WilderShares, LLC

Q1 2022 WilderHill® Quarterly Report: ECO, NEX, OCEAN, March 31, 2022

The Clean Energy Index® (ECO) started Q1 2022 near 150, ended Q1 near 136 down some -9%. Or over last 3 years, ECO rose by +58% in 2019. Then remarkably it rose by +203% in 2020 for about the best performance of any Index or Fund, anywhere. After those 2 gains, not surprisingly it fell -30% in 2021. That drop partly was due to a big reconciliation bill's failure in 2021 that pushed this theme Down hard(!), rising inflation & interest rates (Down!) – which outweighed decarbonizing trends that may favor renewables ahead. After falling early in Q1 1/3rd to near 100 - war since brought speedier shift away from overrelying on (Russian) natural gas – and in the war's first few days ECO jumped +25%; in the first few weeks it rose +40% on the better alternatives found here. Or since 2017, when ECO was 38, it's up some +260%.

History shows the passive ECO & NEX themes can & will at times 'drop like a rock'. Gains, yes - but also big falls happen here as well. Even if renewables bring an energy transition ahead. Even if both solar & wind produce the lowest-prices electricity anytime, anywhere in history, there's great volatility at times, downside. Despite new demand from Europe, US and Asia. Even should new energy global innovation, jobs, infrastructure – overlap climate solutions – there's bound to be grand swings and risks. Perhaps not only solar - but also in wind power, electric vehicles, batteries, energy storage, green hydrogen, fuel cells, thinking informed by ESG and the deep decarbonization of everything – unlike anything seen before.

Last 5 years the Benchmark ECO Index live since 2004 and the 1st for climate solutions is up +180% through mid-Q1 2022. This over a period when any energy gains may stand out. For same 5 years despite huge recent gains, oil & gas were *down* -15% & -40%; they're down -70% last 10 years. By contrast, decarbonization as an organizing theme over past 10 years in ECO is up +100%, & in NEX is up +150%, showing very different returns for sustainable energy.

The first *global* clean energy Index is the WilderHill New Energy Global Innovation Index (NEX), live since 2006, with tracker in Europe; it's up over +100% last 5 years starkly beating fossils. NEX has oft outperformed too vs. a not so clean and less-pure, independent other global 'clean energy' Index in sizable periods of past 10 years, 12 years, since inception etc; the greater thematic purity in NEX & equal weights may help explain that divergence. In sum the WilderHill themes are green, purer-play benchmarks. And energy that's long been dug from deep down underground & burned - increasingly is captured sustainably in whole new ways – using clean fuels gifted to us freely & renewably from up towards the Heavens.

The Clean Energy Index® (ECO) live since 2004, is the first for clean energy, and climate solutions. Benchmark ECO Index® has the longest record & usefully moves differently vs coal, oil & gas. ECO and Global NEX since 2006, are respected pure plays: the best-known for solar, wind, batteries, EVs, hydrogen, fuel cells, & electrifying everything. WilderHill® Indexes are volatile, innovative, transparent, informed by ESG and sustainability & can help to build a diversified portfolio.

Source: NYSE.com

Several pointedly bearish troubles were overshadowing US clean energy when 2022 opened. One, was that only a bipartisan $1 Trillion Infrastructure bill had passed in 2021. Little in it relevant to clean energy – none to climate crisis. Compared to a far bigger draft reconciliation bill with $550 billion focused on clean energy & climate - but that had stumbled/failed 2021, this was a thin gruel indeed. For example, to make US electric grid net-zero may mean +60% capacity upgrades. Yet this passed Infrastructure law only gave a DOE Facilitation item $50 million plus $2.5 billion revolving. Grid resilience got $11 billion, but power failures discussed ahead are real now, and could potentially already cripple states; $3 billion matching grants in this law nowhere near up to task. Overall its $65 billion for overall transmission would be quickly eaten up by spending there on fossils outside of a need for decarbonization.

$66 billion for transportation: if electric rail, OK; but not fossils-based transport expansion. $3.5 billion 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, as discussed below. But $6 billion for batteries was not near enough from 2022. Not when competing China had already had spent multiples of that last decade to 'own' battery manufacturing. The US unfathomably nearly-gave up a global race for batteries; Tesla has been the one great US outlier – but now Asia, and even Europe lead. (Europe looks to install millions of chargers, to match its 130 million EVs expected by 2035).

Globally, early 2022 was strange times: with both some growth - & big equity declines. China, Europe, the US all saw growth in solar, wind, batteries, EVs. Ahead maybe in hydrogen too. Yet interestingly as renewables grew worldwide – risky, high PE green stocks here early 2022 were plummeting even after having already dropped hard 2021. Stocks were hit by inflation, by supply chain disruptions, end of easy-money, uncertainty. How strange! Clean new energy may grow, some real promise ahead – yet stocks here were down very hard early 2022.

Consider say one of world's biggest wind turbine suppliers at start of 2022, Siemens Gamesa. (Especially vital in supplying turbines in West, outside China). Its stock had declined by -45% to early 2022; its market cap likewise had plummeted near half. October to December 2021 its revenues had fallen to 1.83 billion euros; year on year had declined -20%. Plus, it then was expecting its revenues to fall even further over 2022 by between 9% and 2%. It placed blame on supply chain difficulties, on "higher than expected cost inflation". Pointed to volatile market conditions that "impacted some customers investment decisions" for project delays. Its competitor Vestas too noted "supply chain instability caused by pandemic", "increasing transportation and logistics costs" along with the big "cost inflation within raw materials, in wind turbine components and energy costs." All those doubtless, were at issue.

Yet zoom in closer for maybe other factors. Take 2020 orders for onshore & offshore turbines at all 4 key competitors: Denmark's Vestas, GE in US, Germany's Nordex – and Spanish/ German Siemens Gamesa – together they'd seen only 3% decline in new wind business year over year. Orders at all 4 leaders had dipped, but only a bit – to 48.5 GW in 2020 from 49.8 GW 2019. Except for China (its domestic wind manufacturers growing fast in/for that market), these 4 accounted for much wind manufacturing in West/and world. But in rather non-uniform ways. Of the 4, Siemens Gamesa's offshore & onshore wind turbine orders fell most, by -17%. Meanwhile, Vestas saw a +6% *increase* in 2019 as it reorganized. Orders at GE and Nordex both remained fairly steady in 2019, dipping just -1% & -3%. So, what might be involved in Siemens Gamesa's larger declines – that were rather harsher than seen at those other three?

Perhaps partly that was Siemens Gamesa turning away from high volumes to more profitable projects; it departed some onshore markets. Prices stayed stable 2019, although it had closed 2 manufacturing plants and in 2019 saw 90 projects impacted by Covid. Siemens Gamesa also suffered in having been leader in offshore wind for so long. As the biggest, it was the one all the others were gunning for. Vestas had introduced a massive 15 MW offshore turbine in hopes of taking market share. So too GE, with marginally smaller yet huge(!) Haliade-X wind turbine. Vestas & GE hoped to 'eat Siemens Gamesa's lunch' with their huge (non-Chinese) turbines. Siemens Gamesa went from a big 60%-70% offshore wind market share in 2011, to 'down' near 50% in 2021. It's expected onshore wind (ex-China) might grow by rather modest rate the next few years – but new offshore wind instead *may* grow by a compound annual 23% rate. And yet Vestas, Nordex and GE too, were all seeing tough supply issues at the start of 2022.

