March 3, 2020 -- to March 3, 2021:

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

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

Good: Maybe Were many Reasons for Equities Rising So over 2020

For bit of fun, let's call factors behind a big 2020 change, or 'delta': the Good, Bad, and Ugly. Good, were the ***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 a decade ago. Many models long had foreseen dirty coal, or gas as instead, being definitively THE very-lowest-cost power across 2020s! *Lowish-interest Rates, another Good driver in 2020; as were *__unprecedented commitments__* by 3 blocs, China, Europe, US. In 2020 China had made new statements about decarbonizing, announced its aim to be peak carbon 2030, become "carbon neutral" 2060. The devil would be in details to be fleshed out as new 5 Year Plans are released to much anticipation.

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

So, it was a big disappointment as China's 5-year Plan of 2021 didn't take steps to end coal. It's '23, '24 actions were worse. The world needed coal to peak *before* 2025; biggest user China to commit to peaking-coal 1st half of decade. It did not! Instead, it saw CO_2 peaking post-2025, on steeper CO_2 (assumed) cuts, only later. In a fudge, oceans & land as 'nature-based solutions' or 'CO_2 sinks'. Then yet more coal was planned, in use. An alternative -- peak-coal by 2025 -- could have happened. But did Not. Now, CO_2 sinks may become sources, reversals ahead -- even in Amazon Rain Forest. *Instead, China's renewables were always its best answer*. Glinda the Good Witch, in Wizard of Oz, knew Dorothy's ruby-red slippers could take her back to Kansas, anytime. But first, Dorothy had to take a yellow-brick road to gain confidence. China's own ruby/gold slippers, solar/wind + storage -- *could* replace its coal, already. Green energy could have become its very 1st best choice, already, in mid-2020s.

Models by Tsinghua University showed how China could hit net-zero on CO_2 by 2050, on 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 post-2025, means sharper cuts after 2030. Far better, would have been to aggressively Decarbonize now; would've been preferred by so many worldwide. China instead, sees more use coal; it may ramp its nuclear from 'just' 46 plants that made 50 GW in 2021 -- to have many more nukes end of decade though grows odds of devastating radiation accidents ahead. Regardless, China's new energy spends may well top $15 Trillion. Or be greater: estimates are globally that $100 Trillion to $120 Trillion must be invested on green energy + climate tech. So, may be 3x, 4x that. The most ambitious effort the world has seen. Maybe 10+fold growth 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 batteries in EVs & energy storage. Apart from just Tesla in a US -- China most has seized opportunities. So too 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 can surpass 25%/year, 4+ million EVs mid-2020s. Maybe again reasons for volatile 2020 moves in ECO/NEX! Such demand had helped push battery costs down, by 80% in 8 years. (So profits down too!). Perhaps near <$100/kWh in 2022. In some cases demand grew 5-fold+ plus.

America's battery leader in 2020 was Tesla with 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 has been happening. Ford, GM have new goals (dropped in 2024) valuation deltas. If all vehicles electric, maybe >10,000 GWh battery manufacturing/ year. 2x+ that for storage, to replace fossils. Batteries may move say towards lithium metal anode, solid state. Beyond lithium-ion much more is ahead. Perhaps more use of iron that's cheap, heavy, but good for stationary storage uses, deeply discharges, no thermal issue for longevity. Cool EV charging; graphene, GaN, SiC fast charges. Vanadium flow batteries, grid storage, maybe all also 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 diesel fondness once 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 were registered in the US in 1912. But now, the US is once-again letting its EV lead slip away -- which IRA seeks to remedy. Something China, and lately Europe too seem intent not to let happen to them. The Nordics could potentially 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 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 -- for then total 204 GW, 210 GW respectively. In 2020 China had added 48 GW more solar, 72 GW wind. More in 2021. Think of what's needed given CO_2 is now over >425 ppm, and it'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 a rich Europe there are European Climate action plans. It laid out a carbon neutral aim by distant 2050 yet may get to >55% *this decade* by 2030. Little-discussed in US -- yet seminal -- is EU bigger teeth after war in 2022. Perhaps 2030 target of 120 GW offshore wind in North Sea, a 5-fold increase from 2020; then on to 300 GW and more by 2050. Greater goals now. With its key aims to start soon -- not later. 9 nations there had committed in 2023 to 120 GW of North Sea wind by end of this decade. First, Belgium, Denmark, Germany, Netherlands; then in 2023 were joined by France, Ireland, Luxembourg, Norway, and UK for enmeshed grid -- maybe renewable H_2 from North Sea. Europe's decarbonizing aims grew more voluminous. Not just in energy: also in industry, infrastructure, agriculture, water, buildings etc. Broadly, an accelerating EU seeks in the 2020s new carbon tariffs, and carbon taxes. Trillions of Euros € spending, with carbon border adjustment mechanisms began from 2023. That can help account for embedded carbon – on credits with value in future, affecting trading nations. Details to be fleshed out, for paths later in decade for a somewhat decarbonizing world.

There was some thought given to what *might* have happened in US 2022, were big 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/or a handful of Republicans come over -- there *may* be chance for (small) carbon tax, a National Renewables Standard. For US to out-compete akin versus China's green energy ambitions. What might have been: lower-cost US solar & wind, better grid; more swiftly electrified US. More may come, domestic-sourced EVs, batteries, storage, wind, solar, green H_2. Products with less embedded CO_2. And *un*-capped, the extant IRA may lead to $1+ Trillion in public, and say, $2+ Trillion in private investments. Perhaps to $$ Trillions *more* if a handful of House/Senate new votes are found.

Some 'Bad' Factors were maybe at play too, in +200% Equity Gains of 2020

Perhaps to some, were 'bad' (irrational) factors in 2020 gains here up 200%. 'Bad,' in a sense it didn't warrant such exuberance; Hydrogen (H_2) & fuel cells come to mind. Not that they can't, sooner than expected -- be vital. Was more, didn't justify the hype, 'til breakthroughs occur. But these are passive Indexes -- not active managed -- so do not try to predict rises/falls, winners/losers. And H2 fuel cells outperformed big in 2020, in new H2X Index too. Early 2020s, H_2 has been burdened by high costs, sparse CO_2 avoided, low efficiencies. But, H_2 *may* grow increasingly relevant. If from classic natural gas, inextricably it is fossil-spawned, not a worthy solution. That 'Blue' H_2 from fossils even on sequestration, can only pass a very low bar, polluting on methane sources. Yes, big Oil is embracing a chimera of blue H_2 -- but 'blue' might only compete with 'green' H_2 this decade, or until 'til green H_2 scales up. Then neither blue H_2 even on 'sequestration', nor uglier brown/grey/black H_2 made from coal/gas -- may perhaps go up against H_2 if made in truly cheap, renewable and scalable ways.

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

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

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

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

The Ugly: perhaps unpretty factors too, for big gains in 2020

*Ugly, tangential factors can also highlight how much better green solutions truly might be. Take dismal state of the art in CO_2 'Direct Air Capture' (DAC). DAC's an energy intensive non-starter by needing gobs of power, so burning more fossils etc. 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, as may injecting captured CO_2 back underground, to briefly get more oil. But then -- a key question is: Why?!! Why, when To Not Burn that coal, oil, gas is where we ought now be heading in first place? CCS is a non-starter, and it is completely unhelpful if used say for more, ugh, 'enhanced oil recovery'.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

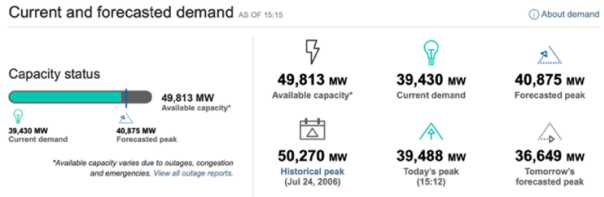
Texas' disaster bad as it was, was minutes from being far worse -- if frequency stability were lost. It did fall from 60 hertz -- to critical 59.25 -- nearly crashing the whole system. Had transformers caught fire, or high voltage lines been destroyed, it could have been weeks, months -- not days with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

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

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

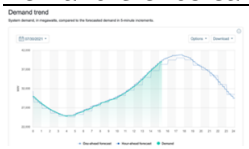
Despite benefits renewables can offer -- curiously some still strongly oppose them. For example, anti-renewables views are dearly held by some Texas politicians. Yet Summer 2023 -- not long after 2021 freeze -- they were ironically saved amid scorching heat, thanks to fast-growth in renewables. In a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

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



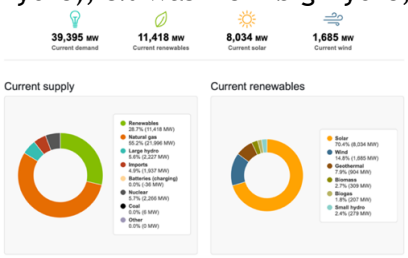
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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



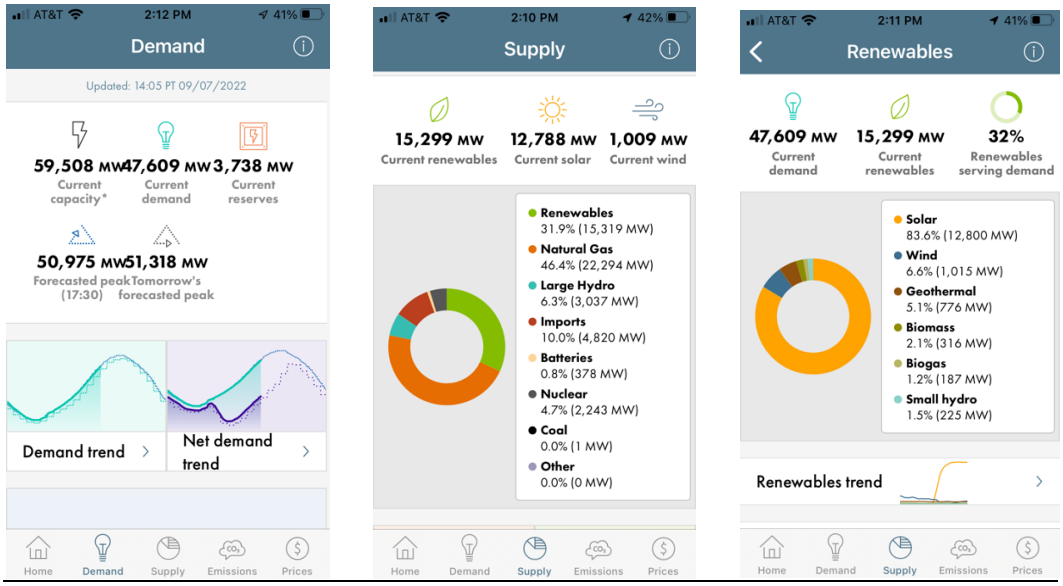
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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



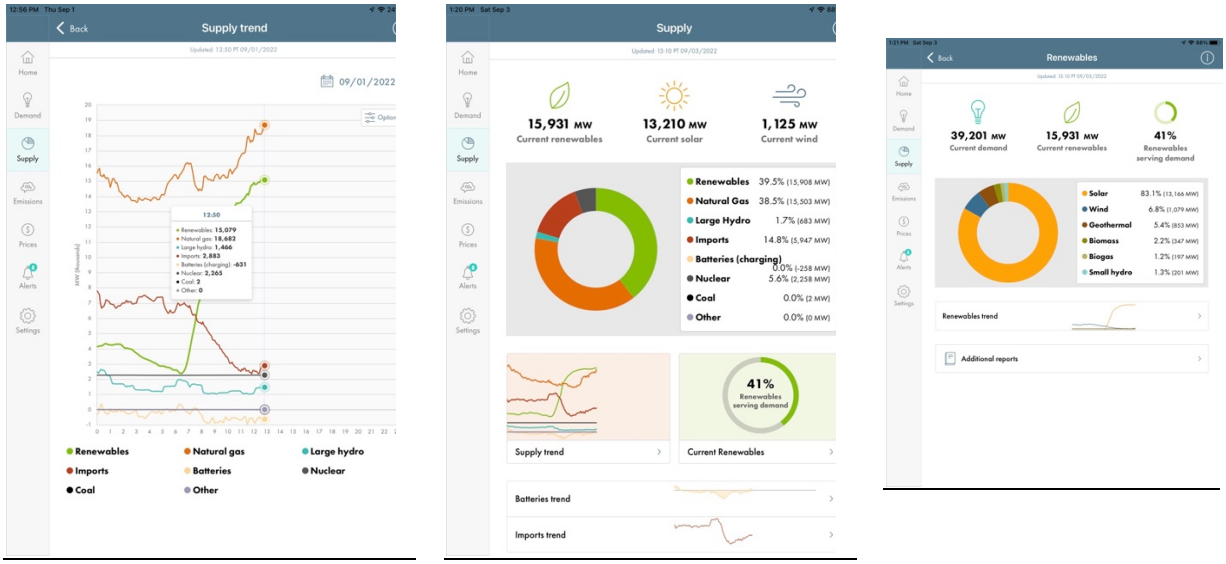
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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



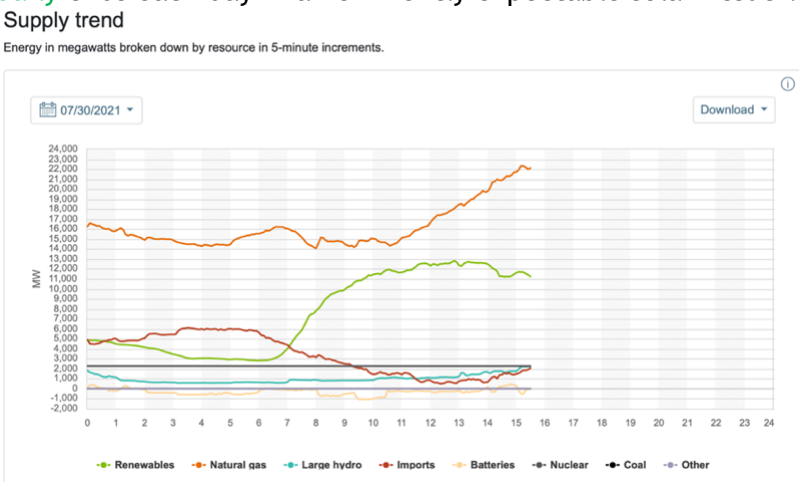
Source: CAISO.com Today's Outlook - On Sept. 7, 2022 at approximately 2 p.m.

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



Source: CAISO.com Today's Outlook -

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



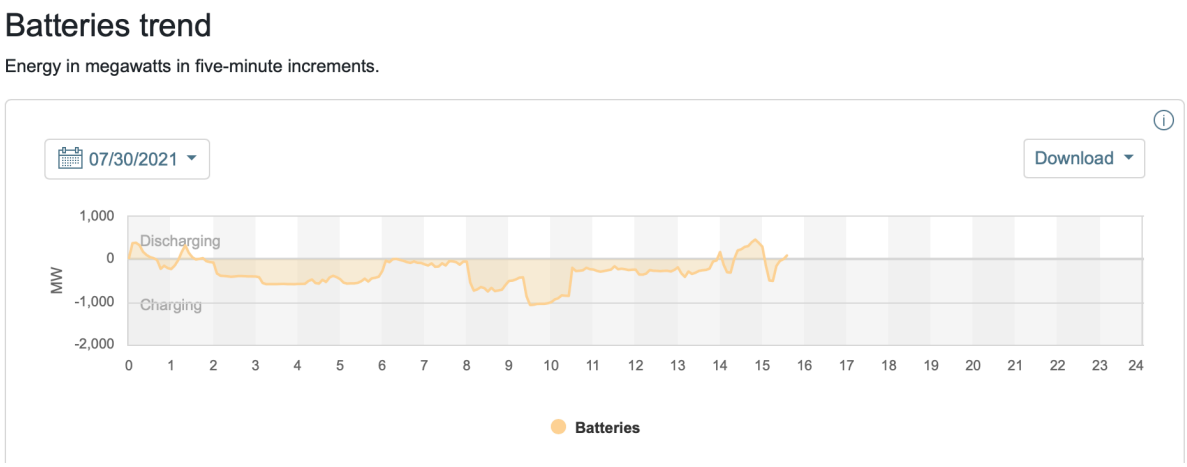
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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

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

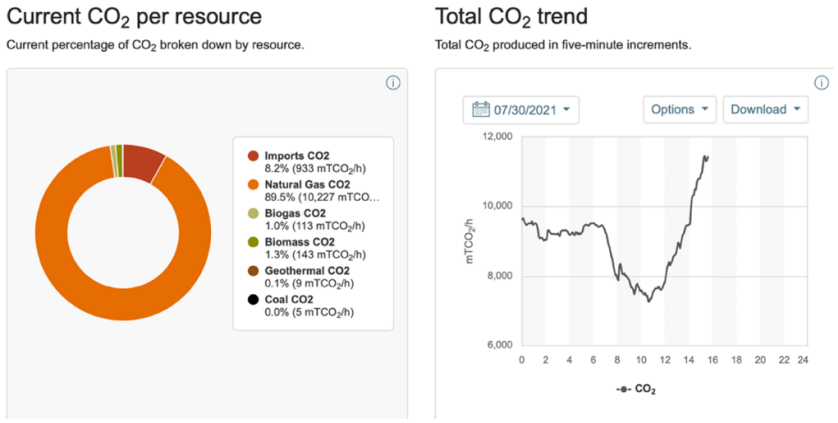
Fast-scaling renewables, creates separate issues of their own. They're not firm. Drought in a changing climate & flooding, are hard on hydro. New wind patterns tough, for wind energy. Distributed generation rooftop solar -- doesn't show up in as-attractive profits for Utility-renewables. But, rooftop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

Back to grid and how millions of homes/buildings are now powered in US. Most of course are Not yet on solar -- Not backed up by (costly) batteries: so there's little resilience. In theory one may think much energy storage today exists on grid; that it would/should kick in fast as 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 day, replace 100% of the GWs, once from natural gas. But the 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 needed now in 2020s is Vastly More Storage -- and better Grid transmission. To help in spatial ways too given there's frequently far-off winds. Batteries can become heroes, but a meager less-than 1 GW was in play early 2020s -- 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 was available when the sun (in 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 in early 2020's had meant we suffer an ongoing dependence on fossils. Needing much natural gas in California, Texas, US, Europe, Asia etc etc -- huge carbon emissions. Big hydro can't scale up; indeed great reservoirs, Lakes Powell, and Mead may one-day become dead pools. Natural gas is not quite as awful as is coal CO_2 per MWh, but its methane leaks vex Earth badly. And we *know* while *measured* CO_2 is an issue – ***un***-measured leaks from methane may make it a climate killer too 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 Given, on hottest days even in wealthy Texas, California, US, Europe, Asia. In drought even in once-hydroelectric-rich Sichuan, China. It's a game now of catch as catch can, as blackouts threaten, pollution's left to go up wildly hot days. That's No solution! It's left to hope, as is seen on Hottest days when California's Governor has to give Emergency Proclamation to shed load -- and 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 are allowed to burn dirtiest fuels in port, rather than use far cleaner shore-based electricity. All scary, when nearing blackouts, that threaten lives.

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

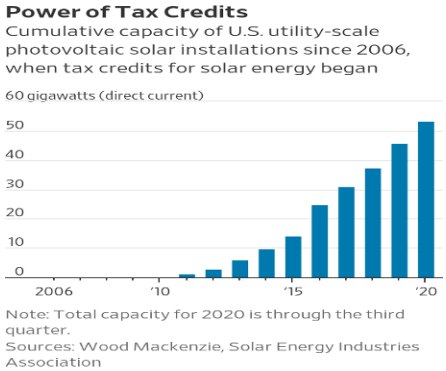
The State uses band-aids. Electrons imported from elsewhere though in demand in regional need and may be from coal, gas, 2nd gen nukes -- all hit by weather issues. All suffering more than renewables in heat waves. Or in drought: less cooling water a growing threat. As Texas showed in 2021 -- cold can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

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

Used to be proponents of US natural gas pointed to it as the energy transition fuel, savior for America. But, they hadn't figured on war in Europe adding volatility, as prices are set globally. True, fracking in America helps reduce natural gas price spikes, as does filling US oil storage. Still… take say, Sept. of 2022: US natural gas had already more than doubled in that year -- which hit utilities hard. US electricity nationally in that Fall of 2022 averaged ~15 cents/kWh, up 7.5% over a year earlier. CPI for electricity costs was up 16% over year prior; largest spike since 1981. Some US regions saw much worse. Like in New England, residential electricity went from 10.67 cents -- to 22.57 cents/per kWh. Due to rises in gas costs, utility wholesale power costs tripled from 2020 to $130 per megawatt-hour. Recall again, the wholesale Bid cleared prices in UK in £GBP/MWh 2022: offshore wind was just 37.35 pounds; onshore wind 42.47; solar 45.99. Yes please! On war, weaponized gas was an Achilles Heal worldwide. A take-away is it doesn't need to be this way. Nor reliance on gas, nor on China for key minerals. In 2020s we keep being 'hit over the head' by climate/and war; both unlikely to go away.

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

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



Sources: Wood McKenzie & SEIA

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

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

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

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

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

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

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

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

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

Real-world Returns for clean energy in this 2018-2020 window, were Up hundreds of percent, hardly 'non-pecuniary'! As ECO was up +300% when traditional Indexes were up more modestly +85% (Nasdaq), +40% (S&P500), +25% (Dow). Fossil gas was then *Down* -60% though would spike -- and then fall. Interestingly too fossil gas vs. clean energy *both* non-correlated with broader 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 in 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 that unworthy Federal attack 2018-2020 reportedly by fossil interests and skeptics on ERISA. At State-level 2022, Texas moved to divest from funds it felt had somehow 'boycotted' oil -- if new energy was just in their name (like NEX)!

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

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

Source: finance.yahoo.com

An artificially narrow window above yet makes point of highlighting differences from fossils. March 2020 to March 2021, ECO had ranged 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 2021-2024 lay ahead. In 2021, China aimed to go from 11% solar/wind generation -- to 16% by 2025. Wind developers jumped then on expiring subsidies – put in 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 proposal was dropped. Point is regardless of certain ongoing volatility, decarbonization has begun figuring in finance.

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

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

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

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

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

US Senators have in past bill drafts, tried to look at getting rare earths from coal waste, of which they've got rather a lot. So wasn't a surprise to see echoes in a 2022 IRA. Studies show greenhouse gas methane is bad at Appalachia's old coal mines. Places unemployment is high, like coal country, arguably special attention should be given to jobs in minerals, cleanup. Legislation has considered incentives for US PV & semiconductor manufacturing, a proposed LIFT America Act for battery-incentives, support US critical supply chains. Still given how far ahead China already is, how fast Europe is moving too, it's questionable if the US can move fast enough in producing minerals, rare earths, batteries and EVs without a huge push. IRA is a start. But sadly, the US is still too-dependent near-term on importing strategic materials. Often means buying from an ambitious, many times goals-conflicted, far dirtier China.

Subsidies for fossils are unlikely to change-soon. Those were even written-into the 2022 IRA, plus new subsidies for nuclear, sequestration too. Oil & gas can write-off expenses, intangible drilling costs, it benefits from lost royalties and deep-water drilling. There's Master Limited Partnerships for fossils. While G20 advocated eliminating ALL dirty energy subsidies and their removal could cut CO_2 emissions 0.5 to 2.0 gigatons, like removing to 2030 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. More $$ was then given to fossils following outbreak of war in Spring 2022, in order to hasten gas exports. Cutting any of those fossil subsidies is sure to be stridently resisted. It's always been a non-starter, in both the US House & Senate.

Still oil & gas do have a fight ahead, as coal can attest. In 2021, International Energy Agency (IEA) predicted that to be climate neutral by 2050, would mean No new coal mines; no new oil & gas fields; un-sequestered coal cut -90%; oil cut -75%; gas use cut -55%. IEA is funded partly by OPEC nations yet it 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 then several of its donor oil-heavy nations had called the IEA's 2021 findings "fantasy" -- not realistic.

IEA has criticized too rich nations for their cumulative emissions. For puny Pledges nowhere close to what's needed for a 2 degrees goal. Calling 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 is mainly electric. Planes run on biofuels, ships ammonia -- *green hydrogen* H_2, ammonia NH_3, methanol CH_3OH, LOHC, biofuel. Carbon pricing worldwide including China to be effective. Subsidies over for fossils including in US. Green hydrogen achieving cheap, high-grade heat needed in industry.

Change is ever-afoot. 2020, an oil Index/Tracker crashed -70% *down* as oil fell. It rebounded in 2021 and after. A Natural Gas Index crashed hugely down over -80%. A few words about that former, the oil Index. Quite unlike ECO/NEX/H2X/WNX, that oil Index instead is based on a commodity - rather than equities. 'Worse', it was based on 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, that oil index went down fast -- unlike the further out 12 months Oil Futures. It's been amply shown there's a floor, beneath which oil prices (rather like natural gas prices) cannot easily fall -- unlike either solar or wind power.

We'll discuss it ahead, but a point is, 2020's oil price crash *was a crisis* for it. Until oil demand rebounded 2021, production restored. By contrast green themes – do move in divergent ways. Clean energy's future, non-correlating, is different. For example in 2020, a consolidating US solar maker moved operations & management to another O&M. Separately an integrated PV name that had vertical-integration, seen before as a positive, split in two. Before, it made panels, with also sales & service; split by spin newly specialized, parent focused downstream on selling PV / storage in Americas. A big market with very thin margins, yet a premium brand. In-country work that can't be outsourced, done overseas by cheap competitors – but, still, future of both was very much in doubt and solar equities were about to fall 'off a cliff'.

That sad path 2021-2024 shines a light on tight margins, competition. Post-spin, the parent in sales (not installs) would never see such valuations again in that space. Nor upstream, did spinoff, a premium PV maker soon win out, either. In 2021 the well-known PV maker's stock was >$30 with some China patent protection & pricing power (~3 cent/Watt commercial, ~5 c/W resi). But margin pressures were unrelenting; it soon shipped cells, instead of panels -- to shave transport costs. Commoditized PV upstream ('just buy good, lowest cost panels') hit profits hard. It was hoped premium name could help hurdle razor thin margins. And 2021 module prices did rise near $0.20/watt, briefly, then resumed falling. Performances at the 2 'sisters' unfolded dismally. 2022, mutual exclusivity softened; one made a premium product -- other was focused on PV sales. In 2024 their exclusivity ended -- but that too couldn't stem loses. Upstream PV maker's stock plummeted again late 2024 to few pennies/share -- then did a 100-1 reverse split so small market cap, but back >$1. Downstream that PV seller's stock which had been high in 2007, over >$30 early 2021, plummeted and in latter 2024 it declared bankruptcy. Its many competitors swiftly moved in to fill that solar sales space.

A different, separate merger in 2020 had brought 2 US solar installers instead together, as 1 behemoth. It was hoped latter *might* see robust valuations, more comparable to that seen in another standalone solar name, less dependent on Net Present Value, NPV. That didn't work well, either. All sought lower-cost access to needed capital, unclogged PV supply chains. For all, solar was beleaguered. Clearly the years 2021-24 were a roller-coaster, or 'solar coaster'; an exhausting time with huge stock drops, remarkable and little seen like it. ECO Reports grew to over 100+ pages. Overshadowing much was a pandemic's lockdown. Many markets cratered -- and may do so again. Oil imploded like not seen in 100 years, then bounced back. Attention to climate & to clean energy solutions, briefly was derailed by pandemic -- resurged some -- then was eclipsed by war, weather extremes, fears of recession, debt. Bold new action on LNG by US for Europe, to get EU past a dependence on piped-Russian fossil gas.

Moving on, briefly consider how fast things change. A decade ago, clean energy and so ECO's picture say mid 2010s, was oft *down*. Breaking that 2019, ECO left a long spell of being Down past few years; as 2019 to early 2021 this became a striking divergence. Clean alone up over +300% as green jumped. While fossil themes were then down -30% to -70%. Next in 2022, fossil natural gas briefly rose, as clean was down hard. 2023/24 saw drops in nat. gas down hard -- clean down as well. At any rate, a few years capture but a sliver of time. And corrections happen, trees don't grow to the sky. After a more monolithic early 2010s of 'all energy going far down, fast', clean/so ECO had changed direction in 2020 -- by a lot. Was then up 6-fold seen from its bottom to top in early 2020s. Then, clean plunged as we've emphasized from Feb. 2021 at 270 – down to just 30s in 2024. While the most traditional fuel for electricity nowadays, natural gas -- that's a key competitor to the clean ECO theme -- went down harder. As past 10 years, clean energy themes have 'beaten' fossil gas, very considerably.

Next is a 10 year chart rolling. For a decade energy past 10 years was often a relative 'dog' -- and our apologies to all dogs. What's changed? In a charting sense, there's steep declines at times, so to include any big falls -- like in 2021-2024, and an earlier slog in the mid-2010s -- bends performance downwards. Still any plunge warrants attention. Thus, here is a rolling chart for past 10 years from 2014 -- to end of 2024. In a change of view, instead of 'just' natural gas for energy comparison -- here too is an oil tracker -- and excellent, passive solar-only theme. Notably gas & oil can be barely seen, as so very far down at the bottom!

Interestingly for past 10 years now at very 'top' is the **NEX, down a bit -10% (in light blue).** Next is the excellent passive **solar-only theme (in pink)** 2nd from top finishing -17%, nearly tied with NEX; both easily beat traditional energy doing far, far better than fossils oil, natural gas. At 3rd from 'highest' but well down by -36% is ECO (in blue) that fell considerably. Thus passive NEX after being many years positive, post-2019/2020, has fallen to just negative. Still, all these three clean energy themes have each and every one, Trounced the fossil fuels!

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

Rolling Past 10 Years, so for from 2014 -- to the end of 2024:
Best are NEX, Solar-only theme, ECO -- trouncing the Oil theme, and Natural Gas

Source:Yahoofinance.com

Clean energy above did 'huge' around 2020, as Clean themes briefly were especially strong -- versus fossils. Versus even all major Indexes too. It was a tale of 2 cities, Past 10 Years has shown at times Big Declines in Dirty energy -- vs Clean Up well by varying degrees. But since then of course, given 2021-2024's reversal, clean plummeted -- yet Not alone in energy. Natural gas has plummeted too. As time rolls on, each of these *may* tell new stories. How a theme is defined is very cogent. Seen next, is how a theme captures 'global clean energy' is key. Ways that a "clean" theme is defined, no backroom matter; it's consequential.

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

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

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

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

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

Source: Bigcharts.com

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

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

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

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

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

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

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

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

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

Arguably, a priority should be to stay true to clean/green. Not be pushed into brown energy. Otherwise, prior focus on good targets like robust zero/low-carbon may drift off-theme. How in the world, can coal, oil be included in a true green (or less-green 'ESG') basket?!! Or, make a claim of 'ESG'??? They can't. But an unfortunate way is via a 'carbon-intensity' metric. It allows a big fossil producer, say on *Revenues* of say 70% oil & 30% natural gas -- to massively ramp its gas to say be 60% natural gas, 30% oil, 10% biofuels -- and claim clean'! CH_4 /natural gas spews a bit less CO_2 per kWh -- vs. oil or coal -- with $$ profits from gas really the dynamic. Nothing zero-carbon of course, but 'carbon-intensity' schemes can lend false numeracy via profits, a seeming quantitative rigor, when the opposite is true. Left side of that equation is correct: carbon footprint can be measured in tons of CO_2 as Scope 1, 2, 3. But right side of equation, 'intensity' grafts 'value', revenues in Dollars, Renminbi, Euros. *Yet air cares not a whit 'how profitably' each CO_2 molecule was made* -- more *revenues* - or less! But sadly, the (ahem, intended) upshot is that dirty fossils and companies can get a free pass.

What 'carbon intensity' wickedly does, is lend fossils a fig leaf. Sounding quantitative, yet lets polluting firms claim 'green' going from oil -- to gas. Sadly, clever marketing, enables fossil firms entry into 'kind of clean' (really brown) basket 'ESG' funds. On ill-conceived notions like 'revenues'/per ton of CO_2 -- that makes carbon 'intensity' slippery indeed. So subtle, it's pernicious. Consider a startup solar firm, tiny CO_2 emissions, negative revenues; it won't score well 'carbon intensity' on few sales. By contrast, a huge fossil firm massively growing brown gas sales, gobs of revenues, scores well. Awful CO_2 eclipsed by swelling profits, for better CO_2 'intensity' scores. Something's patently wrong with that picture.