Vestas is famous for its wind turbines. Yet early 2022 it was reporting dismal 2021 results. Despite record top line revenues up +5.2%, a poor net profit EUR 176 million was off -77.2% vs. previous year. At fault, skyrocketing raw materials costs, tough logistics, Covid difficulties across wind manufacturers. And Vestas was hit by cyber attack, data theft. Yes, its revenues were expected to stay healthy 2022 near EUR 15 billion. But, transport costs, logistics vexed Vestas' bottom line. Of note was the steel that's maybe 2/3rds costs of a wind turbine structure (66%-79% of total turbine mass) – as it had *doubled(!)* in cost in the pandemic.

Siemens Gamesa did expand like in Hull, England - thanks to big UK vision for wind power. Its manufacturing hub built 2016 can make 300 turbine blades per year (each having wingspan of world's largest aircraft) and might employ 1,000 people in 2022, so could build yet even grander blades! One single rotation of one of the huge blades might power a house for a day; the coming, bigger blades might power a whole house for 2 full days /per rotation!

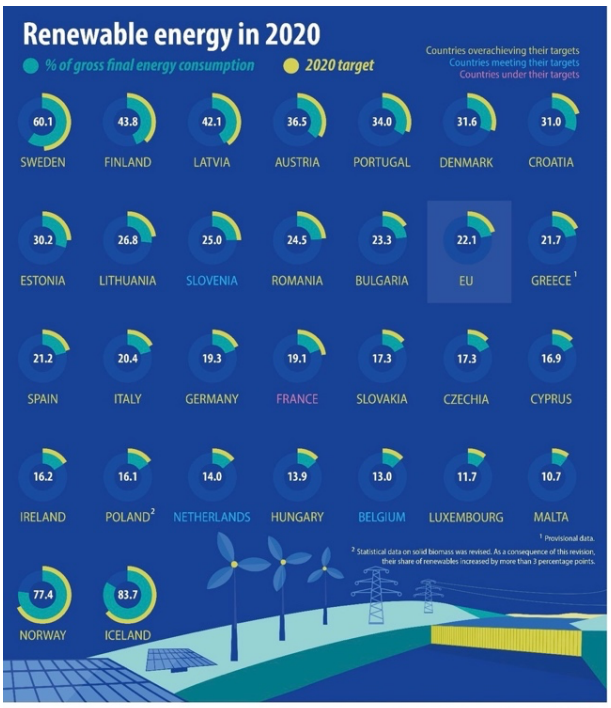
Wind's growth there had meant 25% of UK power lately came from wind over a full year. And UK wants wind to account for more, for one-third+ of its power by 2030. In Europe wind power was generating on average near 16% of its electric power in 2020 and growing. Paired with energy storage, wind/solar could become firm, dispatchable power. Green hydrogen, too, *might* be seen as a viable idea - but only if wind/solar power first can get very cheap.

Wind power in general was THE leading renewable in 2022 in most countries. Onshore wind however was growing at moderate rate many places on NIMBYism and land constraints. True, some places like China onshore wind grew leaps & bounds – despite high steel costs 2022. But it was Offshore wind really taking off from scratch, unconstrained, that started to rocket. Meanwhile, solar has enormous, fantastic potential. Though just a tiny slice of overall power generation, until recently, look for that to change fast this/next decade. In places solar & wind will become greatest 2 sources not just of renewable – but of all energy. Nicely too more affordable than anything else, hastening energy transition. War in Europe in 2022, then moves away from overreliance on natural gas – can hasten renewables' growth this decade.

Once, big hydropower dams were a main renewable source, 1970s & 1980s. Some places it was 10% or more of total energy mix. But its potential is capped (no new places to go in) and it's ecologically harmful. So little regret it's now supplanted by more scalable solar & wind, even smaller run-of-river hydro. Meanwhile, geothermal has much potential: it could go many places, and be firm, always-on power. Some oil firms too may begin to explore that ahead as it means drilling holes in the ground, which they're good at. Yet in 2022, geothermal was costly and near non-existent, except maybe when conjoined with lithium production.

Net result was wind & solar were the 2 main renewables early 2022, with rich Europe a leader. European gross energy consumption met by renewables was then 1/4th, or about 25% of its total demand. 2020 figures below showed highest/best was Norway and Iceland, at a notable 77% and 84% respectively. Among 27 EU member states, Nordics again led with Sweden at 60%, Finland was 44%. Nearby Latvia and Austria were 32%, 36%. But of course, there were EU laggards as well. Belgium was then getting only 13% from its renewables; The Netherlands was at just 14%. Both had only barely met their targets, unusual vs. rest of rich Europe.

Of note, nearly all the EU-27 was *beating* renewables targets. The bloc had set goals in 2009 and while that included as 'renewable' a dubious municipal waste burning (Not classed as clean at ECO), their main focus rightly has been wind & solar. Mostly they exceeded goals. Two lovelies Sweden & Croatia did so by 11 percentage points. Poorer Bulgaria did so by 7 percentage points. Poland (16%) has lagged hard in renewables, but an altered definition let its (dubious) biomass meet EU targets. In all 'less green' energy was an exception: most beat their goals with truer clean energy – primarily wind and solar. Here's how they looked:



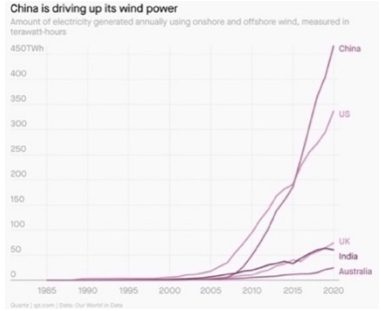
The UK famously had left the 27-member European Union early 2020, and so isn't seen above. But, the UK in 2020 sourced 42% of its energy from renewables, thanks largely to a wind push. Expect offshore wind to go on fast rising in UK & Northern Europe. Yet curiously if renewables' Costs in UK (like elsewhere) are plummeting – why did UK average home energy bills *jump* to GBP 1,200/USD $1,630? Then go *higher* early 2022, when UK wind power was offered at just 5p per kilowatt hour (kWh) – or under ¼ what a homeowner pays?! That, was due to the 4x increases in natural gas prices - for energy markets are set by the *costliest*, the crucial, most needed (still fossil!) fuel. In an awkward energy transition beginning, it still made no intuitive sense to see UK energy bills spiking – as renewables got cheaper! Nearby Ireland shows what could be; February 2022 its wind supplied 53% of needed electricity – a new record. Less windy hours wholesale electricity cost EUR 229/MWh; in windier hours it dropped to EUR 134/MWh. So combine Wind - with far more Storage! Still, skyrocketing natural gas prices, a large source for Ireland's electricity – meant its power costs had jumped 3x year over year.