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

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

Source: The Economist (2021)

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

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

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

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

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

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

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

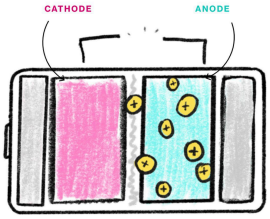
Great uncertainties abound, giving rise to volatility, tremendous risk. Myriad sub-themes *may* see advances: some incremental, some may be non-incremental, perhaps disruptive. Advanced green energy storage & batteries plainly merit focus 2020s, areas ECO & NEX have had exposure to for over 20+ years.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

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

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

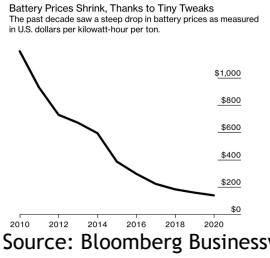
A few chemistries dominate at Cathode. Particular traits/materials are selected for strengths favored: batteries are in fact named for materials at cathode. Traits balanced might be: cost, energy density, weight, calendar longevity, cycle life, fast charging ability, temperature range etc. Favoring one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

a) 4 basic battery parts:



Source: Bloomberg Businessweek

Battery prices are falling hard:

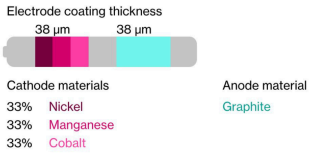


Source: Bloomberg Businessweek

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

Source: Bloomberg Businessweek

NMC Composition back in 2012:

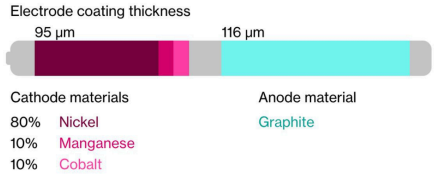


Source: Bloomberg Businessweek

c) NMC as seen in a Nio:

Source: Bloomberg Businessweek

Then, much Nickel, little Cobalt = thicker:

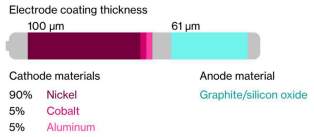


Source: Bloomberg Businessweek

d) Tesla 3 has used NCA:

Source: Bloomberg Businessweek

NCA, light strong battery, no manganese:

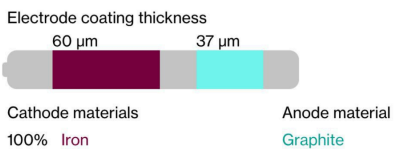


Source: Bloomberg Businessweek

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

e) Electric Buses using LFP lower-cost iron:

Source: Bloomberg Businessweek



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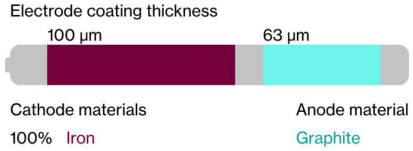
f) Modern LFP, less-energy dense:

Source: Bloomberg Businessweek

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



Source: Bloomberg Businessweek

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

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

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

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

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

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

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

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

Lest that disappoint, gaslighting, or greenwash, or dissembling, are oft last gasps of a waning industry. Fossil interests can/do see writing on the walls. Solar & Wind vs older fossil fuels -- like driving EVs vs gassers -- arguably is superior new technology from start -- and gets better from here! Green has 'won' in one sense. Next decade+ may importantly fill in the blanks. Mid-term, might be incumbent natural gas competing with batteries + storage, maybe H_2 gets nearer economical on gas' spikes. Longer-term it's riskier, but just maybe: perhaps green H_2 *might* viably become cheap, provide industrial heat. As always these are all very risky ideas, volatile baskets capturing evolving themes. And on climate, CO_2 already over 425 ppm, we likely are late. From here maybe innovative-rich latter 2020s, future uncertain. But let's briefly look back, first, at a past 15 years+ of Indexing. This is because from a fixed 2008, we can see some very big drops like in 2009, in brief elucidation of a longer time frame.

First a point re: Charts. An issue with all r**olling** Charts past 5, 10 years etc, is they *may* show very different returns in future for ECO, NEX, also H2X, WNX. As charts leave big falls 2009, tough energy times mid 2010s, 2021-2024, big drops removed, ECO/NEX/H2X/WNX *may* show big relative gains. For that reason a view is needed too with ECO/NEX big declines like 2009, 2021-24 etc forever preserved. Hence this Chart below. From a fixed, not rolling Jan. 1st 2008, looks onwards. As 15+ years & growing this *partly-rolling* chart will always show times of declines. Often fossils lag green. But relative to a purely rolling 10 years, one vibrant point here is green plummets in 2009, mid-2010s, 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 as world's first -- it was calculated in-house, posted Online with Commentary. Original worldwide. Differed from work we now do in formal live Hydrogen Economy index (H2X) since 2022. As ECO/NEX chart below starts 2008 we've uniquely been capturing hydrogen & fuel cells 25+ years, since 1999! For H_2 & FCs info, one can also visit our 25+ year-old 'predecessor site' at Hydrogen Fuel Institute, http://h2fuelcells.org

Note at start *Everything* below in this Chart is well Down, Negative, all underwater! Starting from bottom, fossils natural gas, and oil are the Most Down, hard to see, off -99% and -90%(!). 'Above' them/ so down but less so, is an excellent solar-only theme here off -85%. 'Above' that yet still well down, up much at times yet big falls in 2021-2024 is a solar-only theme at -87%. The ECO Index is also far down, at -81%. Clearly 'highest'/least down across both traditional energy & green energy, is global NEX down -54%. Broad Indexes did *far far* 'better' -- although differ sizably as energy is but only a small sliver, not shown here. Generally speaking volatile ECO, NEX at times may, and can rise strongly; yet clearly they also can and do *plummet very hard too* in declining markets -- going down at times like a rock!:

Past 15+ Plus Years so from a Fixed Jan. 1, 2008 -- rolling here to the end of 2024:

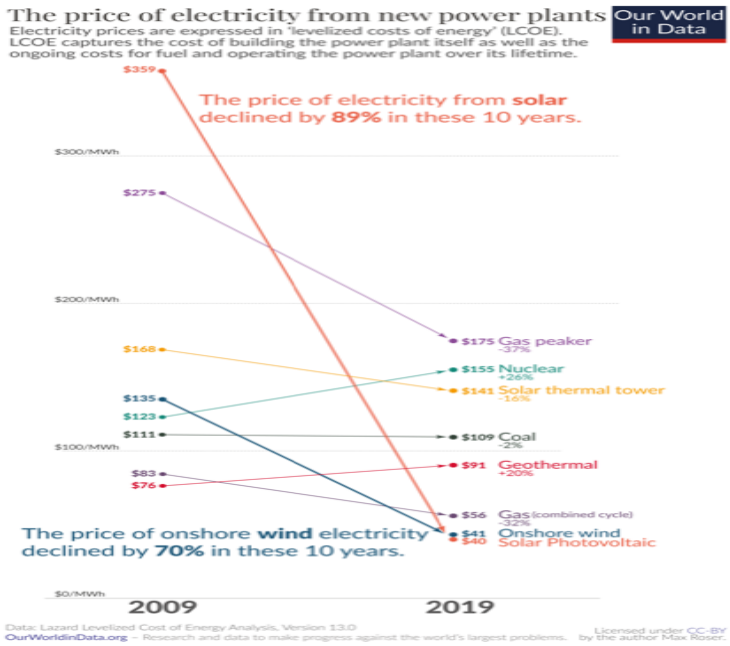
Source: yahoofinance.com

That is looking back, to equities past. Yet a flip side for our planet, is having had near-zero-green power 2008 -- despite growth since, is where are now on renewables in 2020s is *Awful*. Offshore wind in a US 'could' now be hundreds of GWs, instead of near-non-existent. US had a puny total 7 offshore wind turbines in 2021; Europe had 5,400! Solar in 2021 made but 3%, wind 8% of US electricity. Solar/wind *Could* already Meet all EU & US electricity demand. Instead, electrified ships, electric planes are but tiny, global rounding errors. It may 'feel' mid-2020s like we've come a long way -- but it's mainly due to how dismally we began.

In political sphere as regards green themes past two+ decades since 2004, we offer a mere observation. Looking back, it's counter-intuitive perhaps, yet clean energy stocks and so ECO jumped when two conservative party presidents held the white house, though neither loved green energy. Inversely, ECO fell hard under two liberal party presidents, though they had favored clean energy. At times conservatives held smallish House majority, liberals Senate or visa versa for mainly mixed leadership (rarely 1 Party holding all 3 branches). Meanwhile in all energy more broadly, oil producers had once oft hiked output to keep a lid on oil prices -- but after sparse profits last decade, they're keen to keep oil supplies tight, prices higher.

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

Coal is the most harmful energy source. In 2020, it generated 37% of electricity + the 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 costs dropped sizably in a fracking era going down low mid-2010s -- shot up 2021 in a gas shortfall (outside US), then fell again. Still any price drops there are dwarfed by renewables; solar costs fell by -89% -- and wind costs were down -70% as seen here from 2009 to 2019:



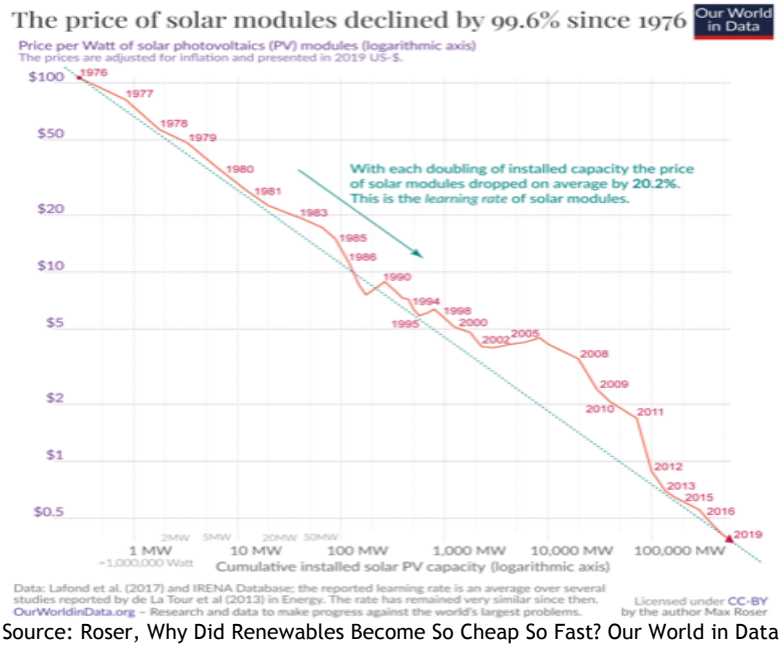
Source: Roser, Why Did Renewables Become So Cheap So Fast? Our World in Data (Dec. 2020).

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

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

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

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



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

Solar prices thus fell enormously -99.6% since 1976(!) on technology. In 2022 US tariffs on PV made in China were temporarily stopped so enters US freer, cheaper still. Fossils -- by contrast -- are Not all about technology; they may be doomed in long-term even apart from carbon. Costs declines in wind too make it impossible for dirty to catch up. How can coal, oil, or gas hope to keep up for decades with this lovely curve? They can't if economics is metric. But do fossils have inertia, influence, capital, lobbying to keep deploying it. No doubt they will Not go gently into that good night. Natural gas & carbon-free nukes have notable roles yet in this energy transition. In sum, it's no wonder solar & wind power make up most power plants newly built today -- along with growing new storage. In green baskets, storage is crucial. How an Index is constructed, where it aims for as we'll next address -- is very significant.

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

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

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

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

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

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

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

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

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

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

Past 5 years to end 2024 for steadiest FTSE 100, FTSE 250, and volatile global NEX tracker,

Source:YahooFinance.com

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

Changes Seen in Early 2020s -- and perhaps possibilities ahead:

US energy Bills proposed in early 2020 were just a start: there'll be much more legislation debated this decade. What happens next years in 2020s *may be* historic for clean energy. *Just possibly be* 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 too, youth worldwide are demanding a greener future.

A glimpse of what may be sought later on in this decade, may be 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 nearly all will be tried, or accomplished -- but some will. Work shall unfold next few years, much getting dashed on rocks of reality. Yet any robust steps begun this decade towards real decarbonization, would be a big change.

Planning in 2020 was no small beer; far more ambitious & aggressive than ever contemplated before. On ever-changing Oval, House, Senate, this decade **may** unfold like nothing before. "Transformative" is a big word -- yet it *could* be, along with an ambitious Europe, China. Yet bear in mind if expectations get too ahead of reality -- say fossil advocates frame each energy crisis, price spike as fault of renewables -- expectations may shatter. Change requires much support, legislation, a US Senate that's home to compromise, inertia, realpolitik.

Consider as well how little was done for US clean energy in Covid. In summer 2020 federal pandemic aid for fossil fuel-heavy sectors reached $68 billion: much 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 a future pandemic wave. Still, solar businesses 2021 re-gained bit of momentum. Utility scale PV grew some 43% in 2020, to 19 GW. Many big installers re-reached their pre-Covid expected levels. By early 2021, US residential solar installs had grown 25% YoY. As for the world, 2024 saw global PV capacity grow by 600 GW in a 29% rise vs. 2023; and that 2023 was up 87% vs. prior year 2022.

In 1H 2020 global offshore wind had done especially well -- despite an onslaught of Covid. In fact, first 6 months of that year were then best recorded for offshore wind! First part 2020 more investments went to new offshore wind, $35 billion, than all 2019. Had tripled world figure 1H 2019. Offshore wind decisions in 2020 had included to green light 1.5 GW Vattenfall project off Netherlands then largest to date at $3.9 billion; 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; some 17 installations were financed by China such as 600 MW Guandong Yudean that was expected to cost $1.8 billion. But as we've seen, inflation soon raged and ravaged much.

A prior driver had been declines in wind costs -- mind you, before inflation hit latter 2021. Plus, looming subsidy cliffs. Unlike solar that as semiconductor crams ever more capacity into chips, wind is more about advances in heavy fabrication, bigger blade designs. From 2012 to 2021, levelized offshore wind costs had dropped 67%. Onshore, wind rubs up against limited space, but oceans are immense windy places for massive turbines far from view. Big wind farms may provide good returns on capital too. Renewables investing had risen in covid-addled 1st half 2020 to $132 billion, vs 1H 2019 at $125 billion. Yet wind that was growing strongly in diverse places worldwide, was soon hit by Covid, inflation, and choked-supply chains.

3 nations did in 2020 see big renewables investing, partly thanks to offshore wind. China rose still by some +40% over 2019. France tripled; The Netherlands in 1H 2020 grew by 2 ½ fold -- vs 1H in prior year. Let's briefly take a look at one particular issue that arose in offshore wind development in 2021, which back then had stood out. This was oil giant BP's winning bid of £924 million for option to develop 2 new offshore wind sites off Northwest England & Wales. Their winning Bid placed in 2021, had perhaps said several things.

One maybe, was that BP with its big money was late to the wind party. Their bid with German partner Energie Baden-Wuerttemberg was well outside norms for bids in wind. It meant they'd pay British Crown Estate near £231 million per year over 5 years, for each of 2 sites at the end of which they'll only then decide whether to proceed: £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 had surpassed too £83,000 MW/year by joint Total & Macquarie to another site. And that BP figure was way more than £89,000 MW/year & £76,000 MW/year in 2 bids made in 2021, as 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 had promised to go carbon neutral by 2050. But there's a cost to coming late. Its shareholders had earned high-returns in older oil/gas production. So, BP maybe felt considerable pressure to earn something like those rich 8%-10% prior returns.

Problem was, BP paying so much at start made it harder to reap high returns later. Arguably 10% returns are a tough target, anytime, especially if aiming for low-risk. Too, oil & gas had earlier showed poor returns in 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 earned over $100K+ working just part-time: that bubble may be partly gone. Hard to think of a job matching what fossils paid, that lets workers stay same place all their life. Today in green energy, a worker in wind, a few years of experience & training, may make around $80Ks/year. Geothermal with drilling, high $80Ks. Solar with years of experience, $70Ks. But unionization rates have dipped everywhere including fossil production. Work like pipefitters, unionization rates are relatively higher, come with sizably better Wages/Benefits. Those rich salaries seen in the fossils, have been tough for most anything else to beat.

Wind farms, once built, can offer investors a stable attractive return on capital. Still, it's a province of business venture, so luck/fortune favors the bold. Best returns in new energy innovation, likely are most enjoyed by first-mover risk-takers. Otherwise, lumbering fossil fuel giants like a BP or supermajor following others' prior leads, may instead experience lower returns nearer say 4%-7% -- rather than a perhaps hoped-for nearly risk-free 8-10%.

A number of serious bidders lost to BP. Shell for instance offered nowhere as much. Yet in offshore wind, Europe's supermajors such as BP, TotalEnergies, Shell may at last be starting to genuinely transform towards 'energy companies' (not mere greenwash) That puts them well ahead of the US supermajors -- who have instead made it clear they do *Not* seek to venture into renewables. By contrast, take Orsted, of Denmark. It plainly divested out of old oil & gas -- to focus on true green energy. A leader like Orsted, or even slower-changing BP, Shell, or TotalEnergies of Europe -- all can contrast sharply with America's Big Oil. US oil may cling to just touting notions of 'sequestrating carbon' or resort to some blue H_2 marketing -- so soldier on in fossil-centered business models. Those paths perhaps, will be non-starters, or mere runner-up ideas, as may be one day reflected in market caps seen in 2050s/2060s.

Raymond James' 2020 data on renewable clean tech investing at big cap oil & gas firms, had shown that of 7 Big Oil firms committing to net-zero emissions for 2040 to 2050 -- fully 6 were based in Europe. Of the top 7 all in Big Oil, those 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 at ExxonMobil in US, spending 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; Big Oil stocks valuations mostly had Declined a prior, past 5 years. It's of note. Perhaps longer fossil behemoths defy change, the more they **may** head long-term to be 'Not-So-Huge'caps'. Firms most wedded to high-CO_2 may, possibly (Ahem, no polite way to say this) move towards Irrelevance later this century. Like coal, steam before them.

Denmark's Orsted is rather posterchild for a once-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 the fossils. Orsted robustly launched into wind, solar, bioenergy. Benefits since shown in market capitalization -- as BP trailed. Results 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 that can be reduced even if a firm sells fossil products. Big Oil could stay in dirty fossil lane while reducing Scope 1 & 2. But, Scope 3 refers to customers' carbon footprint using their product. Hence only a green transition (like Orsted) to sustainable energy satisfies this. Even if Big Oil is determined to stay in dirty energy on facile CO_2 accounting. Or claim 'offsets', an oil firm may pretend its rock gas is 'clean'. Make dubious marketing claims -- yet it's true Scope 3 nonetheless will grow ever-tougher.

Big Oil in Europe, so BP, Shell, TotalEnergies moving into offshore wind arguably were right to do so: wind is clean, unlike oil & gas. Big oil has cash, experience, engineering know how -- like say, Equinor Norway for US wind. What's needed too, besides wind, 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.

Not yet being sufficiently looked at, there's much potential in Geothermal. Maybe lithium-rich hot brine for cleaner power & also 'lower-carbon lithium'. Maybe ultra-deep drilling for geothermal power -- done anyplace on earth! The US big oil names could lead here. For example the Salton Sea in Southern California hosts Geothermal resources; it also could produce both form energy -- and the lithium needed for n extraordinary number of EVs to be built in the US. Men good jobs, where unemployment is high. So one must ask, Why Not!?

UK lessons-learned can also assist a US like how to place, construct necessary undersea cables. Facilitate building off-take connections needed onshore as well. In a US for example, coastal Oregon in the West had first tried in 2024 to stimulate development of new offshore floating wind by an auction: it proved a total flop. Large wind companies familiar with the needs and the certainty to be required, pulled out. Hence even mid-2020s the US is badly trailing behind UK on offshore wind. In 2021 UK then had a 'sizable' (yet-not-so-much-now) 10 GW offshore wind -- which had made them a world-leader. After, UK had aimed in 2022 to quadruple+ its offshore wind within this decade -- that aim derailed there briefly in 2023. It could/should be doing more. In 2025, China for instance was planning new floating turbines sized 20 MW *each;* when the world's biggest wind farm was just 88 MW, run by 11 turbines. In June 2024 it turned on the world's then-largest solar farm; 2024 it also built the world's biggest offshore (fixed/attached to seabed) wind turbine at 26 MW: no grass growing under their feet. US in 2021, pathetically, had near-zero offshore wind. Less than a big turbine, though windy lengthy shorelines! One 15 MW unit -- they began operating in Europe 2023 -- could power 20,000 European households. China's 18 MW turbines, could each power 40,000 homes: think 1,000 big units plus with storage; such could power 40 million homes, fuel new transport.

Data from Bloomberg New Energy Finance (BNEF, our long-time prior NEX partner) & US NREL 2021 showed how badly America was lagging Europe & China in offshore wind. All can use big turbines -- GE Haliade 12 MWs, Siemens 14 MWs, Vestas 15 MWs, 18 MW China CSSE turbines -- yet a key Wind obstacle in US and EU has long been: Permitting. (Like in Grid, Solar etc). US in 2022 had but 2 tiny, not even-commercial-sized offshore wind farms, one a 30 MW site, like just 2 big turbines! Ought to have been huge; is growing a bit -- but 1st commercial-scale US offshore wind farm only opened 2024, a modest 132 MW, so still much too little! Breaking down US wind Pipeline, it's made of 1st -- a Project Planning stage (developer, Agency initiates site control), then Site Control (lease/contract), Permits (plan+offtake agreement), Approval (regulatory OK), Financial Close (sponsor investment), last Construction (build), Operations. That doesn't include myriad lawsuits on the way. Or political opposition. Sparse infrastructure to offtake power, all halting offshore wind, mid-2020s before it begins. Perhaps less wonder that wind power had been so absurdly absent from US shores to mid-2020s.

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 30 MW, and 12 MW approved -- 0.1% of 28 GW planned in 2021. 6 GW more US offshore wind 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 being canceled in 2023.

US states farthest along in 2021, those in Site Control/Permitting were: 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 slowly as 2020s ramped. Confoundingly all but 2 of the 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 on 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: low wind speeds, devastating hurricanes!, little required offtake. That said, BNEF raised estimated US offshore wind projections by +70% from an 11 GW by 2030, estimated in 2018 – to a 19 GW estimated by 2030, then in 2019. Growing since.

Big changes may be ahead in offshore wind so relevant to Index themes WNX, ECO, NEX, H2X. US, and world. For scope of potential changes, consider how puny all offshore wind was even recently. Then, imagine what *may* come late this decade escalating fast 2030 and just after. Until 2019, global cumulative offshore wind capacity had only reached 27 GW. And that was still mostly concentrated in 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 new global capacity, in just one year 2019. More since then.

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

More granular gets interesting from mid-2020s as US may become a big player in new *floating* offshore wind. With immense tracts of available space. Offshore wind fixed to seabed has 'mainly' (barely!!) been all it can boast of offshore, on America's East Coast as waters are shallow there. But floating can open up the US West Coast, in waters thousands of feet deep: a new ballgame. Thus floating platforms tethered to deep seafloor can be a game-changer. US may actually start to hold its own, a significant change, both vs. Europe -- and 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 operational in 2020 proved potential. Is early days yet. And Asia's leadership in floating wind isn't just in China only, nor 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 its own 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 in 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 made up 89% of the substructures by choice. And note that for fixed wind towers built on the seabed, with huge 12-16 MW wind turbines, the number of vessels able to install that nacelle mass >500 tons, hub height >100 meters, rotor diameter 200 meters(!) is vanishingly small. Highly specialized vessels (WTIVs) for installing offshore wind must be built, for monopiles on seafloor, jackup depths over 50 meters. New US-built vessels needed too given the US 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 get favorable vs. costlier current technology-nuclear, or coal, oil & gas. Once enough energy storage enters the scene, older energy although firm, maybe can't compete with such price decline trends of their own.

In Europe, levelized offshore wind had fallen by 2021, from 18 cents/kWh, to near 9 cents. US offshore wind was 9 cents 2020; Mayflower Wind off Massachusetts one of the 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 that inflation spike seen early 2020s.

Once *offshore wind* gets a US toe-hold latter 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, solar is faster advancing; China confounded expectations of a slow solar 2020 on 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 pre-war 2020 -- unlike power interruptions in California & Texas. And the crunch 2021 in Europe/UK -- was mainly due, once again, to burning *fossil fuels,* especially imported natural gas issues.

Back in 2020 a pre-war EU-27 had made 40% of electricity by wind, solar, hydro, nukes, bioenergy. 34% from fossil fuels. Standout Austria had made 93% from renewable hydropower (yet was dependent on Russia for its gas). Portugal made 67% from its renewables, Germany 54%. In Denmark, 2020, wind & solar made 64% of its electricity; Ireland 49%. Germany 42%. In absolute terms Germany in 2020 went on building renewables -- 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 on dirty coal were higher -- near 5 cents kWh. That was all Before the outbreak of horrible war.

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

One surprise in 2020 was US extended a 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 had trouble getting credits, unless bundled with solar. Nor was a $7,500 credit re-extended for 2 big EV makers. But, things since 2020 changed fast. With newer IRA of 2022, a key Production Tax Credit (PTC) for wind that offers tax credits per kWh generated and once had gone for 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 short term extensions seen in 2020. With that 2022 IRA, at projects put into service after 2025 credits instead remain until later of either 2032, or until US electricity sector carbon dioxide emissions are equal to or below 25% of 2022 levels. Wow!! Because a threshold is that CO_2 emissions must fall <25% of 2022 levels, it won't be reached until after 2032, maybe in 2040s. A net effect is that the new Tax Credits can last decades and provide not $ billions -- but maybe over $1 Trillion for renewables! Incentivizes for wind, solar, plus storage too. Likely to lead to many new start-ups. Long ways from when just a very few, small, clean energy candidate possibilities for ECO and NEX we recall, back in 2006.

Facts reveal an energy landscape changing so fast, it challenges all we 'know' about energy. Clean energy can begin to better fossils on price. Compellingly, maybe *beat them No subsidies* -- so growing more affordable than fossils & easily vs. current-gen nukes. Economics changing, everything. And yet. 2021-2024 did see strong inflation that hammered growth, maybe ahead, recession. China may experience deflation; it could cut back on its vast overcapacity. Not our Grandparent's energy world -- or maybe it's just one that's simply very different!

For years coal prices had hovered near levels -- while renewables & natural gas costs fell. Thus, natural gas & renewables became leaders. In 2020, on-war, demand loss, Utilities turned 1st to their low-cost sources, natural gas & renewables. Coal more & more left out. Gas is big, firm, capable, flexible. Shale frack pushed costs down near $2 per million BTUs. Then on war in 2022 it shot up near $8 -- before drifting back. Still, fossils lack prospects of ever being sustainable -- especially vs. getting-oft-cheaper, green decarbonizing energies.

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

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

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

As we'd learned 100 years ago from Mr. Einstein, later in quantum science, flat to increasing entropy (disorder) gives us Time -- a second law of thermodynamics -- and Time moves in one direction (centered on basic C, velocity of light). What's notable too is time's arrow here, like 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, newer solar panels will enjoy maximum efficiencies higher still, vs. silly old heat engines. And since fuel (sunlight) is free, that doesn't so much matter! On time's arrow, gifted by entropy, we've learned how to harness Mr. Sun's free photon packets, at ever-lower, better, less costs per watt. Unlike fossil fuels, there's learning curve ahead. Profoundly it shall push hard and ever-downwards on solar costs, at times very rapidly.

It goes deeper. For centuries Newtonian Physics seemed to explain 99% of a world around us. We'd built entire industries, societies; fortunes-made around it. Nothing in our human-made world could approach C, velocity of light. And so, its approximations of how the real world actually worked, had served us well enough -- and yet, it was actually really quite wrong. In a metaphor, fossils served us for centuries. We 'learned', advanced within their limits, on those constraints we still accept today (like pollution, inefficiencies). Yet much that we came to 'know' about energy, was wrong. For instance, we've long known electricity generation -- must instantly match demand. Given power plant costs, we have built big-enough -- but have avoided waste. We'd never build fossil or nukes power generation 'way too/overly big'.

Like at limits of Newtonian physics, the 'known' can mislead as Einstein showed. Quantum strangeness very unlike even Einstein's brilliant equations; we can use that. Weirdly different, quantum shows reality too. Usefully harness ahead, say, a quantum entanglement like in fast charging EVs in future. That physics has already led to cell phones, GPS, Lasers, MRI Imaging. Computers will use quantum effects not-known until recently, from 2025. Ahead may lay speedier computing, quantum kernel algorithms. Revolutionary ideas: beyond an Einstein-Podoleky-Rosen paradox, 2 entangled particles linked in real-time sharing information. A recent Nobel Prize was won closing Bell's alternate loopholes. From 2025, new ways to share information via quantum-entangled pairs of photons, quantum teleportation even on optical fibers already sharing conventional data traffic C-band. We progress as we learn new ideas. Einstein built -- not so much Newton – as on James Clerk Maxwell's electromagnetic waves, itkept constant C/ the speed of light. Space is not true vacuum; virtual particles can briefly snap in & out of existence. A wonderful Dr. Richard Feynman's Rules of probability are very weirdly, profoundly deterministic. All fresh tools well-derived from the actual truth.

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

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

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

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

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

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

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

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

In conclusion, a burden is on Xinjiang-based materials: solar, wind, quartz, textiles etc etc to prove Absence of forced labor. Plus, companies may be removed, others not added to themes -- on a possibility of forced labor; indications can lead to removal. It is an unnecessary risk, one to be watched closely, with moral implications. Xinjiang products now have that burden to prove No Forced Labor in supply chains; some firms may opt to relocate away from that coal-powered region. Traceability services, 3rd party Independent Audit Verifications may arise -- as GWs of solar PV were kept from entering US on UFLPA. Europe is looking into this as well. Separately, China's Auditors subject to inspection -- or may lose access to US capital markets under HFCAA, https://www.sec.gov/hfcaa In sum forced labor mustn't ever seep into supply chains, anywhere. Looking ahead one coming issue is transparency; also ending-*all-coal-use* in manufacturing; decarbonizing upstream manufacturing, everywhere. Green circular manufacturing has begun of late, as seen for instance in the Nordics. Yet even they've had to look at places where electricity is the most cheap available, and all costs less.

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

Musing on dynamics in 2022, that backdrop had then changed. Much incremental; yet new $ Trillions *may* be invested globally this decade, on new climate solutions. Infrastructure improvements to go green. In the US, utility-scale solar for example might grow by over >100 GW/year. In US, battery storage could grow by >50 GW/year, over time approaching today's total for all electric generating capacity. In a US that's long been a renewables laggard.

This decade 2020s, there's greening in Europe. Its old-world stolid economies once-long overly dependent on foreign (Russian) gas imports, fast went to LNG due to war. 2 things seem likely short-term. One is, Europe that fast moved from Russian gas to LNG, may see energy crises next few decades -- *but that is not due to a fault of renewables*. UK for example earlier shuttered much of its gas storage capacity. Little left, with tight natural gas supply, little storage, has meant gas-fired heating, and power generation may, at times, get costly.

Spikes in natural gas costs, with little storage, are far more an issue about gas -- than about renewables. And such crises would have happened anyway had solar/wind not existed. Yet renewables will be blamed -- rather than vagaries of gas markets. A gas draw-down -- with little energy storage -- risks prices rising, populist backlash if energy prices do spike. Yet, around the world, people are also on a steep energy learning curve. Past mis-directions like Texas where blame was put on wind, *when natural gas* froze -- in time see truth come out. Still on China's voracious demand for coal, oil, & gas, and Europe's moves towards LNG whilst energy prices and tensions are both high -- means energy crunches & crises likely ahead.

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

Just maybe, a flowering of green growth. In the US, a carbon tax arguably is one simple direct way to get there, although politics continue to get in the way. Countless obstacles lay ahead. So too, do opportunities. Think of obvious fruit. Low-cost safe batteries, storage lasting over 4 hours are a hardy perennial aim; so is green hydrogen for less than $1 per kg, lodestones to improving intermittent renewables & EVs. Battery capacity may improve, going from say, <300 Wh/kg to near 1,000 Wh/kg. "Made in USA" can = good jobs. Solar manufacturing globally on climate risk alone, should be >1,000s GW/yr. Scary scenarios on climate, let alone new power crises -- all calling for *Terawatts* more clean energy, batteries, and storage.

But now it's less than 15 years to 2040, under 25 years to 2050, and in this crucial period, a laggard US *may* pivot towards a truer carbon-free grid that saves money to boot. Would be a drastic change, yet it's feasible! We'll look ahead next pages at freshening US possibilities. Maybe a transformational next 10 years, as well in Europe and Asia. It's conceivable to envision possibilities in under 10 years to 2035. Ways renewables get closer to being dominant. A coming 10 years, far beyond what was thought possible, just a few years ago.

First, where had a US power grid stood recently? And what will it take to be zero carbon? Have a look at 2019 data from US Energy Information Administration. Electricity generation in 2019 accounted for much (though far from all) US CO_2 emissions. Power generation made 4,000 terawatt/hours of electricity. 38% of that 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(!). And 2% was from miscellaneous other sources.

When US coal power had waned in Covid, gas & renewables became cheapest power -- some CO_2 did drop at first, due to shuttering the most highly polluting coal plants in US, and Europe. But it produced only awkward, short, unintended blip of reductions. As energy saw renewed demand, new AI/data centers from mid 2020s ensured carbon will NOT soon drop. Instead, implies what a huge slog lays ahead, for zero-CO_2 American grid. That said on economics, to start soon in these 2020s and go hard will actually be the most profitable path. Current-gen nuclear can't fast offer much help; unlike solar & wind getting cheaper & better -- US nuclear instead has only gone up in cost. And it's hard to do more there without enormous subsidies like a Price Anderson Act that limits nuclear's liability. Building a nuclear plant once had cost 'just' ~$7 billion each. Now a ridiculous-costly Georgia plant has cost $25 billion! Inflexibility here once touted as an asset, instead was flipped to become an issue vs. renewables.

Getting US to zero CO_2 means eliminating all 668 coal plants; shuttering most of 6,080 gas-fired plants. Faster-ramping solar (15% faceplate capacity), & a wind that was just 9% of US energy in 2019. They're not-firm, intermittent; nada from wind on windless days, no solar at night. We'd started in US 2020 with just 104 gigawatts of wind power. 36 gigawatts solar. Then came about 12 GW of new wind, another 16 GW solar built 2021. At that growth rate at 50% faceplate capacities, we would not have gotten a US to 100% renewables until 2070.

That's 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 fossil generation, to be 100% clean by 2035. For 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 global firm turned on those 531 turbines. Extrapolating on that means roughly say $1 Trillion starts to sizably replace today's US fossil power. Yet really needed is 2x that to account for intermittency -- resolved too by new storage.

Happily, renewables are getting far cheaper -- so actual costs are likely far less. Renewables also enjoy free fuel, so as coming pages will show -- this actually can lead in time to Americans paying *less* for their power in 2035 -- than they had back in mid-202s! From there the savings snowball. Factor in reduced hospitalizations, greater health -- and it gets only better!

It's been assumed by opponents, that this means unwanted top-down *diktats* by officials. But fast solar/wind growth in Texas -- vs. a slower rate in heavily-regulated California -- suggests opening up markets to competition can spur renewables. It's estimated US solar & wind can naturally get to 55% by 2035, just based on their better price alone. Add wonkier mechanisms, like technology-neutral clean tax cuts -- 'Clean Asset Bonds & Loans', or a US carbon tax -- and doubtless it gets us nearer, with not as much help needed. The pace is what's key.

Because this seems (and does) fly in face of what we've 'known' in energy last 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 in under 10 years to 2035.

1st we assume the climate science is correct. So, we must act far faster to cut CO_2 emissions in ½ by 2030, to see 'only' 1.5 degrees C ravaging heating. We're nowhere near 50% cuts. Actual global trends mid-2020s would go languidly decades before decarbonizing. That creates a much, much too hot of a world, so any genuine zero-CO_2 goals realized far too late.