Meanwhile a US that in 2020 got only 19.8% of its energy from renewables, lagged Europe at then 22.1%. Then, with war in Feb. 2022, Europe fast-upped commitments to renewables – as a US at 20% lagged. Of America's own 20% renewables, 13%, or 2/3rds was solar & wind; 7% or 1/3rd hydroelectric. In 2021 US did see a record $105 billion in investments in renewables, batteries etc – record 37 GW solar & wind. Yet gas was making Twice, or 2x that power: 40%. As Europe pulled ahead in renewables, big picture was that neither Europe, nor US, were making anywhere enough clean power. Each must grow by at least 2x faster to meet decarbonization goals. Yes, war changed much in 2022; Europe, and acutely Germany resolved to grow renewables far faster. EVs too. Europe's light duty vehicle sales were already 19% late 2021 – double an 8% world average – near 1 out of every 6 cars sold in Europe (and China) were EVs; that vastly beat US's 1 out of 20. But the fact remained that for Europe: 1/3rd of its oil, and more of its gas 2021 came from Russia, nightmarish with invasion of Ukraine.

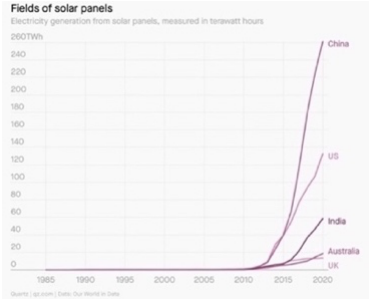
What then of China lately? As one of - if not, THE most important bloc for renewables? China 2020 was world leader in absolute green energy generating capacity. Yet its 342 gigawatts (GW) of capacity made (only) 14% of power from renewables. Still, figures can be deceiving. For China total energy demand was/is so enormous, ramping renewables even pretty fast can be bit of a damp squib. Yes, relative to Europe or the US, its GWs growth trajectory was far outstripping all, everywhere. Late 2021 it promised to install 1,200 GW of new wind & solar by 2030. Unlike the at times hollower promises of the West, China tends to meet goals it lays out for itself. And 1,200 GW can indeed be envisioned. Yet a burning issue early 2020s, has been that China is utterly reliant on burning record-breaking-amounts of polluting coal.

In long run up to 2022 Beijing Olympics, China had put its renewables growth into overdrive. It added 134 offshore wind turbines, able to power up 900,000 homes. 17 GW new offshore wind built 2021, taking its total to 26 GW: more than being built by rest of world, last 5 years combined. Besides its 21 GW onshore wind. It had added in 2021, 55 GW of solar capacity. That took its total solar installed capacity to 305 GW – 1/3rd the entire world. A startling pace of change 2022 as China simply put, was far outpacing the world in new green GWs:

Wind & Solar Power Growth in China:



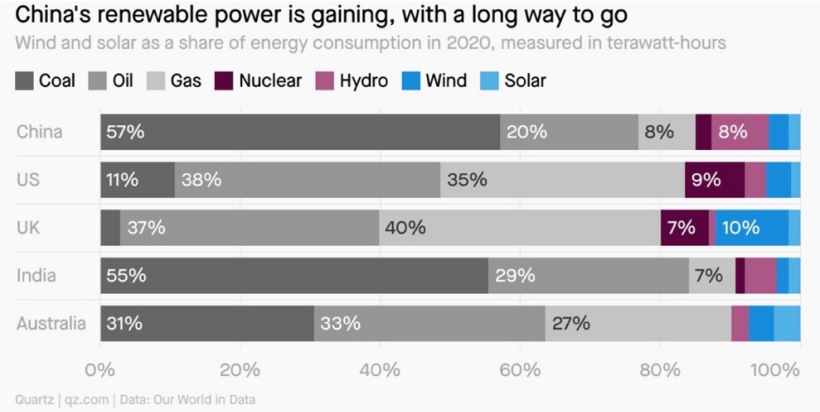
Source: Quartz / Our World in Data.



Source: Quartz / Our World in Data.

Yet China's voracious energy demand puts all in perspective. In 2020 China needed 40,170 TWh of energy - only 15% was met by 'renewables' (in China can include current-generation nuclear). Not far off, was a US, where of 23,927 TWh needed, only 17%-20% was met by renewables. With Europe only somewhat ahead of them 2020, there's been so much room for improvement all 3 major places. Especially coal – where China is the undisputed pejorative 'king of coal'. But before a rich US or UK climb up on their 'burning-less-coal' grandstands – they, like Europe are burning immense amounts of oil for transport. Natural gas for power. And with 2022 war, coal demand jumped globally on spiking costs of natural gas. Thus 3 fossils still: natural gas, oil, and far too often coal – now overshadow the world's energy mix.

Seen below is how 5 big economies fared lately. In dull colours, charcoal, brown & gray, it's clear the 3 fossils still were dominating at left, in 2020. Meanwhile at right, bright colours light and dark blues & pink, we can see solar, wind & hydro with mild penetration near 20% in 2020 - though growing. That leaves (way too) much room to improve (as Rome burns):



Source: Quartz / Our World in Data

In 2022 a coal-loving Australia for instance, relied on coal for 60% of its electric generation. Though renewables could prove themself a better bet. Eg a wind farm in Badgingarra, Western Australia early 2022, hit a capacity rate (how much time operating) of a big 64%, so competing well with coal plants that must shut for maintenance, repairs etc. And coal always must pay for fuel, nukes for the waste, unlike clean wind or solar that instead get ever cheaper.

World fossil linchpin China still burns so much coal, that in absolute & relative ways, it ensures our globe releases unprecedented amounts of CO_2. In 2021 China's coal production leapt to 4.07 billion tonnes in a year of acute concerns on climate, up +4.7% over prior year. Rising electricity demand there was met by +9% *increase* in coal use. 2022 was worse. Meanwhile we're releasing other potent greenhouse gases like methane into air, freely, like to a sewer, treating them as meaningless. This trend has gone on decades despite flowery words by rich nations like the US to the contrary. It's been allowing – no more truly it has been *making* – today's climate crisis an exceptional, maybe existential threat right under our noses.

Even supposed climate leaders flailed 2022. For a regional case, take California. Its quasi-governmental public Commission close to utilities (favoring big, centralized thermal power generation mostly run-on fossil fuels) - proposed to consternation of many in this green leader State – that it *reverse* incentives for home rooftop solar. Move from solar payback in quicker 7-9 years - which makes solar a sound economic choice – to over 20 years. Thus, making it unaffordable or purely non-sensical to just about everyone. This, in green California!

An expert in Net Energy Metering (NEM) called that 2022 draft 'NEM 3.0', dystopian. Writing of the 2022 proposed decision (PD) that may gut rooftop solar, that expert pointed out while its backers claimed to want more battery storage, the PD makes home roof solar uneconomic - so without rooftop solar, few will install batteries in first place. Noted payback isn't a short 3-4 years (as PD claims) – but is near 7 years [born out by our own experience]. Installed solar doesn't cost a low $2.38/watt as proffered in PD, but is near $4/watt. To place huge costs on solar PV – retroactively too – would kill distributed home rooftop solar.