If action occurs soon, note plunging solar, wind, energy storage costs *immediately can change everything*. A US grid with 90% (or as a goal 100%) less CO_2 is not only feasible, it is reachable -- on *cheaper* electricity. Competing analyses differ on the last pieces in a 100% zero-carbon puzzle. Yet models often *agree* on getting to 'just' 90% – (we use 100% as a goal), so a 2020 Report that blueprinted how to get there from UC Berkeley was useful. 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 now mid-2020s to this Berkeley Report, and from Princeton.

It shows how carbon-free can be achieved swiftly in (then 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 it is (for it can be done) -- and on how costly as it saves money in a clean US path.

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

> "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."

Their study allows all known 'zero-carbon' generation options. As expected, its focus is on clean 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 for current nuclear, nor sequestration). In contrast to Zero Carbon path, a No New Policy is merely 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 reliable, all firm, fully dispatchable power, as is needed. It meets all demands in every hour of each day. There's no compromise on performance. That said it initially had a longer lead-time to 2035 -- back then it was 15 years when written and now is under 10 years since time marches on -- hence we less time now to act.

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 rough, tiny 15 GW solar installed 2016, and from a 13 GW of wind installed in 2012.

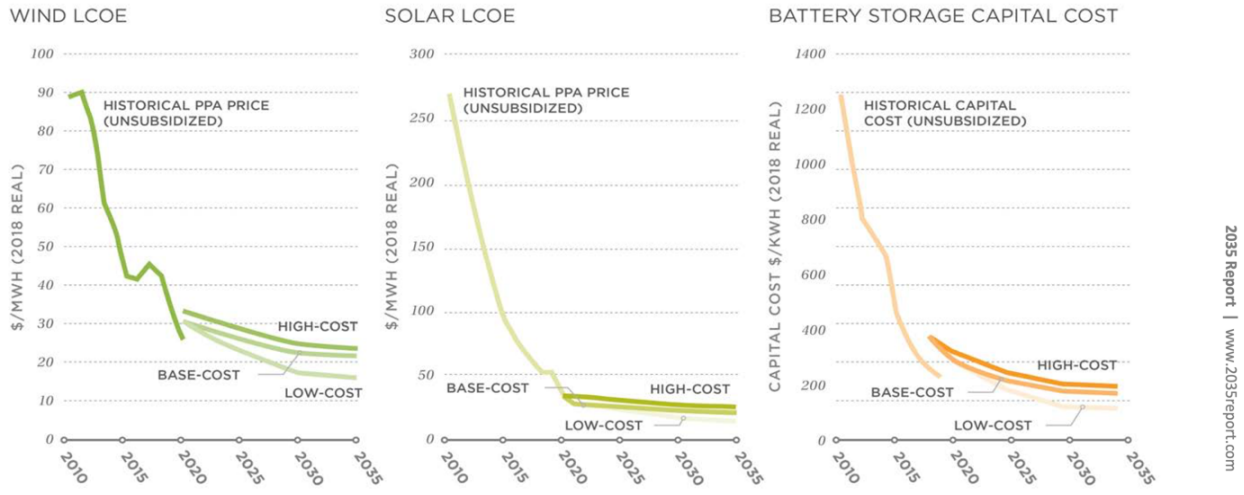
US energy generation growth has gone big before; Natural Gas grew by 65 GW in 2002. Now what's needed, is changed: *energy storage* is 3rd leg triad to solve renewables intermittency. Key, new storage deployment needs to grow by 25% each year. Starting from a measly 523 megawatts storage in 2019, it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

Happily, more modest new transmission necessary to interconnect expanding clean power, so less pressing need for slower-to-build intergenerational lines. Not tough overturning of grid infrastructure requiring long lead times. But, grid modernizing is needed and Infrastructure bills have sought this. What changes is composition of generation & storage over this now faster-arriving 2035. Texas may connect to US East/West grids for resiliency, but that's a different matter. First off, all US coal plants need to permanently shutter by 2035 under this plan. Places like California, it's done. Extant coal elsewhere oft have been running for years so added years yet in this Plan leaves them time to recoup capital investments. It is doubtful coal owners would want to burn much longer, given high costs, liabilities vs. clean power -- but recouping those costs in the time 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 U.S.; in this Plan, 361 GW of dispatchable gas is kept going to 2035, another 90 GW is kept in reserve for reliability. Natural gas meanwhile, is used for only generally some 10% of generation -- going down to zero.

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

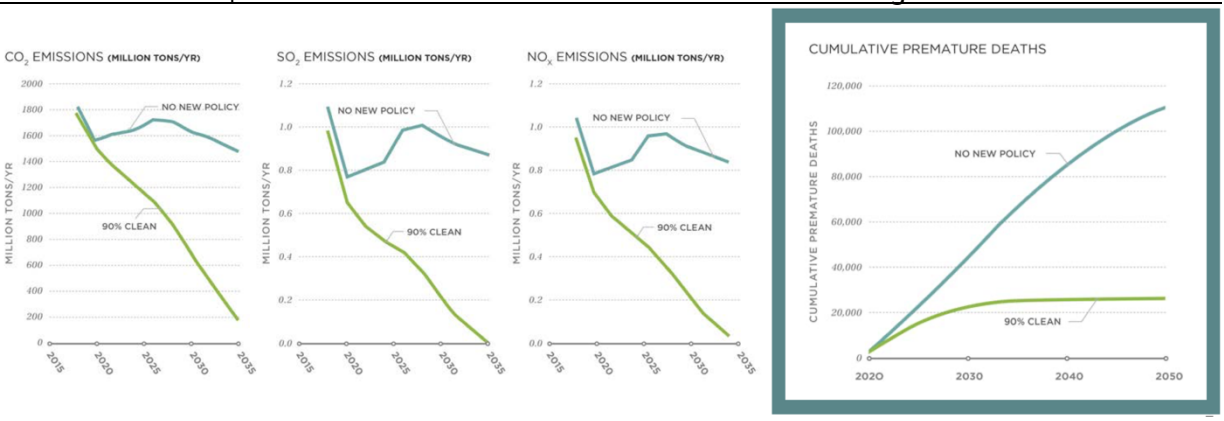
<u>Dramatic Declines in Costs Have Arrived 2020 Far Sooner than Expected:</u>



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

Relative to a status-quo of 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, is that this 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! That seems a No-brainer.

<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, on 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 up in most of the country. The public may assume solar needs warm 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 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's then-high natural gas prices (on war), if by 2035, the renewables may be relatively cheaper still!

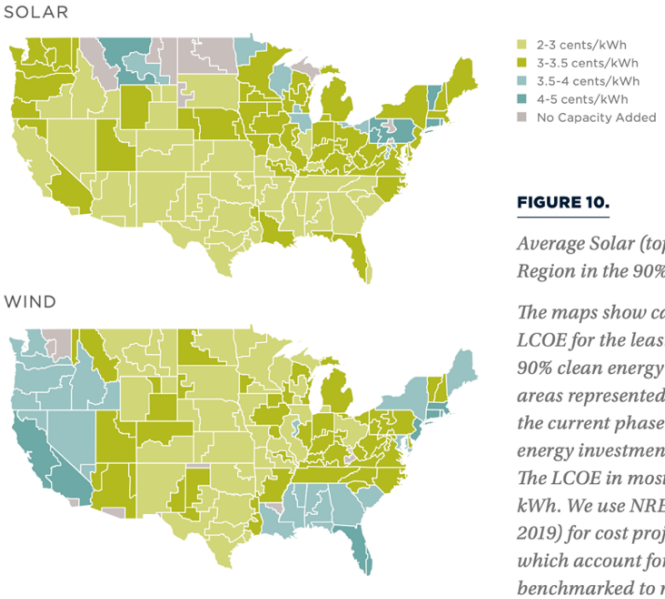


FIGURE 10.

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 sited near closing fossil fuel plants; new jobs building solar, wind, storage going where fossils shutter. Jobs will be front-loaded & prolific in construction -- not as much later in operations since as non-fossil fuel, not much maintenance is required. It's surely crucial here to assist local communities too once depending 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 IPCC Report, global emissions would have to be halved soon, 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 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 close to 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. Yet studies done not too many years ago, 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 for over 60,000 hours. Done for every hour, across 7 weather years. In each one of these hours, sufficient power was assessed as able to meet 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 possible, is how far storage costs have dropped -- *and will go on doing 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 met by storage. Limits to computer models keep battery storage capabilities envisioned to 4-hour window. Real world data too, as was shown here have noted how hard it's been for California to meet 50,000, 60,000+ MW of demand; again, new storage is key.

Renewables are oft criticized, as 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 Liability, vs. nuclear, coal, natural gas. And it means aiming for a 100-fold more PV faceplate capacity faster now -- to 2035. But it's a characteristic, not a flaw.

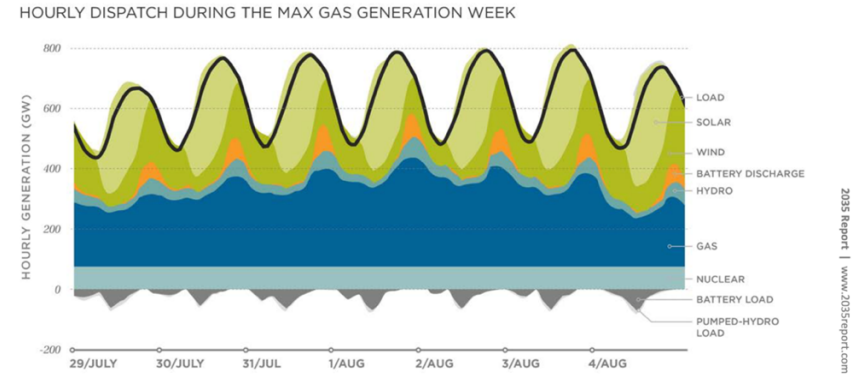
Over 7 weather years modeled, in normal conditions, wind, solar, battery storage generally, regularly provided 70% of annual generation; hydropower & nuclear provide another 20%. But when there's very low generation by renewables solar/wind -- and/or unusually high demand, extant natural gas plants, hydro, 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 say shuttering a last plant 2030). 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 will make zero(!!) power all night long. So, what happens if high demand evening -- overlaps with a time of little wind -- drastically curtailing output? And/or when there's a 'wind drought': expected higher seasonal winds don't show up?!?

Let's start with a tough-case; no-solar, 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 evening, no wind or solar -- greatest natural gas capacity needed to meet demand would be 360 GW. Intermittent solar + wind near zero despite high nameplate capacity. With total demand of 735 GW, immediate dispatch needs are met partly by 2 other key, zero-carbon sources, hydropower & nuclear -- and key 80 GW battery discharge. And as noted a key reserve 360 GW of natural gas capacity. That's in such worst-case scenario.

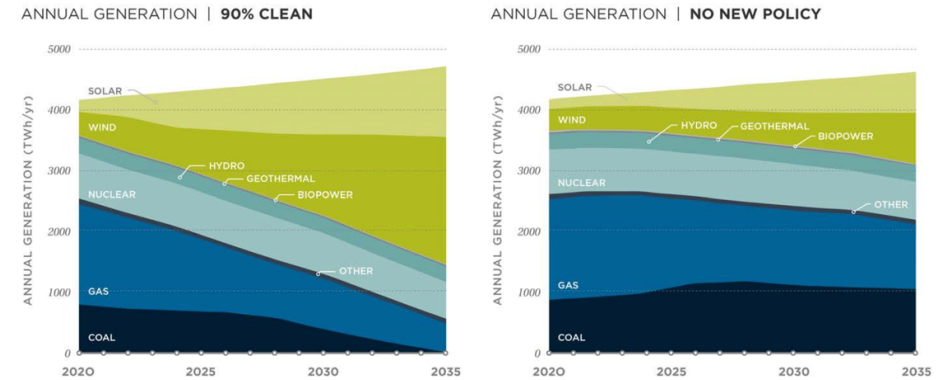
A Worst-Case Generation Period for Renewables: Still Moving Off of Fossil Fuels/Nuclear:



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 usually in August, least wind -- 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 in new clean energy investment. Enormous, yet akin to COVID stimulus rounds, with more positive lasting benefits. (Add efficiency improvements ahead too, like barium sulfate painted-bright white rooftops, to better lower demand).

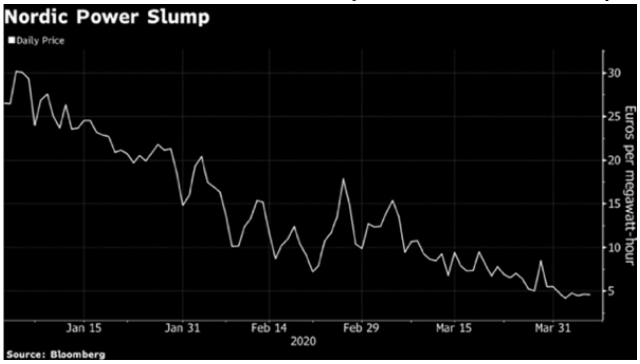
Recall some pre-Covid *applied* clean energy trends back in 2020. When renewable prices were falling good & snowballing ways (unlike oil/gas). Start with Solar; costs had then hit a new record low: *only 1.35 cents per kilowatt/hour* at a big 1.5 GW solar farm going up in Abu Dhabi! True, that's excellent solar circumstances, in a vast desert. But there's vast deserts in Western US; in 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 would soon vex solar -- so future is uncertain. But competing natural gas had jumped in 2021 by more (then fell thanks to shale). And solar prices, too, then again were falling dramatically early 2020s.

Or consider pre-Covid how 2 renewables had joined up at say a world-green-leader, Sweden. There, clean energy tells a startling story. For as more renewables get built, new synergistic eco-possibilities can 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 a costly non-renewable like nuclear. That new wind farm owned by a Dutch Pension Fund has 80 large turbines 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.

Sweden already had/and has much hydropower for power. So very rapidly, indeed on just a 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 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, they 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 Arctic, in Minnesota etc work great in freezing areas, putting a lie to critics who'd wrongly claimed in tragic Texas freeze 2021, that renewables can't 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.

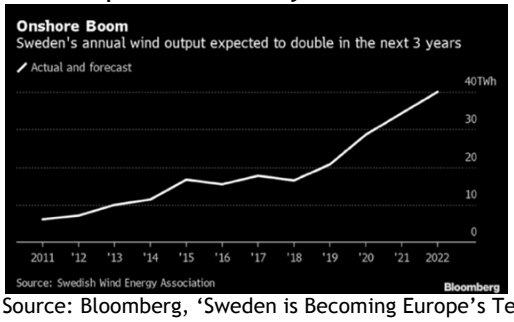
Yes, renewables wind/solar are intermittent. Winds not always blowing, no sun if cloudy or nights, or no rains for hydro. Yet at such times, then other renewables may be tapped. For instance geothermal might possibly grow as firm power. Especially if oil rig counts drop, geothermal may grow attractive.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

US big Oil in 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 -- 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 may grow more affordable. Its electricity generated may be exported too, like from say from 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 then lowest-ever. In pre-Covid early 2020, electricity day-ahead prices fell by half. For a comparative break-even, let alone profitability, that region's nuclear plants needed a much higher price floor. Still current-2nd generation (and so costly) nuclear, thus is facing a thorny dilemma, given how low renewables *can* go. Especially if a region combines many resources like wind, hydro, perhaps solar, and geothermal too.

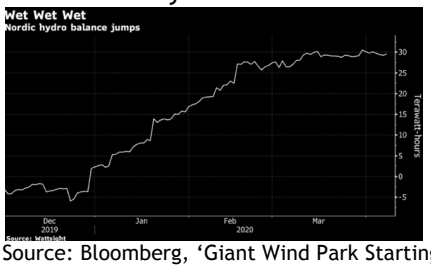
Dirty, yet cheap northwestern China's coal, long attracted PV industries. Cheap electricity in eg Liuzhou was an incentive to make EVs too. Yet Northern Nordics may potentially do it more cleanly ahead. If cheaper renewables make green steel, aluminum -- industries will welcome that -- as low-embedded carbon. Sweden's mills, smelters, miners, manufacturers are energy-sensitive. Big hydro static potential capped, is limited to big dam-able areas with ecological burdens. Wind power instead can scale up in green ways. A BNEF article aptly entitled "Sweden is Becoming Europe's Texas for Wind Power" -- has showed how Sweden along with Norway and UK are a bit like Texas which have all seen a wind boom.

Back 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 -- 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 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, to near -- or below zero! Woohoo for off-takers (though tough for generators)! Little wonder wind power in Texas had got low as 2.6 cents per kWh back in pre-covid early 2020. Here's a 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 Nordic regions may see booming renewables, hydro & wind push down energy costs, bit reminiscent of coal in northwest China. China's aim of "climate neutrality" may in time, mean No coal, just not nearly soon enough -- and its effort got relaxed in a 2020s 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 tons fell well below green Europe's 6.4 tons. So a goal ahead for it, is to avoid "carbon leakage" like importing say cheap higher-carbon 'brown' cement like from Russia, Turkey, Belarus. Yes intermittency's a fact in renewables; wind/ especially is not firm power. And 2025, offshore wind in Sweden encountered several issues including conflicts with military radars to monitor an aggressive Russia, plus more acutely, low-costs at times here for wind can go negative and make all wind investing, problematic. Yet, we're in only the early innings; one hopes to see a flowering soon of varied renewable /and in particular energy storage ideas ahead to solve intermittency. Here's in the immediately pre-covid days; 2020 in Sweden:



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

As for US, it started making some progress in 2010s, thankfully going beyond big hydro. A decade+ ago, all America's renewables together had made just 10% of US electric power in 2010s -- and mostly that was just big hydro with ecological impacts, little room for growth. Noteworthy then, US renewables' slice of pie after grew to near 20% end of 2020, mainly on more scalable, greener solar & wind. These 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 may be thought of as roughly a small nuclear plant, yet solar is intermittent -- hence unlike firm nuclear, coal, gas. So, by 2020 solar & wind had gone from nearly at zero back in 2010 -- to 10% of US electric power combined -- *but not always On*. Hopeful yet underwhelming: we need 20x, 50x that! Note too how growth happened. Partly by China pushing down solar costs, also consolidation. Its world's biggest PV firm went bust in 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 were lost at huge rate, a $800 billion stimulus American Recovery and Reinvestment Act (ARRA) gave then-crucial $90 billion to clean energy etc.

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

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

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

New wind power hit another marker in 2015 as more US renewables were installed at 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 on 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 hydro, biomass 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. Aimed for 30 GW by 2030.

By generation type, renewables pulled ahead of nukes. In a first in its own 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, met 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! In 2010 its dirty fossil fuels met ¾ of demand, 10x renewables. But its renewables had jumped to 40% by 2020, gaining in UK as coal-power fell from 70% in 1990, to 4% in 2020. Coal might have near-ended in UK then -- were it now for war in 2022 and so a push for all energy of any kind mid-2020s and on.

Global annual solar panel production gained enormously from a once-puny 15 GW in 2010. Yet as emphasized, a key issue for the renewables (apart from geothermal / big hydro) is their intermittency. That's held them back -- but needn't do so ahead. Like overcoming high early costs in solar & wind -- the 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 could ascend. We *can do much* in renewables.

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

So much is ahead worldwide. Solar cells may yet utilize more wavelengths: say in group III-V semiconductors that allow 'more sunlight' to be captured than ever before. Or concentrate the sun with mirrors; that 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 cheaper PV one day, perhaps delivering 50% more efficient solar cells than today. An ability to capture less light may open new possibilities ahead. Solar is getting ever-cheaper -- yet as we emphasize, clean energy in the 2020s is still in infancy, and nowhere close to what's now needed -- given the global heating emergency.

Confronting all, is the fact Earth doesn't care renewables 'so strongly' grew from zilch. We ought not pretend either, that 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 the role of CO_2 in heating, have no ground on which to stand with ocean acidification. For oceans' CO_2 uptake is undeniable. Rising CO_2 concentrations doubtless equal acidifying seas. Devastating already to reefs, kelp forests, fish populations, shellfish, marine mammals, more. Marine life now weakened by that acidification -- stands less chance of surviving stresses, marine heat waves, collapse.

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

Post-2050s deep seas may warm at rates maybe 7x now – a climate velocity sure to overthrow life evolved in very stable, deep thermal settings. There will be tipping points. Complex & cascading losses. In sum, renewables are vital. Still, we perceive of clean energy -- and ocean life -- as being 2 separate, independent matters. 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 ((already?) over 1.5 C warming. By releasing 40 $GtCO_2$/year now, we have no extra time 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 threats today to seas include greenhouse gases like CO_2, methane, more CFCs; overfishing; non-point source pollution; habitat destruction, ocean acidification, and more -- all deadly harmful to marine life & biodiversity. Each one complex, cascading. Each also appears at first to be daunting, prohibitively much too big to solve.

And yet. Seeming intractable, most vexed, hardest to remedy is CO_2 & climate. It's surprising then, that solutions here are both economical and ecologically sensible, saving life & money to boot! Key, of course, is renewables: the sun shining on our cheeks, winds blowing overhead. Thus, a question is how to get from brown paths now -- to green soon, given their inertia? What, will it take, to power the world off mainly solar & wind -- with much energy storage? Seen another way, given the narrower 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 well before 2020 was then maybe $1/100^{th}$ of what we'll need -- to have enough PV fast. By 2020 we'd then made more at around 100 GW/year. Tiny, yet was far better than puny 0.250 GW in 2010! We saw PV manufacturing becoming a very low-margin, commodity business. A decade of consolidation, wringing out costs, more capacity, PV growth steepening. Early/mid 2020s saw rising inflation -- plus war.

Much lately is changing -- yet much also is trending about same. At very start of the 2020s, nine of every ten PV panels was being made in Asia, planet's biggest PV factory 2020 was in Anhui, China; its capacity 60 GW modules per year, going up in 4 phases. Yet from a separate, independent view of what's needed, to bring down global CO_2 emissions fast, that scale was only a start. Still wildly small, if 60% of globe's electricity demand must soon be met by solar alone. Only a couple years later, 1st half of 2020s many nations had reacted to its 'monopoly' and were taking action via tariffs etc, to counteract China's dominance across clean energy: in solar, batteries, lithium, strategic minerals, processing etc -- along lately in EVs too.

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

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

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

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

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

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

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

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

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

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

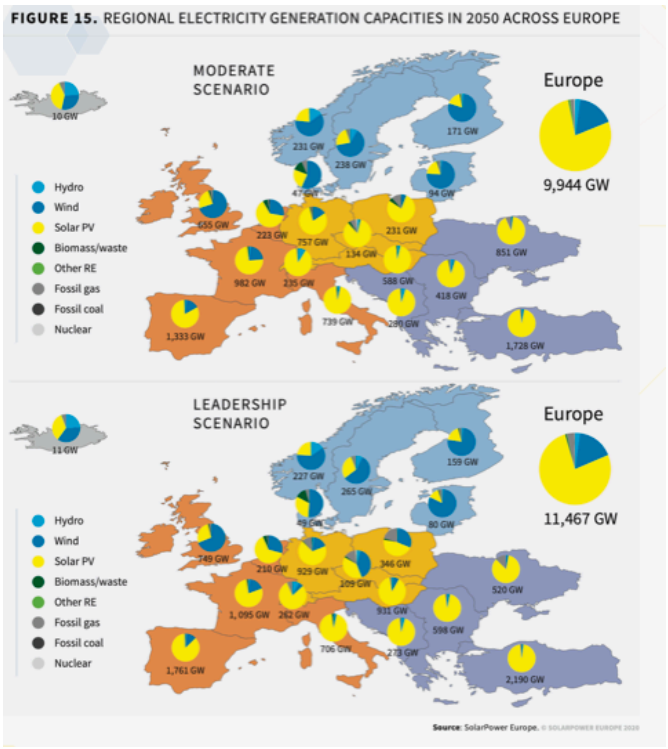
Many points above challenge the conventional wisdom, so are worth unpacking. Start with the idea moving *more quickly* to decarbonize, will cost *Less* than status-quo incremental adds of solar & wind. In part thanks to renewables getting cheaper, their 'Leaders' scenario shows greenhouse emissions can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

Their Report recommends policymakers begin immediately creating a framework targeting installed 7 TW of solar power -- plus 1.7 TW of wind as well to be reached before 2040.

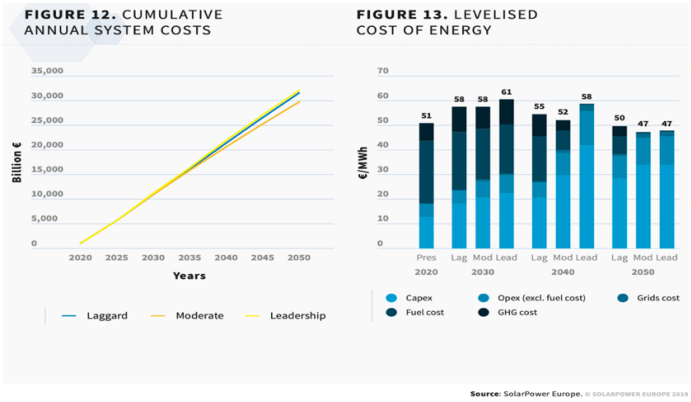
That assumes 2 factors: start upswing soon as possible -- and grow PV manufacturing abilities fast. With CO_2 a pressing issue, we may need to build 100 factories worldwide, each one capable of making 60 GW PV like factories going up mid-2020s in China. Ramping to around 7 TW extant solar in 2040. This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

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

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



Source: Solar Power Europe 2020.



Source: Solar Power Europe 2020.

Surely, we can't plead ignorance. A brilliant scientist, Eunice Newton Foote had back in 1856 published a paper 'Circumstances Affecting the Heat of the Sun's Rays' predicting changing carbon dioxide can alter climate. In 1860s, John Tyndall added infrared radiation, methane. Arrhenius explained a century+ ago mechanisms of global cooling or heating via carbon lever, predicted massive 4 degrees C heating can come on each doubling of CO_2 -- nearish later estimates -- although a 2024 paper in Science postulates past sensitivity has been nearer to an ~8 degrees C on each doubling! We've gone from 315 ppm to >425 ppm in this author's lifetime. On GHGs suite + methane, is like we've gone over 500 ppm. Roger Revelle alerted all to this in 1950s & 1960s (and he had great impact on this author at Scripps in 1980s!). Or, we continue as is, let the vagaries of oil & gas throw energy markets -- so us all for loops -- over & over. Take our time, delay, so making any eventual turn towards clean -- tougher than was needed. As to vagaries, look next at wicked oil dynamics in oil, 2020 and 2021.

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

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

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

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

E.g. May 2020 front-month WTI contracts would expire late-April. So, if a -25% less demand was not met by production cuts, fears grew of 'tank tops' as in landlocked Cushing, Oklahoma. May contracts would need to be unwound fast, by traders with neither a desire, nor capacity to take crude delivery; it pushed front-end WTI oil briefly under zero, some -$37 by April 20th. That brief (artificial) move in finance, wasn't really a great surprise! Not too much should be read into such an 'artificial' -$37 close. Contracts many months out were less distorted. But WTI oil near $20, showed US/global oil markets in distress. Even a better global benchmark, the costlier North Sea Brent crude briefly dropped down near $20 by late April. Not near zero, yet oil @$20 meant production cuts worldwide. Perhaps 1 million oil patch jobs lost, expertise may potentially disappear. Rig counts may fast drop, wells shut-in, bankruptcies -- some wells perhaps might not be (expensively) re-started. Maybe forcing some US shale producers to shut in, pain perhaps was an initial aim, like 2015. But this time, oil's ramp in supply began just before pandemic's demand destruction. That, on Covid, made disorderly consequences greater than was initially expected. Come 2024 oil would again be near a 'desired' $70-$90 -- with US then the biggest oil producer in the world! But that all of course was unknown to the oil industry, back in a panicky 2020/2021. (And later on from 2025, a question was if huge US production increases, & maybe tariffs/trade wars, could again impact oil prices).

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

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

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

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

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

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

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

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

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

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

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

Consider CO_2: A Topic Gaining Importance

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

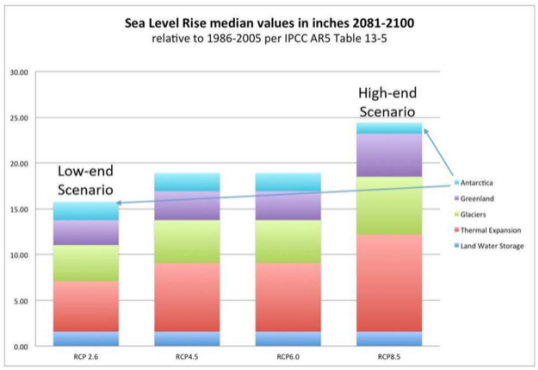
Imagine just ~70 years hence. Note then, that projections by an Intergovernmental Panel on Climate Change (IPCC) for sea level rise in year 2100, may misleading. For end of century rise may be unwinding then at far more rapid accelerating rates, than what was projected by IPCC. Getting that so wrong,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

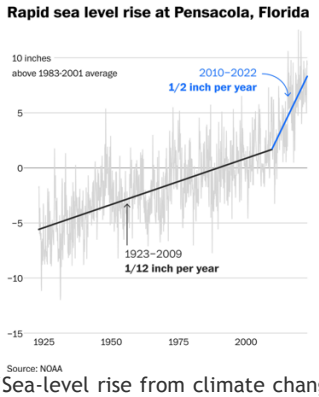
The idea that actual sea levels in 2100, could be greater than IPCC projections is well laid out in 2020 piece, 'Twenty-first century sea-level rise could exceed IPCC projections for strong-warming futures' by M. Siegert et al., One Earth (Dec. 18, 2020). Their first paragraph nicely lays out cogently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

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

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

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





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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

For where we're going on CO_2 already at 425+ ppm & rising fast, think first: the Pliocene. Earth 3-5 million years ago once had a forested arctic: we might reach Pliocene temps 'soon'. Of course, it'll take a lot longer for flora & fauna to react, reach an equilibrium. Means vast changes ahead with mass-extinctions. Those hotter temps happened million of years before we humans evolved in a once-comfortable 230 ppm world. Could then get hotter still, like the Miocene: 400-600 ppm when coasts of today were submerged. Interestingly at 'just' a 400 ppm Pliocene, Greenland's ice sheet was gone on only 'modest' warming. And note millions of years ago, those CO_2 changes had naturally taken thousands of years to occur. Tens of thousands of years+, to slowly rise or fall. By contrast in a single human lifetime now, we're exploding CO_2 by astounding 100 ppm and more(!). So, plants & animals only are beginning to react. Cascading extinctions are unavoidable. Thus, it's Not Only The Fact of Great Change -- but rather also The Extreme Pace of Such Change that's bound to be deadly.

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

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

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

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

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

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

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

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

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

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

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

Keep in mind what big rates, scales of change may mean. A difference of 'just' 7 degrees F had separated our recent "ideal" climate for us -- from extreme conditions of an ice age. In a refresher, the Ice Age not long ago had 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 7 degrees F 'delta'. Ice had stood a mile tall over some of North America(!) making 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, ways hard to fathom. Looking back to Earth's record it's conceivable on a temperature rise of "only" 2 to 5 degrees F, seas could rise fast in non-linear ways, say going 15 to 65 feet higher. Drowning so much today, like great State of Florida. In a thought experiment, 5 degrees F of warming is imaginable, on current CO_2. So, it is reasonable to see seas fast going up 60+ feet higher. No seawall could stop that. It renders the shapes of whole countries as we know them, today, a distant memory.

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

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

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

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

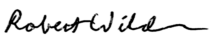
Conclusion:

Clean Energy Index® (ECO) that began Q4 at 41.84, ended at 42.25, so up, yet near nil. Despite 2023's hopes inflation may slow, Fed pivot, it hit this interest-rate sensitive theme. When rate cuts didn't arrive, clean energy/ hence ECO Index® that then started out 2024 at 62, touched last year's low of 36. Yet, in the final 4 months of last year, ECO gained even with -- or *perhaps partly because of* the re-election of a president to their 2nd term -- we saw that in this president's prior 1st term 2017 to 2020, ECO rose dramatically. Or look back at a last few years and ECO rose by +58% in 2019. Remarkably, it rose strongly +203% in 2020 for about best performance of any Index, or any Fund, anywhere. Unsurprising maybe after such strong gains 2019 & 2020, ECO fell -30% in 2021, -46% in 2022, -22% in 2023, and -30% in 2024; that overshadowed any decarbonizing trends that might yet favor renewables ahead.

Deletions from ECO for start of Q1 2025 were: Arcadium, Gogoro, Piedmont Lithium, Wallbox -- and the ECO Additions for Q1 2025 were: Energy Vault, FuelCell Energy, Gevo. At the Global Clean Energy NEX for Latter Q4 2025, Deletions were: Eurogroup Laminations, Fuelcell Energy, Meyer Burger, Fugro, Subsea, TPI Composites -- and the NEX Additions at Latter Q4 were: Aker Carbon Capture, Green Plains, Legrand SA, Grenergy Renovables, Gevo, and Sanyo Denki. At the Hydrogen Economy H2X the Deletions for Latter Q4 were: Chart, Eurogroup Laminations -- and the Additions were: Deme Group, Evonik, Gevo, Solvay SA. At Wind Energy WNX, the Deletions for Latter Q4 2024 were: Fugro, SBM, Subsea, Eurogroup Laminations, and TPI (also Greenvolt Energias was removed from the WNX infra Q4 effective on 31 Oct. 2024) -- and Additions at Latter Q4 were: Covestro, DEME Group, Eos, Jl Mag, Mersen SA, Valmont.

As always, we welcome your thoughts and suggestions.