Discriminatory anti-solar, fixed charges paid only by homes with solar PV, were rare: they've been seen only at 2 of 172 investor-owned utilities nationwide, so <3%. While 27 times in past various utilities *proposed* adding such charges onto solar customers only, nearly all later were withdrawn, or were rejected outright. None imposed retroactively, like asked here.

Utilities saw they could take a 'holier than thou' approach, showing concern most of all over home solar 'shifting costs' to non-solar customers. Yet, providing electricity has long been "riven by cost shifts". There are cost shifts eg, as between low users vs heavy users, between rural and urban users, apartments vs. single family homes, those who invest in efficiency vs those who do not. Cost shifts going on for decades have been well-accepted. Utilities may lay out 'cost shifts' as their primary anti-home roof PV rationale, but it's a bit dubious as the real top cause, given their major concerns over fast-growth of decentralized home solar.

Utilities are accustomed to large, centralized, thermal-power plants they control. They may support too, large-scale solar farms they own – which haven't much lowered yet retail power that's still costly: about 25 cents per kilowatt hour (/kWh). By contrast, decentralized rooftop solar PV in California can instead fast cutback retail costs by one-half to two-thirds.

In 2022 a (rich) customer say, at one of California's 3 big investor-owned utilities, could save about 50% by upgrading – going from buying utility-supplied electricity & driving a gasoline burning car – to instead solar power on home rooftop & driving an EV. This PD sought to quash that option, even in progressive California, even in 2022. Pushback was swift & vocal. Notably what California will do on this shall be of interest, ahead, nationally. It has only piled more uncertainty atop of 2022, and has pushed down a solar sector (already hit) even more.

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

A bit like California, it centered on net metering, how much a solar customer gets back on their bill. Usually, they're reimbursed at retail rate. Florida had come late to a home solar party, but was rising fast. By 2022 it grew to 90,000 solar roofs (1%) - vs about 1.3 million in California. Florida's utilities could see writing on the wall. Another state, Nevada had made a big change like this (after trying 6 years earlier and failing). In its case, Nevada's nascent solar industry then plummeted there. It was later repealed, but impacts lingered. In sum utilities may favor big centralized power they alone sell – even from their big-scale solar farms – but as for individual rooftops making decentralized home PV power, not so much. That said, there is a regressive aspect to net metering in California – it favors wealthy, predominantly white populations. Thus a Plan to directly assist or subsidize lower-income families who want to go solar – transparently from the State budget, can make some good sense.

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

Just as vital as what California might add next 20 years – is what it may take away in the Plan. 2 big targets in its crosshairs, are to *slash Natural gas due to its greenhouse gases – and to *end current-generation nuclear as exceptionally risky and costly. Cutting back on natural gas near-term, however, is a huge ask. Gas has long been a core, at heart of California's power – both in-State and imported. In 2021 natural gas was key 48.35% of in-State power generation; it was 37.06% of State total energy mix that includes its imported power.

So, to target any energy turn away from natural gas in power generation, is no small thing. Filling a gaping firm power hole, this Plan seeks for utility-scale solar to triple. Energy storage short-term <4 hours via batteries jumping 15x from 2.6 GW it was at in 2021. Longer-duration >4 hours energy storage (like pumped water) rising to 4 GW. Of course, these were just plans in 2022. How, nearer-term to actually replace those GWs of firm natural gas – plus its lone 1 last nuclear plant by mid-decade – with anything near as energy-rich? In 2022 the answer wasn't 100% certain, with threat of rolling blackouts ahead, ahem, real. All in an early energy transition that's so far highlighting the demand for yet *more* natural gas – not far less.

The 2022 Plan anticipates 12 GW of renewables brought in from out of state. A new 5.2 GW of wind/sun on the SunZia line from New Mexico/AZ, 4.7 GW transmission of Wyoming's wind by TransWest project. They can't happen too soon. CAISO's draft Plan projects going from 7.8 GW California wind power, to utilizing 24 GW new wind including from many places 2040. In past a lengthy 8-10 years has been needed for grid permits; that's now too long as green electrons are needed, fast. Helpfully, regulatory bureaucracy is being cut of late. And its $30 Billion for transmission upgrades seen as do-able. Like $11 Billion to improve substations & powerlines; $8 Billion to allow local off-takers to make use of offshore wind, $11 Billion to bring wind power in from out of state. Of course these are Billions - huge sums. (As Senator Dirksen joked, 'A billion here and a billion there, and pretty soon you're talking real money'). But put in context of vast sums spent for oil & gas, $30 Billion for renewables is relatable. Particularly when it means a better resilience for California's $3 Trillion economy. Were that state a nation, it'd be the 5th largest in the world, ahead of even India and the UK.

A biting issue 2020s was poor grid resilience across the US – power being lost too frequently. In 2021 there were 180 major power disruptions; 20 years earlier, there'd been fewer than 2 dozen. Not just oft unprecedented weather extremes at fault. The US grid is aging badly. 70% of transmission & distribution are far into 2nd half of 50-year lifespans. 600,000 miles of major transmission lines, 5.5 million miles of local distribution. Back in 2010, thermal coal, natural gas & nukes made most US power; natural gas since then became king when shale/ fracking made it very cheap (beating coal/nukes). Renewables then began to compete with, and even at times, beat gas. But lacking storage, given intermittency of renewables, the problems at all 3 fossils, razor-thin power reserves – plus an old grid, power supply grew less resilient. And it will stay this way until vast new storage comes online. There's no easy answer: on ever-more abundant, ever-cheaper renewables, new storage has got to become key.

Yet storage takes time to be built. So, what to do soon/er, about 2 big pieces in this puzzle: natural gas, and current gen nuclear 2020s are key near-term issues. This decade California will need all this 25 GW of new renewables supply – added to an extant total of ~50 GW of generation. Of this, a new 17 GW (17,000 MW) big centralized utility scale solar and even utilities will support that. Offshore wind capacity that starts spooling up; by late-2020s, 3 GW+ new wind. Plus 13 GW in short-duration batteries. All of that can make California's major grid by year 2032, happily 73% from renewables & 86% greenhouse-gases free.

Summing early 2022 a huge climate & clean energy reconciliation bill that had lately drove up green energy hopes as almost passable a prior year, when new President & 50/50 Senate took office: was dead. Political capital and trillion/s of dollars needed had first, fastest gone to needed Covid emergency spending. Conservatives arguably had a point that early trillions in Covid relief spending would be inflationary. And progressives, were arguably right that high gasoline prices at the pump weren't due to US energy policy nor a rise in green energy (that's anyway not inflationary) – rather, oil price is set by markets worldwide. Unsurprisingly after the oil industry refrained swiftly ramping back supply on new demand (it suffered huge losses in the last bust) – followed by the exigencies of war – the price of oil jumped.

For clean energy, inflation plus war spiked costs for key inputs - like nickel. EV batteries may thus soon favor chemistries instead needing No nickel – like iron/phosphate. Benefits include less fire risk, so each battery needn't be individually surrounded by liquids. Thus, whole battery pack architecture could, on new design contain far more battery material, going from say 40%, to double that and becoming cheaper, lasting longer and going much farther.