Sincerely,



Rob Wilder
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Appendix I: ECO Index (via independent tracker PBW) components in descending % order infra-Q3 on 11/1/2024, about ~7 weeks before rebalance to start Q1 2025. 68 Stocks**:

Arcadium Lithium PLC**	3.16	OPAL Fuels Inc	1.45
EVgo Inc	2.83	Brookfield Renewable	1.39
Standard Lithium Ltd	2.72	Itron Inc	1.39
Wolfspeed Inc	2.67	Universal Display Corp	1.38
Lithium Americas Corp	2.66	Lifezone Metals Ltd	1.38
Lithium Americas Argentina	2.15	Joby Aviation Inc	1.36
Eos Energy Enterprises Inc	2.14	QuantumScape Corp	1.35
JinkoSolar Holding ADR	1.98	Bel Fuse Inc	1.35
MP Materials Corp	1.90	Ballard Power Systems Inc	1.35
Enovix Corp	1.84	NEXTracker Inc	1.34
Sigma Lithium Corp	1.84	REX American Resources	1.32
XPeng Inc ADR	1.76	Rivian Automotive Inc	1.32
Navitas Semiconductor Corp	1.72	ChargePoint Holdings Inc	1.31
Albemarle Corp	1.65	Bloom Energy Corp	1.30
Ormat Technologies Inc	1.64	First Solar Inc	1.27
MYR Group Inc	1.63	Solid Power Inc	1.26
Hyliion Holdings Corp	1.61	Shoals Technologies	1.23
Tesla Inc	1.61	Gentherm Inc	1.22
LanzaTech Global Inc	1.60	ReNew Energy Global PLC	1.22
Altus Power Inc	1.58	Ameresco Inc	1.19
Sociedad Quimica y Minera	1.56	TPI Composites Inc	1.19
Canadian Solar Inc	1.55	SolarEdge Technologies Inc	1.17
Quanta Services Inc	1.54	Wallbox NV	1.14
American Superconductor	1.53	Sunrun Inc	1.02
Archer Aviation Inc	1.51	Enphase Energy Inc	1.01
NIO Inc ADR	1.50	Piedmont Lithium Inc	0.82
Array Technologies Inc	1.50	Amprius Technologies Inc	0.78
Advanced Energy Industries	1.49	Sunnova Energy Intl.	0.67
Darling Ingredients Inc	1.48	Atlas Lithium Corp	0.65
Monolithic Power Systems	1.48	Blink Charging Co	0.55
Preformed Line Products	1.47	Emeren Group Ltd ADR	0.50
Corteva Inc	1.47	Freyr Battery Inc	0.45
Fluence Energy Inc	1.46	Gogoro Inc	0.45
ESCO Technologies Inc	1.46		
Plug Power Inc	1.46		

Some strong representation above in *Lithium, in *EVs/EV Chargers, and *Power electronics.

** Arcadium above was bought out in October 2024 and so was removed in 4th Quarter.

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

INDEX (ECO) SECTOR & STOCK WEIGHTS FOR START OF Q1 2025. 67 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 (7 stocks @1.57% 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.
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 - 24% sector weight (15 stocks @1.56 each + 1 *banded)
Albermarle, ALB. Lithium, specialty materials in batteries for energy storage.
Amprius Technologies, AMPX. Silicon anode batteries, greater energy density.
**Atlas Lithium,* ATLX. Lithium, battery metals nickel, rare earths, graphite.
Chemical & Mining of Chile, SQM. Lithium, large producer in energy storage.
Enovix, ENVX. Silicon-anodes, 3D for improving new lithium-ion batteries.
Freyr, FREY. Greener batteries, now solar manufacture, 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.
Quantumscape, QS. Battery, solid state lithium-metal energy dense fast charge.
Rivian, RIVN. Electric vehicles, trucks and commercial fleets, charging
Sigma Lithium, SGML. Lithium, in planning & pre-construction, sites in Brazil.
Solid Power, SLDP. Solid electrolyte battery, Earth-abundant materials.
Standard Lithium, SLI. Lithium, from brine in U.S., vs. traditional ponds.
Tesla, TSLA. Electric vehicles, pure-play across EVs, advanced energy storage.
Xpeng, XPEV. Electric vehicles, advanced mobility, swappable batteries, China.

Power Delivery & Conservation - 18% sector (11 stocks @1.59% each + 1 *banded)
Ameresco, AMRC. Energy saving efficiencies, net zero CO_2, decarbonization.
**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.
Itron, ITRI. Meters, utility energy monitoring, measurement & management.
Monolithic Power, MPWR. Chipmaker, better efficient power management.
MYR Group, MYRG. Grid transmission, distribution aids solar & wind farms.
Navitas Semiconductor, NVTS. Gallium Nitride GaN fast charging EVs.
Preformed Line Products, PLPC. Grid products & transmission OEM, solar.
Shoals, SHLS. Solar, for electric balance of system, wiring, combiners.
Universal Display, OLED. Organic light emitting diodes, efficient displays.
Wolfspeed, WOLF. Electrifying power, Silicon Carbide SiC, converters.

Energy Conversion - 20% sector weight (13 stocks @1.53% each)

Advanced Energy, AEIS. Power condition: inverters, thin film deposition.
Archer Aviation, ACHR. Electrifying aircraft, vertical takeoff & landing.
Ballard Power, BLDP. Mid-size fuel cells; PEM such as in transportation.
Bel Fuse, BELFB. Transformers, power supplies, circuit protection, AC/DC.
Bloom Energy, BE. Stationary fuel cells, not-yet cleanest/renewable fuels.
Enphase, ENPH. Microinverters, also energy storage systems and software.
ESCO Technologies, ESE. Power management, shielding, controls, testing.
Gentherm, THRM. Thermoelectrics, heat energy, battery management.
Joby Aviation, JOBY. Electric aircraft, cleaner, more energy efficient.
Lifezone Metals, LZM. Low-carbon battery metals, Nickel no smelting.
MP Materials, MP. Rare Earths, domestic U.S. source Neodymium, NdPr.
Plug Power, PLUG. Small fuel cells, for eg forklifts; drop in replacements.
SolarEdge Technologies, SEDG. Inverters, solar optimizers, inverters.

Greener Utilities – 14% sector weight (9 stocks @1.55% each)
American Superconductor, AMSC. Wind, grid conditioning; superconductors.
Brookfield Renewable, BEPC. Renewables hydro, wind, solar; energy storage.
Energy Vault, NRGV. Gravity energy storage, is longer-duration but limited.
Eos Energy, EOSE. Zinc batteries, a safer li-ion alternative, longer-duration.
Fluence, FLNC. Battery storage, for renewables and digital applications.
Quanta Services, PWR. Infrastructure, modernizes grid, power transmission.
ReNew Energy, RNW. India renewables, among largest there in solar & wind.
Sunnova, NOVA. Solar provider, operating fleet for residential, plus storage.
Sunrun, RUN. Residential solar systems, PPA, lease or purchase rooftop PV.

Cleaner Fuels – 12% sector weight (8 stocks @1.50% each)
Corteva, CTVA. Canola oil, renewable in sustainable aviation fuels (SAFs).
Darling Ingredients, DAR. Renewable biodiesel, sustainable aviation fuels.
FuelCell Energy, FCEL. High temperature fuel cells, uses a variety of fuels.
Gevo, GEVO. Biofuels, decarbonizing chemicals, new aviation fuels, RNG.
Hyliion, HYLN. Enables variety of fuels or waste heat, efficient linear engine.
Lanzatech, LNZA. Carbon to more sustainable fuels, material bio-recycling.
Opal Fuels, OPAL. Renewable natural gas RNG, CH4 from landfills, dairies.
Rex, REX. Biofuels, adding CCS sequestration, But Not in advanced biofuels.

Appendix III: **WilderHill New Energy Global Innovation (NEX)** via independent tracker (PBD) on Oct. 31, 2024 – or about ~4 weeks before next Rebalance for Latter Q4 2024. 110 stocks:

EVgo Inc	2.07	Energix-Renewable Energies Ltd	0.93
Eos Energy Enterprises Inc	1.69	United Renewable Energy/Taiwan	0.92
XPeng Inc ADR	1.53	Delta Electronics Inc	0.92
NIO Inc ADR	1.29	Shoals Technologies Group Inc	0.92
Yadea Group Holdings Ltd	1.27	Darling Ingredients Inc	0.91
JinkoSolar Holding Co Ltd ADR	1.22	Landis+Gyr Group AG	0.90
Flat Glass Group Co Ltd	1.21	Mercury NZ Ltd	0.90
Tianneng Power International	1.18	Kingspan Group PLC	0.90
Ganfeng Lithium Group Co Ltd	1.15	Canadian Solar Inc	0.89
HD Hyundai Electric Co Ltd	1.14	Array Technologies Inc	0.88
Xinyi Solar Holdings Ltd	1.08	Plug Power Inc	0.88
Wolfspeed Inc	1.06	Motech Industries Inc	0.88
Hubbell Inc	1.05	Boralex Inc	0.88
Ceres Power Holdings PLC	1.04	Corp ACCIONA Energias Renovables	0.88
HA Sustainable Infrastructure	1.04	Shihlin Electric & Engineering Corp	0.88
Voltronic Power Technology	1.04	Fugro NV	0.87
Rexel SA	1.02	Nordex SE	0.87
Ormat Technologies Inc	1.01	Phihong Technology Co Ltd	0.87
China Datang Corp Renewable	1.01	West Holdings Corp	0.87
Xinyi Energy Holdings Ltd	1.00	Innergex Renewable Energy Inc	0.86
Universal Display Corp	1.00	Chung-Hsin Electric & Machinery	0.86
Nibe Industrier AB	1.00	AcBel Polytech Inc	0.86
Itron Inc	0.99	LS Corp	0.85
Ameresco Inc	0.99	Wacker Chemie AG	0.85
Teco Electric and Machinery	0.99	Atkore Inc	0.85
NKT A/S	0.99	Elia Group SA/NV	0.84
Brookfield Renewable Corp	0.99	QuantumScape Corp	0.84
Prysmian SpA	0.99	Scatec ASA	0.84
GS Yuasa Corp	0.98	Ecopro BM Co Ltd	0.84
Signify NV	0.98	Doosan Fuel Cell Co Ltd	0.84
Sociedad Quimica y Minera	0.97	Allis Electric Co Ltd	0.83
REC Silicon ASA	0.96	Tamura Corp	0.83
Terna - Rete Elettrica Nazionale	0.96	Core & Main Inc	0.82
Nexans SA	0.96	TPI Composites Inc	0.82
Samsung SDI Co Ltd	0.95	Archer Aviation Inc	0.82
Orsted AS	0.95	NFI Group Inc	0.82
Eurogroup Laminations SpA	0.94	EDP Renovaveis SA	0.81
SPIE SA	0.94	RENOVA Inc	0.81
Neoen SA	0.93	Wasion Holdings Ltd	0.81
Acciona SA	0.93	Blue Bird Corp	0.81
Verbund AG	0.93	Ballard Power Systems Inc	0.80
Enlight Renewable Energy Ltd	0.93	Toyo Tanso Co Ltd	0.80
Lotte Energy Materials Corp	0.93	Solaria Energia y Medio Ambiente SA	0.80

First Solar Inc	0.80	Lucid Group Inc	0.68
CS Wind Corp	0.79	NEL ASA	0.68
Verbio SE	0.79	SMA Solar Technology AG	0.67
Bloom Energy Corp	0.78	Sunrun Inc	0.67
Sino-American Silicon Products	0.78	Kempower Oyj	0.66
Fortune Electric Co Ltd	0.78	Enphase Energy Inc	0.66
Ta Ya Electric Wire & Cable	0.78	ChargePoint Holdings Inc	0.65
LS Electric Co Ltd	0.78	SolarEdge Technologies Inc	0.64
Subsea 7 SA	0.78	Sunnova Energy International Inc	0.59
Alfen N.V.	0.76	Meyer Burger Technology AG	0.30
ITM Power PLC	0.75		
Vestas Wind Systems A/S	0.74		
Rivian Automotive Inc	0.70		
FuelCell Energy Inc	0.68		

There's strong representation above from *EVs & EV Chargers, *Batteries; *Solar, *Grid/ Efficiency.

Appendix IV:
WilderHill New Energy Global Innovation (NEX) - for Latter Q4 2024. 110 Stocks.

Name	Description	Sector	Currency	Activity
Acbel Polytech	Green energy electronics, PV & EV, power supply.	ECV	TWD	TAIWAN
Acciona SA	Sustainable infrastructure, separate is renewables.	RWD	EUR	SPAIN
Aker Carbon Capture	Carbon capture, in blue hydrogen, waste to energy.	ROH	NOK	NORWAY
Alfen NV	Electric Vehicle charging, smart grid, energy storage.	EEF	EUR	NETHER.
Allis Electric	Transformers, power transmission, smarter grid.	ECV	TWD	TAIWAN
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
Delta Electronics	Power systems, EV chargers, fuel cell development.	ECV	TWD	TAIWAN
Doosan Fuel Cell	Fuel cells, high temperature and hydrogen, S. Korea.	ECV	KRW	S. KOREA
Ecopro BM	Battery materials, cathode and precursor for Li-ion.	ENS	KRW	S. KOREA
EDP Renovaveis SA	Wind power, among the largest producers, Iberia.	RWD	EUR	SPAIN
Elia Group SA	Smarter grid, high voltage transmission Europe.	EEF	EUR	EUROPE
Energix Renewable En.	Wind & solar, producer Poland, US, 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
Eos Energy	Zinc batteries, longer-duration and safer than li-ion.	ENS	USD	US
EVgo	EV charging, an early leader in fast charging.	EEF	USD	US
First Solar	Thin film solar, CdTe low-cost alternate to polysilicon.	RSR	USD	US
Flat Glass Group	PV panel glass, solar engineering & construction	RSR	HKD	CHINA
Fortune Electric	Transformers for power transmission, switchgear.	ECV	TWD	TAIWAN
Ganfeng Lithium	Lithium, produces compounds, metals, for batteries.	ENS	HKD	CHINA
Gevo	Biofuels, renewable fuels, drop in RNG, and SAFs.	RBB	USD	US
Green Plains	Biorefining, lower-carbon fuels, renewable SAFs.	RBB	USD	US
Grenergy Renovables SA	Solar & storage, integrated project developer.	RSR	EUR	SPAIN
GS Yuasa	Battery technologies, also lithium for EVs, Japan.	ENS	JPY	JAPAN
Hannon Armstrong	Energy efficiency, capital & finance for infrastructure.	EEF	USD	US

HD Hyundai Electric	Transformers, circuit breakers, smart ships.	EEF	KRW	S. KOREA
Hubbell Inc.	Electrical equipment, grid infrastructure, utilities.	EEF	USD	US
Innergex Renewable	Renewable power, run-of-river hydro, wind, solar.	ROH	CAD	CANADA
ITM Power plc	Fuel cells, uses PEM technology; also hydrogen.	ECV	GBP	UK
Itron	Meters, Utility energy monitor, measuring & manage.	EEF	USD	US
JinkoSolar	Solar, wafers through solar modules, China OEM.	RSR	USD	CHINA
Kempower Oyj	Fast chargers, EVs, cars, trucks, aircraft, vessels.	EEF	EUR	FINLAND
Kingspan Group plc	Efficient Buildings, insulation, conservation, Ireland.	EEF	EUR	IRELAND
Landis+Gyr Group AG	Advanced meters, modernizing grid, Switzerland.	EEF	CHF	SWITZER.
Legrand SA	Electrical, energy & digital infrastructure in buildings.	ECV	EUR	FRANCE
Lotte Energy Materials	Rechargeable battery materials, elecfoils in batteries.	ENS	KRW	S. KOREA
LS Corp.	Cables, wind power transmission over distances.	RWD	KRW	S. KOREA
LS Electric	Smart grid power transmission, wind, solar, storage.	ENS	KRW	S. KOREA
Lucid	Electric Vehicles, premium, higher-voltage, range.	EEF	USD	US
Mercury NZ	Clean power, 100% renewable hydro, geothermal.	ROH	NZD	NEW ZEA.
Motech	Solar, cells and modules manufacturing.	RSR	TWD	TAIWAN
Nel ASA	Hydrogen, in fuel cell vehicles, renewably, Norway.	ECV	NOK	NORWAY
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, eg 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
Sanyo Denki	Power supply, cooling systems, solar management.	ECV	JPY	JAPAN
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

Sunnova	Residential solar and energy storage installation.	RSR	USD	US
Sunrun	Residential solar, leases, PPA or purchase PV.	RSR	USD	US
Ta Ya Electric Wire	Power cables, wires, magnet wires, Taiwan.	ECV	TWD	TAIWAN
Tamura	Transformers, battery chargers, power modules.	ECV	JPY	JAPAN
TECO Electric Machinery	EV motors, wind converters, in electrifying all.	ECV	TWD	TAIWAN
Terna Rete SpA	Transmission of electricity, increasingly is renewables.	EEF	EUR	ITALY
Tianneng Power	Hydrogen fuel cells, batteries for wind and solar.	ECV	HKD	CHINA
Toyo Tanso	Graphite, used in solar, wind, H2, LEDs, SiC, more.	ECV	JPY	JAPAN
United Renewable Energy	Solar, also energy storage, hydrogen and fuel cells.	RSR	TWD	TAIWAN
Universal Display	Organic light emitting diodes, efficient displays.	EEF	USD	US
Verbio Vereinigte BioEn.	Biofuels, manufacturer supplier to Germany, Europe.	RBB	EUR	GERMANY
Verbund AG	Electricity supplier, hydro, 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

110 stocks = Weights
Latter Q4 2024 **WEIGHT EACH COMPONENT % =** 0.90909

0.90909091

NEX Additions for Latter Q4 2024: Aker Carbon Cap., Green Plains, Legrand, Grenergy Renovables, Gevo, Sanyo Denki.
NEX Removals for Latter Q4 2024: Eurogroup Laminations, Fuelcell Energy, Meyer Burger, Fugro, Subsea, TPI Comp.