Bigger picture, Russia's invasion had put Europe on a war-time footing to faster reduce dependency on piped natural gas. Germany had so long depended on Russia's Nord Stream I, cheap piped gas – that even its verdant Green party is growing willing to accept short-term prolonging of nuclear, even shipped LNG – to get quicker to deep 100% renewables. Arguably, an understandable choice – and one Conservatives worldwide are applauding as 'mature'.

Something a bit like that might happen next in US as well. A narrow lane for US passage of a $550 billion Bill for clean energy in 2021 has closed – discussed here ahead. Yet maybe a more bipartisan-type package looks plausible. In particular acknowledging facts on the ground: the Fall 2022 elections can end a razor thin Democratic control of Senate – and/or small House advantage. In that case, there may be US re-thinking on energy expectations ahead too.

Conservatives for their part see writing on the wall; clean energy's not going away. Instead, it's fast becoming economically best-option; some red-states even embrace it (reluctantly). Renewable solar/wind, perhaps even green hydrogen in future (stored say, under salt domes), geothermal led by fossil companies, wind power say in the Midwest – and soon too offshore.

US progressives, will understandably find it hard to accept some added life to natural gas, or current-generation risky/costly nuclear. US coal is firm but it can be cut dramatically; on its high costs, health burdens – and fact it can readily be replaced. Natural gas not so much, and the world began to call for more LNG in 2022 to replace piped gas from Russia to Europe. Conservatives, to win these carbon sources and nukes – may be willing to accept some clean energy they heartily oppose. It's a question of how swiftly more renewables and especially energy storage can be brought online. And now, by middle of this present decade.

To get some of their goals, progressives may swallow hard and accept a big bill akin to 'All of the above' approach for 'energy independence'. America isn't then energy-independent – each barrel of oil entering global supplies isn't identifiable as barrel a, b, etc. But, if it gets massive support for renewables, that could ramp them this decade. Oil is fragile, wrought by politics; dependent on subsidies (only renewables can exist without subsidies ahead in future). But at this point, some new grand compromise may happen. On the other hand, a tremendous downside to this (world of politics, which we prefer to avoid), is that it might doom us from the wider, more real, vital, objective, carbon and climate-perspective.

It's easy thinking above of near-term politics to forget how climate change really matters. Politics so-far ignores the risk, even though science indicates that this oversight may revisit us all many-fold. Work is happening in future-gazing arenas of science, like getting models to help us better see what may lay ahead, right. Clouds in particular, have long bedeviled forecasts. Just how clouds/water vapor will interact ahead contributing to heating due to all greenhouse gases (GHGs) is vital. Potentially clouds *may* mean the Earth gets yet hotter still. Or, maybe bit less of a blazing cauldron (at least) than what prior models have predicted.

According to National Center for Atmospheric Research projections, Community Earth System Model 2 (CESM2) implies more impactful heating *may* come about, sooner too than forecast by 20 prior models. So scientists in 2022 aimed to re-work CESM2. More granular, sophisticated than prior models, a bigger amplification that it saw as perhaps possible from clouds, maybe, should be, rather a bit worrying. Clouds may reduce heating (yay) or instead supercharge it – so getting clouds' complicated impacts right, is of the essence. Like methane and the GHGs besides just carbon dioxide (CO_2) – these consequences could be on planetary-scale.

Past brute models have been somewhat right - even if they've at times *understated* heating. A look at 17 basic models, used 1970 to 2007 showed pretty good overlap with what was soon after actually seen. Still modeling clouds, due to complexity, vexes. Older models expected that if CO_2 levels were to double from start of industrial era – going from an earlier roughly 270 ppm, to 550 ppm ahead (where we're fast headed with CO2 already at 420 ppm), then we'll all be baked soon by between 2.7 degrees F - and 8 degrees F (1.5 C - 4.5 degrees C).

But a new CESM2 implies a nearly-unbearable 9.5 degrees F (5.3 degrees C) baking is possible, a result of doubling+ CO_2 – this partly due to clouds. Nearly one-third higher temperatures, than prior models implied, so getting accurate modeling was of no small interest in 2022. This 9 degrees F would feel many places like a furnace. Upon accuracy of climate models then, much may depend ahead. And its an entirely different way to forecast what may be, than looking back in geologic time to when CO2 levels were roughly similar, and determining what temperatures were like then. (Maybe it's back to Pliocene, then Miocene for us)! Either way a transitory heating we may feel in a first century or two at 550 ppm, can pale to a hotter equilibrium unfolding over several millennia. With rising seas discussed ahead.

That's why a review of 39 climate models, that found 13 newer ones showing much higher heat ahead partly on impacts of clouds, was potentially (quite) troubling. This 'wolf pack' of outlier results hasn't matched actual temperatures – so models were reworked 2022. And UN climate assessments have stayed away from high heating predictions, given that uncertainty. But a concern has got to be, what if these latest models prove even partly right. To say nothing of an unstoppable melting of permafrost, or undersea methane or clathrates.

Markets & public policy have brought greater look at global new energy innovation – than was seen at turn of the millennium (some two decades ago), or even one decade ago. Companies in clean/new energy have also seen greater market capitalizations. As a practical matter a market consultation Feb. 2022 resulted in a few changes to NEX Index Guideline, March 2022. Average daily value traded (ADTV) floor grew to USD 1 million for new components Past 90 days; and USD 750k for existing components; screens included UN Global Compact Principles. These are noted here for the NEX, https://cleanenergyindex.com/about_nex.php

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Let's turn to stocks & clean energy; and perhaps to reasons 2022 opened rough for equities. Broadly, investment banks were already late 2021 predicting sparse profits for all 2022. Earnings targets for S&P500 firms foresaw 'lower-highs, lower-lows'. Take newish S&P500 component, Tesla: its huge market cap was among S&P's biggest when it entered that 500 (funny enough maybe hesitancy over reputational risk) yet it set a tone for 2022 as its brilliant head aptly expressed concerns over supply chains risk lasting a whole coming year.

A high end 2022 estimate for S&P500 was just +9.1%, other forecasts were flat, even negative, like one that saw the S&P ending down -7.7%. Averaging late 2021 predictions of 9 major institutions, saw a puny +2.8% for 2022. Causes for the dismal pessimism importantly weren't transitory either; such headwinds could turn out to be sticky across the year.

Partly it was that valuations began 2022 very high. Late 2021 S&P500 price/earnings (PE) ratio of 27.2 maybe meant more likelihood of falls, room to plummet – than gains. A very high 27 PE hadn't been seen since a tech bubble - and we know how that had ended. To expect future earnings, would surely justify such a very rich PE of 27, was maybe a fool's errand.

Back in 2019, there'd been good reasons for optimism ahead on earnings & growth. S&P500 profits hit a record. Government stimulus about to flow due to Covid. Profits jumped +25% to new record. But those operating margins soon hit a plateau. By late 2021, there wasn't the room for such prior rates of growth, as were seen only a couple of years earlier.

2022 pessimism backed by metrics, like a cyclically-adjusted price earnings (CAPE) which hit 40. CAPE since 1877, had only hit 40 once-before – in dot.com frenzy and again we all recall how that ended. Back when S&P dropped a total of -40% over a long 3-year dot.com decline, it would then be another 13 years until the S&P again reached its prior level.

Another broad headwind, the rising interest rates that can, & will kill risky equity themes. Not long ago, investors got near Zero percent for bonds - for years. So there was demand for higher-risk themes, better-returns (at times) in volatile themes like here. But if lower-risk alternatives could boast respectable rates - then eg US Treasuries, corporate / government bonds can find a flood of available capital looking for a smart place to call home. Real rates 2014-2018 had meant inflation-adjusted 10-year Treasuries yielded expected +1.0%. They fell in Covid emergency to eyebrow-raising *negative -1%*. PEs shot up from a near common 21 – to a high 27. CAPE went from 20s - to (wow) 40. On rate hikes, reversion to mean can be very bearish for stocks, especially here. All maybe were fundamental points early 2022.

If a threat 2022 was not of unprecedented inflation (given it was so awful in 1981) – then maybe it was terribly high inflation taking root, growing hard to kill. Inflation is partly a state of mind, partly psychological. If expectations take root, it can be persistent, hard to knock down. Combine rising rates with stagnant, or sluggish economy (stagflation, slugflation) and Fed Rates tool gets wickedly un-useful going into recession; no central bank wishes to hike rates going into a recession, economy cooling. And equity-risk premium of holding onto stocks (vs safe bonds) makes equities a decidedly less happy place. As interest rates may rise, money becomes no longer free. High rates are something a younger generation may not viscerally remember. For over a decade going to 2022, no G7 central bank had put its rates at above 2.5%. But back in 1990, they were all above 5%. Broadly then 2021-early 2022 was maybe not so good a time for risky, volatile, high PEs themes like green/technology.

Thus, compelling forces were pushing themes (green too) broadly down hard early 2022 like: *A fierce Inflation much worse than Fed initially recognized; so *Rising Interest Rates all 2022 that can hammer themes reliant on future income; and *Capital Shifting towards Value & risk-off; thus *Re-Pricing Risk, and External issues too like *war in Europe, tensions in China/ Taiwan. In sum the *End of Liquidity too sent clean plummeting. For a theme as volatile, as risky, as dependent on future earnings as ECO & NEX, it was all a poisonous setting.

Made worse early 2022 by factors more narrowly in clean energy. A key US Senator eg had *Just Declared late in 2021 that a huge reconciliation bill that might have brought $550 billion to clean energy & climate … was Dead! Slimmed down, relevant tax credits might just perhaps be resurrected in 2022, re-introduced for climate – or perhaps *Not*. *Inflation too roiled and had hit solar & wind & EVs hard - after a decade of welcomed great price declines. Plus, *even progressive California along with sunny Florida were considering reversing their residential solar incentives – which could thrash rooftop home solar in both key States.

All dour. Changing topics to lighten mood, coincidences may be seen *looking back in time, only*. For example, ECO had hit a prior high on Dec. 26, 2007 at 297 (297.05 close) – just coincidentally its next intraday peak, Feb. 10, 2021 proved near-ish that: 287 (286.89). Or, passive ECO in going up/down last 2 years had twice plummeted by a strangely not-imprecise ½ to a nadir low in both 2020 & 2021. Thus, in calendar 2020, it fell by nearly neat -50% going from a 94 intraday high (92.53 close) – down to a 47 low (47.37 close). Afterwards it rose 6-fold from 2020 nadir to February top. It 2021 again fell by unambiguously coincidental -50% from a peak 287 high close (286.89 intraday) in February – down to a 142 low close (142.39 intraday) late in 2021. Both again just by chance, seen looking *back* only at these data. Oddly 2 rather-not-imprecise consecutive declines of both near a 'perfect' -50%.

Just spotting coincidences in data rich past, is meaningless looking forward. Does though point out how volatile ECO is – like down -50% or more even in big gains years! Take say, a non-calendar 12 months from end Q1 2021 – through end of Q1 2022. The Q2-Q4 was mainly near a 150-200 band; from a peak April 1, 2021 at 211 close (211.09 intraday) – followed by 12 months to low nadir at similar bottoms on Jan. 27th & Feb 23rd remarkably both 107 close and 102 lows intraday. Huge volatility. (And come to think of it, funny how 2 very similar lows were both not far off a neat -50% from 211 – to 107 again)! Then February 2022, the invasion of Ukraine sparked a brief +25% rally up in clean energy. But to cherry-pick these data is NOT predictive. Only bit of fun looking back, to see coincidences playing with ample past data. As Mark Twain had so humorously & aptly put it, "Lies, Damn Lies, and Statistics". Playing with ample passive data is really more a parlor trick, of no real help when looking forward.

Hence one mustn't read too much into all that, other than to confirm the great volatility here – and frequently down. Like Jan. 2022 alone, ECO fell a nearly neat -30% in blow-out selling month (post reconciliation bill's death). For sure, no predictive value in ephemera. Might only lend a bit of attention to an age-old notion of 'enter on dips'. Lastly just for giggles, let's say *if* year 2022 high remains 154 peak (154.41 intraday) seen early 1st week on Jan. 4, 2022 - then a hypothetical 3rd calendar year fall by ½ - could then (playing here) - take it to a nadir neat 77 in 2022. Any realistic nadir's possible of course – and all the maths indicate it's very, very unlikely to be that figure! (That would be a level seen Summer 2020 for a quite bearish look – yet it could go lower still – say on global events like larger war, soaring inflation, and/or big recession). May be interesting to see where that 2022 low nadir in fact, will fall. Highly unlikely it's to be near such 77! There's simply No Telling at all, looking ahead.

From 2021 through Q1 2022

2 Big events overshadowed Q1 2022: more recent was war by Russia on Europe's Eastern flank – impacting the world. Something not seen in a generation; once it invaded all Ukraine beyond Crimea/Donbass, with that 'all hell broke loose'. In just a few days, the ECO Index jumped +25% from intraday low 101.64 on Feb. 24th (cusp of Invasion) – to 125.79 on Feb. 28th. Then went higher. Maybe on re-assessments done 'round the world – especially in Europe and Germany on speeding up a transition to renewables and the alternatives found here. Energy security too: 13 European nations were dependent on Russia for over 1/3rd of their oil.