110 Stocks for Latter Q4 2024.		**#**
Energy Conversion	**ECV**	**26**
Energy Efficiency	**EEF**	**26**
Energy Storage	**ENS**	**12**
Renewables - Biofuels &	**RBB**	**4**
Renewables - Other	**ROH**	**6**
Renewable - Solar	**RSR**	**24**
Renewable - Wind	**RWD**	**12**
		110

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 Q4 2024 (64 components):

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

Opmobility SE	H2 and fuel cell technologies in automobiles, trains.	HT	FRANCE
Orsted A/S	Green hydrogen directly from wind power, early stage.	GH	DENMARK
Plug Power Inc	Green hydrogen, and fuel cell systems in development.	HI	USA
Renesas Electronics	Hydrogen gas sensors, power controller systems.	HG	JAPAN
Renew Energy Global	Green hydrogen activity, India, Egypt, elsewhere.	GH	INDIA
Resonac Holdings Corp	Lower-CO2 hydrogen from used plastics; graphite uses.	HI	JAPAN
Scatec ASA	Green Hydrogen produced by solar power.	GH	NORWAY
Schneider Electric SE	Gas analysis, automation for advanced H2 storage.	HS	FRANCE
SKF AB	Advanced bearings, for H2 by compressed transmission.	HS	SWEDEN
SMA Solar Technology	Electrolyzer converters, green H2 from renewables.	GH	GERMANY
Solvay SA	Advanced materials, membranes & polymers for H2.	HI	BELGIUM
SungEel HiTech	Recycling platinum from fuel cell spent catalysts.	HI	S. KOREA
Spie SA	Hydrogen in mobility, H2 production, distribution.	HT	FRANCE
TE Connectivity	Hydrogen pressure sensors, fuel cell connectors.	FC	SWITZER.
Thyssenkrupp Nucera	Electrolyzers, a purer play in hydrogen generation.	GH	GERMANY
Tianneng Power	Hydrogen, fuel cells, Li-ion and other batteries.	FC	CHINA
Toray Industries	Membranes for H2 purification, generation, fuel cells.	HI	JAPAN
Toyo Tanso	Graphite, nanotubes H2 storage, brushes in wind.	HS	JAPAN
Verbio Vereinigte Bioenergie AG	H2 from biomethane, biofuels, agriculture.	HG	GERMANY
Voltalia SA	Renewables generation for green H2 internationally.	GH	FRANCE
W-Scope	Water electrolysis, by anion exchange membranes.	GH	S. KOREA
Wacker Chemie AG	Green H2 from water using renewables, into methanol.	GH	GERMANY
Weichai Power	Hydrogen uses in forklifts, fuel cell buses, Asia.	GT	CHINA
Wolfspeed	High power fuel cell systems, SiC, GaN.	HT	USA
Yara International	Green ammonia, H2 catapult aims for H2 <$2/kg.	GH	NORWAY

% Weight each component: **1.56250**

64 Components % each = 1.5625

H2X Removals for Latter Q4 2024: Chart, Eurogroup Laminations

H2X Additions for Latter Q4 2024: Deme, Evonik, Gevo, Solvay.

Hydrogen Index H2X Sector	**#**
FUEL CELLS (FC)	11
GREEN HYDROGEN (GH)	15
HYDROGEN GENERATION (HG)	9
HYDROGEN INNOVATION (HI)	11
HYDROGEN STORAGE (HS)	9
HYDROGEN in TRANSPORT. (HT)	9
	64

Appendix VII:
WilderHill Wind Energy Index (WNX) for Latter Q4 2024 (70 components):

Name	Description	Sector	Activity
Acciona	Sustainability infrastructure, engineering.	SG	SPAIN
Alfen NV	Smart power grid, energy storage systems.	SG	NETHER.
Allis Electric	Transformers in grid, switchgear, inverters.	SG	TAIWAN
Arcadis NV	Engineering, EPC, develops wind projects.	WI	NETHER.
Atkore	Conduit, cables, electrification assemblies.	SG	USA
Belden	Wind cables, turbine data communications.	WM	USA
Boralex Inc	Development and operation of wind farms.	WF	CANADA
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
Covestro AG	Large polyurethane wind blades, recycling.	WI	GERMANY
CS Wind	Wind power, both onshore, and also offshore.	WF	S. KOREA
DEME Group NV	Offshore wind infrastructure, undersea cable.	WI	BELGIUM
Daihen	Transformers, power distribution, inverters.	SG	JAPAN
EDP Renovaveis SA	Wind, among the world's largest generators.	WI	PORTUGAL
Elia Group SA	High voltage power transmission, Europe/UK.	SG	BELGIUM
Energix Renewable	Wind, solar, independent power producer.	WF	ISRAEL
Enlight Renewable Energy Ltd	Builds and operates wind, also solar sites.	WF	ISRAEL
Eos Energy	Zinc batteries, safer alternative to Li-ion.	SG	USA
ERG SpA	Wind, going from fossils to clean renewables.	WF	ITALY
Fluence	Energy storage, using intermittent wind in grid.	SG	USA
Fortune Electric	Wind power transmission, grid transformers.	WI	TAIWAN
Fujikura	Power cables, overhead transmission lines.	WM	JAPAN
Furukawa Electric	Cable connectors, electrical conductors.	WM	JAPAN
Grenergy Renovables	Wind, development, construction, operation.	WF	SPAIN
HD Hyundai Electric	Power transformers, circuit breakers for grid.	WM	S. KOREA
Hubbell	Electrical gear, modernizes grid, utilities.	SG	USA
Hydro One	Electricity transmission, distribution, Ontario.	SG	CANADA
IMCD NV	Wind lubricants, 100% recycled blade foam.	WM	NETHER.
Infineon Tech AG	Converters and inverters, wind power systems.	WM	GERMANY
Innergex Renewable Energy	Independent renewable producer, wind.	WF	CANADA
JL Mag Rare Earth	Permanent magnet materials, wind rotors.	WM	CHINA
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
Mersen SA	Carbon brushes in wind power, & graphite.	WM	FRANCE
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
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
Shinfox Energy	Onshore and Offshore wind, better grid.	WF	TAIWAN
SKF AB	Wind gear rolling bearing, seals, mechatronics.	WM	SWEDEN
SMA Solar Technology	Wind power conversion; green H2 from wind.	SG	GERMANY
Spie SA	Energy infrastructure sustainability, Europe.	SG	FRANCE
Sumitomo Electric	Power cables for offshore wind, grid, SiC.	WM	JAPAN
Ta Ya Electric Wire	Power cables, wires, magnetic wires, grid.	SG	TAIWAN
Taihan Electric Wire	Submarine cables wind, solar; high voltage.	WI	S. KOREA
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
Valmont	Strenthening grid, for more wind & solar.	SG	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

70 components = 1.42857% Weight each **1.428571**

WNX Removals for Latter Q4 2024: Fugro, SBM, Subsea, Eurogroup Laminations, TPI.
WNX Additions for Latter Q4 2024: Covestro, DEME, Eos, Jl Mag, Mersen, Valmont.

4 WilderHill Wind (WNX) Sectors	**#**
SMARTER GRID (SG)	20
WIND FARMS (WF)	15
WIND INNOVATION (WI)	17
WIND MATERIALS (WM)	18
Total =	70

Greenvolt Energias bought out was removed from WNX in intra-latter-Q4 effective 31 Oct. 2024)
Covestro bought out was removed from the WNX in late-Q4 effective 5 December 2024)

Market Consultation for NEX, H2X, WNX Indexes: was issued on 24 October 2024, and change became effective as of 13 November 2024:

Content of the Market Consultation

Solactive AG has decided to conduct a Market Consultation with regard to changing the Index Methodology of the following Index/ Indices (the 'Index/Indices'):

NAME	ISIN	RIC
Wilderhill New Energy Global Innovation Index (USD)	US96811Y1029	.NEX
Wilderhill New Energy Global Innovation Index (GBP)	DE000SLA4668	.NEXBP
Wilderhill New Energy Global Innovation Index (GBP Total Return)	DE000SLA47E7	.NEXBPN
Wilderhill New Energy Global Innovation Index (GBP Total Return)	DE000SLA47A5	.NEXBPT
Wilderhill New Energy Global Innovation Index (EUR)	DE000SLA4650	.NEXEU
Wilderhill New Energy Global Innovation Index (EUR)	DE000SLA4650	.NEXEU
Wilderhill New Energy Global Innovation Index (EUR Net Total Return)	DE000SLA47D9	.NEXEUN
Wilderhill New Energy Global Innovation Index (EUR Total Return)	DE000SLA4692	.NEXEUT
Wilderhill New Energy Global Innovation Index (JPY)	DE000SLA4676	.NEXJY
Wilderhill New Energy Global Innovation Index (JPY Net Total Return)	DE000SLA47F4	.NEXJYN
Wilderhill New Energy Global Innovation Index (JPY Total Return)	DE000SLA47B3	.NEXJYT
Wilderhill New Energy Global Innovation Index (USD Net Total Return)	DE000SLA47C1	.NEXUSN
Wilderhill New Energy Global Innovation Index (USD Total Return)	DE000SLA4684	.NEXUST
WilderHill Hydrogen Economy Index (EUR NTR)	DE000SL0F5H2	.H2XEUN
WilderHill Hydrogen Economy Index (EUR TR)	DE000SL0F5J8	.H2XEUT
WilderHill Hydrogen Economy Index (EUR)	DE000SL0F5G4	.H2XEU
WilderHill Hydrogen Economy Index (GBP NTR)	DE000SL0F732	.H2XBPN
WilderHill Hydrogen Economy Index (GBP TR)	DE000SL0F740	.H2XBPT
WilderHill Hydrogen Economy Index (GBP)	DE000SL0F724	.H2XBP
WilderHill Hydrogen Economy Index (JPY NTR)	DE000SL0F765	.H2XJYN
WilderHill Hydrogen Economy Index (JPY TR)	DE000SL0F773	.H2XJYT
WilderHill Hydrogen Economy Index (JPY)	DE000SL0F757	.H2XJY
WilderHill Hydrogen Economy Index (USD NTR)	DE000SL0F5E9	.H2XUSN
WilderHill Hydrogen Economy Index (USD TR)	DE000SL0F5F6	.H2XUST
WilderHill Hydrogen Economy Index (USD)	DE000SL0F5D1	.H2X
WilderHill Wind Energy Index (EUR NTR)	DE000SL0F450	.WNXEUN
WilderHill Wind Energy Index (EUR TR)	DE000SL0F468	.WNXEUT
WilderHill Wind Energy Index (EUR)	DE000SL0F443	.WNXEU
WilderHill Wind Energy Index (GBP NTR)	DE000SL0F484	.WNXBPN
WilderHill Wind Energy Index (GBP TR)	DE000SL0F492	.WNXBPT
WilderHill Wind Energy Index (GBP)	DE000SL0F476	.WNXBP
WilderHill Wind Energy Index (JPY NTR)	DE000SL0F5B5	.WNXJYN
WilderHill Wind Energy Index (JPY TR)	DE000SL0F5C3	.WNXJYT
WilderHill Wind Energy Index (JPY)	DE000SL0F5A7	.WNXJY
WilderHill Wind Energy Index (USD NTR)	DE000SL0F427	.WNXUSN
WilderHill Wind Energy Index (USD TR)	DE000SL0F435	.WNXUST
WilderHill Wind Energy Index (USD)	DE000SL0F419	.WNX

Rationale for the Market Consultation

Solactive has determined that to align with EU Paris-aligned benchmarks, the following changes will be added to align with Article 12 Exclusions with Commission Delegated Regulation (EU) 2020/1818. This is to allow all products that track the index to have a clean energy or sustainable label to maintain attractiveness to investors.

Proposed Change/(s) to the Index Guideline

The following Methodology change/(s) is/are proposed in the following point/(s) of Index Guideline

2.2 Selection of the Index Components

From:

Product Involvement screens: (by field name)	Exclude if
Controversial Weapons Tailor-made and essential-Category of Involvement	>0%
Controversial Weapons Significant ownership (Tailor-made and essential)- Range Ownership	≥20%
Controversial Weapons Non tailor-made or non essential-Category of Involvement	>0%
Controversial Weapons Significant owner. (non tailor-made or nonessential)-Range Ownership	≥20%
Cannabis Production (Recreational Cannabis)-Level of Involvement	>0%
Cannabis Significant ownership (Production Recreational Cannabis)-Range Ownership	≥20%
Cannabis Retail (Recreational Cannabis)-Level of Involvement	>0%
Cannabis Significant ownership (Recreational Cannabis)-Range Ownership	≥20%
Military Contracting Weapons-Level of Involvement	>0%
Military Contracting Weapon-related products and/or services-Level of Involvement	≥5%
Small Arms Civilian customers (Assault weapons)-Level of Involvement	>0%
Small Arms Military/law enforcement customers-Level of Involvement	≥5%
Small Arms Key components-Level of Involvement	≥5%
Small Arms Retail/distribution (Assault weapons)-Level of Involvement	≥5%
Small Arms Retail/distribution (Non-assault weapons)-Level of Involvement	≥5%
Small Arms Civilian customers (Non-assault weapons)-Level of Involvement	>0%
Thermal Coal Extraction-Level of Involvement	≥5%
Thermal Coal Power Generation- Level of Involvement	≥5%
Tobacco Products Production-Level of Involvement	>0%
Tobacco Products Related Products/Services-Level of Involvement	≥5%
Tobacco Products Retail-Level of Involvement	≥5%
Oil Sands Extraction-Revenue Level of Involvement	>0%
Oil Sands Significant ownership (extraction)-Range Ownership	≥20%
Arctic Oil & Gas Exploration Extraction-Level of Involvement	>0%
Arctic Oil & Gas Exploration Significant ownership (extraction)-Range Ownership	≥20%
Shale Energy Extraction-Level of Involvement	>0%
Shale Energy Significant ownership (extraction)-Range Ownership	≥20%
ESG Risk Score	>40%

TO: (HIGHLIGHTED boxes are additions)	Exclude if
Controversial Weapons Tailor-made and essential-Category of Involvement	>0%
Controversial Weapons Significant ownership (Tailor-made and essential)- Range Ownership	≥20%
Controversial Weapons Non tailor-made or non essential-Category of Involvement	>0%
Controversial Weapons Significant ownership (non tailor-made or non essential)- Range Ownership	≥20%
Cannabis Production (Recreational Cannabis)-Level of Involvement	>0%
Cannabis Significant ownership (Production Recreational Cannabis)-Range Ownership	≥20%
Cannabis Retail (Recreational Cannabis)-Level of Involvement	>0%
Cannabis Significant ownership (Recreational Cannabis)-Range Ownership	≥20%
Military Contracting Weapons-Level of Involvement	>0%
Military Contracting Weapon-related products and/or services-Level of Involvement	≥5%
Small Arms Civilian customers (Assault weapons)-Level of Involvement	>0%
Small Arms Military/law enforcement customers-Level of Involvement	≥5%
Small Arms Key components-Level of Involvement	≥5%
Small Arms Retail/distribution (Assault weapons)-Level of Involvement	≥5%
Small Arms Retail/distribution (Non-assault weapons)-Level of Involvement	≥5%
Small Arms Civilian customers (Non-assault weapons)-Level of Involvement	>0%
Thermal Coal Extraction-Level of Involvement	Sum
Thermal Coal Supporting Products/Services-Revenue Percentage	≥1%
Thermal Coal Power Generation- Level of Involvement	≥5%
Tobacco Products Production-Level of Involvement	>0%
Tobacco Products Related Products/Services-Level of Involvement	≥5%
Tobacco Products Retail-Level of Involvement	≥5%
Oil Sands Extraction-Revenue Level of Involvement	>0%
Oil Sands Significant ownership (extraction)-Range Ownership	≥20%
Arctic Oil & Gas Exploration Extraction-Level of Involvement	>0%
Arctic Oil & Gas Exploration Significant ownership (extraction)-Range Ownership	≥20%
Shale Energy Extraction-Level of Involvement	>0%
Shale Energy Significant ownership (extraction)-Range Ownership	≥20%
ESG Risk Score	>40
Oil & Gas Production-Exploration and Production Oil Revenue Percentage	Sum
Oil & Gas Production-Refining Oil Revenue Percentage	≥10%
Oil & Gas Production-Transportation and Storage Oil Revenue Percentage	
Oil & Gas Supporting Products/Services-Revenue Percentage	
Oil & Gas Production-Exploration and Production Natural Gas Revenue Percentage	Sum
Oil & Gas Production-Refining Natural Gas Revenue Percentage	≥50%
Oil & Gas Production-Transportation and Storage Natural Gas Revenue Percentage	
Oil & Gas Supporting Products/Services-Revenue Percentage	
Thermal Coal Power Generation-Revenue Percentage	Sum
Oil & Gas Generation-Revenue Percentage	≥50%

The changes mentioned above became effective on 13 November 2024.

see, https://www.solactive.com/methodology-change-several-wilderhill-indices-effective-date-13-11-2024

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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