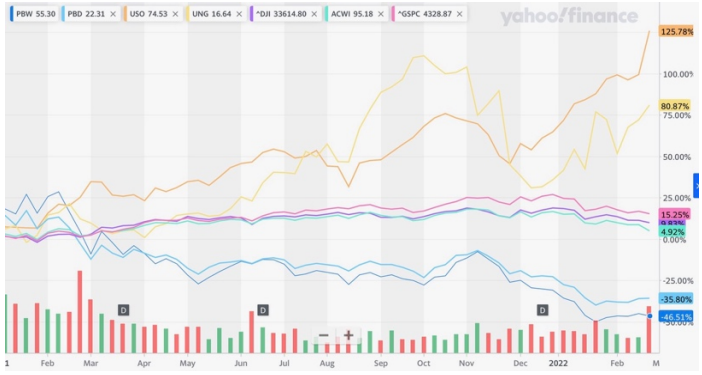
Among global intelligence assets who'd watched in the weeks of run-up to war, there were warning signs. To wit 1-2 months prior to its invading Ukraine, Russia moved 3 large LNG ships to its geopolitically vital yet stranded territory of Kalingrad Oblast on Baltic Sea. Natural gas piped from Russia-ally Belarus (or Russia) first needs to go via Lithuania to reach Kalingrad – preventing Belarus/Russia from possibly shutting-off gas to Lithuania. So if effect, by their re-positioning 3 ships to Kalingrad, it gave Russia a new option to potentially sever gas to Lithuania should it seek to do so, while leaving Kalingrad with 4-5 weeks of needed gas.

Militarily-vital outpost Kalingrad Oblast lets Russia alter an equation of NATO's power in its backyard. So it was notable Gazprom sent 2 LNG carriers, Energy Integrity, Velikiy Novgorod – as well as a big 3rd LNG vessel – that can also convert LNG to needed gas. Maybe not too surprising vessel Marshal Vasilevskiy launched 2019 went there Jan. 2022; it's named for the Officer who'd led Soviet recapture of Kalingrad in WWII and it fits there well. But until just before then, it was being used instead to carry LNG from Russia Far North, to Asia. And Integrity travelled twice a distance in getting from Cameroon to Kalingrad, as was possible to instead reach other destinations. About half that Cameroonian gas had been sent to China instead in a past two years (and only 2 of 58 shipments went towards Europe, both to Turkey) so it was all unusual. Having moved these 3 LNG ships to Kalingrad just before invasion, meant if a conflict goes beyond Ukraine unintentionally or otherwise, then Russia could (if sought) keep strategic Kalingrad Oblast outpost about 4x the size of Manhattan, militarily significant, well energized with its ample gas supply for several weeks.

Responding to start of war, Germany moved at once to start to end reliance on Russian gas. Both Germany & Russia earlier had promised Nord Stream II was solely a commercial project – not any political leverage at all – yet war proved it to be the opposite! So Germany drafted new plans, bringing forward by 15 years its aim to be powered by renewables, now by 2035. To achieve this dramatic shift, Germany abruptly started planning from 2022 big increases in renewables. Its solar capacity might be growing annually by 20 GW latter decade; onshore wind grow annually by 10 GW. Its offshore wind capacity starting from scratch, was next slated to hit 30 GW by 2030, 70 GW by 2045. Germany's Green Party with a clear voice in the new government was willing to see 2 big port LNG terminals be built near-term, in order to achieve very deep, long-term 100% renewables goals. While some then criticized the Greens for this, they arguably had made the right call: given that its nuclear was being all shut and coal ratcheting down fast, something needed to fill that gap as vast new renewables got built. Hence attention to both filling gas storage, and access to LNG, 'til renewables fully take over – when such natural gas dependence and nukes could be removed entirely.

The second event – was fossil themes natural gas & oil jumped this period unlike anything in recent memory. All at a time clean renewable stocks were declining sharply; from January 1st (Q1) 2021 to late Q1 2022, the passive ECO Index had dropped by a neat -50% to its low-point nadir (and as we've noted, the coincidences of falling by a pretty precisely -50%).

The clean energy & climate solutions stocks theme has been longest, arguably best captured by ECO & global NEX. Here the 2 are seen vs. other relevant themes 2021 to mid-Q1 2022. Interestingly a new situation presented itself in these ~5 Quarters to early 2022: unlike a past 5 years, or the past 10 years etc, here clean ECO & the NEX *were clearly at bottom*. *Down by* -46% & by -36%. As seen in Chart, middle were Dow, S&P500, and world theme up +5 to +15%. Very top were oil & natural gas to mid-Q1 (March 5) 2022: oil was hugely up by +125%, and natural gas was up by +80%. Oh my, what reversal it was from what we've long seen!



Source: finance.yahoo.com

As we'll notice ahead in stepping back, this only happened after very long, very steep falls in all 'fossils' (fossil fuels). So that probably should be taken into account. Too in 2021/early 2022 inflation & rising interest rates had hit speculative clean energy themes very hard. Whether there's any reversal ahead more like the past with fossils falling – and a clean theme maybe rising – is yet to be seen. That, doubtless, will be a keen topic in Reports ahead.

In sum 2021 to early 2022 clean fell hard, as passively reflected in themes dropping steeply – back to where they'd been 2020. Meanwhile, fossils jumped in a (possible) energy transition being characterized by much volatility. It showed too energy prices worldwide are still dominated by fossils: oil, gas, and coal – and there's deep issues persisting in all fossils which accounted for most turmoil seen across volatile-energy in 2021 to early 2022.

Energy pricing tends to reflect the 1 fuel most crucial to supply – and for grid stability. Rather like income tax rate reflects the very highest marginal figure paid on very last dollar earned. Here, natural gas was key, and as its price spiked worldwide – energy costs did too overall. Even US electricity still made from coal, rose +22% in sympathy 2020-2021, a one-off. More energy crises will doubtless recur even if renewables' costs rise a small bit - or hold steady, or decline as we'll see pages ahead. In sum, fossil pricing *rose* hard 2021-22 – after long deep lows. Prior years, green themes oft did better than fossils. That changed here as oil, gas, coal - admittedly all coming off their years of very deep lows - instead jumped.

To underscore boom & bust cycling, it was only *after* fossils dramatically plunged 2020. Only *after* US coal production had hit 50-year lows, 151 mines were closed or idled. Only after oil hit historic lows in 2020 on global Demand Collapse. Oil industry needs oil at least in $60s, so oil down near 'just' $50 per barrel 2020 had punished indebted shale producers, $40 oil means misery ahead for oil producers, whole countries. Equities are inherently forward-looking thus oil's volatile theme in 2020 hadn't then been attractive for investment. It was only after first big supply cuts/shuts downs + then renewed demand discussed ahead that fossils rose in 2022 to over $110/barrel on supply constraints - and if Russia occupies Ukraine for a time, it will be no surprise to see key Nord Steam I gas pipeline sabotaged). At any rate spiking gas may again make renewables relatively more attractive ahead - vs. gas or coal-fired power.

A key point to be repeated, is that *Costs for solar/wind electricity by contrast can go & stay very low at times, naturally.* This is a characteristic, indeed a key trait of renewables. Oil by contrast, faces make or break price floors beneath which its industry suffers. Oil busts mean lost capacity, jobs, non-producing wells shut in like 2020 when oil saw no floor. What changed dramatically, after demand destruction – was a demand rebirth. It's aptly said that 'the *cure for cheap oil, is cheap oil'* - and thus lo and behold, fossil prices jumped in 2021 & 2022.

Said another way, were a prior 100m+ barrels/day of oil still supplied in 2020, then that could have prolonged collapse. As for coal, it's no longer tracked by an ETF, no new coal plants are being built in US. Yet demand for coal/and prices jumped by +25% in 2021, mainly on overseas demand and a gas crunch/price spike 2022. US coal economics are dismal, so miners look to where it's being burned; here Asia (even again Europe) had a huge appetite 2022. Today, the fact that America's own domestic coal supply had once been last century's cheapest, dirtiest and most stable source of electricity, suddenly is no longer much in its favor.

Discussed ahead too so just touched on here, is fast-growing greenwashing by fossil interests. Much hype for 'blue hydrogen' – though methane leaks render H_2 (hydrogen) from gas about as awful as burning gas directly - and Russia's 2022 invasion may have killed 'blue H2' in Europe. Yet electricity from gas will still be huge in US & China in 2030. Given climate crisis that's a huge worry, as is burning any coal. Rich Europe *may* 2030 have reduced gas-use sizably – nukes & coal more so (with big stumbles like acute gas shortages discussed ahead). But by end of 2021, China hit a coal record, mining 385 million tonnes of coal, walloping its previous monthly record for prior production 2021. A new record, up +4.07%. Global coal grew +9%. More coal use gained in 2022 as natural gas costs rocketed. Even in rich US/EU, coal made more electricity than a year before. A result is Western Europe, notably Germany, *may be* getting 50%+ of its electricity from renewables by 2030. Yet conversely, the fact 2 of world's 3 biggest blocs mostly still rely on non-renewables at end of this decade, looms large.

Another issue discussed ahead has been a possibility of China forced labor. Horrid to contemplate, it did lead 2021 to a Withhold Release Order by US Customs. Any solar products even possibly made on forced-labor-tainted sources, are wholly unwanted. Thus, panel makers and others must carefully address supply chains. Tracing these supply-chains can and will be done but takes time & effort. Or some solar panel makers may choose ahead non-China polysilicon to manufacture their products – even for panels built right in China.

Change is afoot. Sometimes at swifter pace than expected. Maybe an EV + battery + solar firm writes software to allow it to harness deployed PV systems to sell power directly – competing with Utilities. Maybe a spiff electric aircraft firm challenges a past hegemony of fossil fuels, for more efficient air transport. Or cleaner power for ships. Perhaps batteries made for less-cost & on lower-carbon lithium, sodium, graphite. 'Greener' rare Earths in wind, EVs. Likely, recycled batteries, improved anodes/cathodes, circular economies. But given that CO_2 levels already were over 410+ ppm and growing fast, there's no realistic possibility of holding global heating to 1.5 C aims let alone 2 degrees C. Climate emergency is a certainty ahead.

Thus, all the above may be very welcome & necessary - yet nowhere near fast enough. With some irony Russia attacking Ukraine, the threat to Eastern Europe – may mean a new 'Marshall Plan for Energy'. Building new solar, wind, green hydrogen; though it comes with more LNG terminals and nuclear power – a compromise even Germany's Greens may accept. Of course the cost from more natural gas in particular, is a climate opportunity, lost.

A year 2021 had been wracked by record heat, drought, storms, floods. Yet in just a few decades or even sooner, people might look back at 2021 with all its miserable heat, floods, bitter cold, hurricanes, rapidly disappearing sea ice and start of rising seas - as having been part of a cooler, more stable, much more desirable past. One that can never be recovered.

Data from 2020-2021 made clear too there never was any hoped-for 'green recovery'. No post-pandemic moves *away* from fossils, since CO_2 emissions first dipped then exceeded pre-pandemic by over 5%. Then got worse 2021 & 2022. From climate perspectives we're losing badly. Climate facts so far, are no cause for optimism. Not this decade, nor century.

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

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

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

Progressives weren't concerned over pay-fors. Nor the $3.5 Trillion reconciliation size. For them new taxes on wealthy worked fine, or deficit-spending like by conservatives to cut taxes. They'd noted blood & treasure were spent on wars without benefit. They feared their own party's moderates were too concerned over pay-fors, not enough on climate – so might go for a smaller $1.2 Trillion bipartisan bill only. Moderates won a vote deadline on the smaller bill, so there was tension late Q3 to agree on BBB bill too. Liberals aimed for $3.5 Trillion top line dollar figure – not wanting a lesser $1.5 - $2 Trillion hinted at by that coal state Senator who resisted naming a final $ figure. US Debt default also grew possible – so shutdown. End of Q3 it grew self-evident any BBB figure would be well under $3.5 Trillion, so there was choc-a-bloc uncertainty. All got pushed into Q4 - when a deal might finally happen near Christmas - or it might all fall apart. If BBB died, there'd perhaps be a narrow lane to resurrect parts say as pro-clean energy tax credits in a more piecemeal fashion later in 2022.

Were just a $1T bipartisan fossils-heavy bill all that could pass, that was worse than nothing to many progressives; so several wouldn't support that. Progressives' leverage was to link the 2; they knew several moderates sought $1T on roads & bridges, maybe 'carbon sequestration', 'advanced nuclear' too. Many progressives were willing to deny that, to get reconciliation done. One progressive leader felt $6 Trillion BBB was right given scale of problem, new taxes and/or deficits could pay for it and $3.5 Trillion was already a compromise. But such leverage was challenged late in 2021 by a real possibility of perhaps No Deal on either.

Meanwhile, conservatives no-doubt had enjoyed that moderate's call to pause BBB. They also could threaten to Not raise US debt ceiling, historic US debt default, shutdown. It came to: whom would blink? All sides would perhaps be getting less than what they'd wanted.

While the infrastructure in that moderate Senator's state was poor, their willingness to wait, or move goal posts meant BBB's window would soon close. Finding a sweet spot soon on $$ size was key. All agreed Infrastructure = jobs. That Senator as a Committee Chair had helped sculpt the bipartisan bill, so desired it. Goodies could also make much possible (recall Bob Byrd?) bringing moderates off fence. But, could $1.5T reconciliation BBB *also* happen? Or, just smaller bill only? Might internal dissension in liberal party sink both bills/all!?? Progressive members were arguably wise to try to hold to all or nothing – as there was 'nothing' for climate in roads and bridges Bill. And yet infra-party dissension could kill both. All came to a juncture just before G-20 meeting, then 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 – win unanimous support needed? Progressives had felt it should be all, or nothing. They saw $1T Bipartisan bill as wedded-to fossil thinking, baby steps only, no answer. Several would thus vote No if small bill was all on the plate. But 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 now on a $1T Bipartisan now – and more compromises on a $1.5T BBB (yet maybe falling apart) was a nub of it.

Had a $3.5 Trillion progressives wanted won out, an analysis had shown 7.7 million US jobs might have been created in clean energy growing US economy by $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 a very start of this decade in clean power this way - could both have saved money, and have made clean electricity *much less-costly* than dirty fossil fuels.

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

Several House members were unable to support it, consistent with concerns they'd long voiced on climate. Thus, a dozen or so conservative Party members were needed to vote for a $1.2 Trillion Infrastructure Bill to pass. Though it was not relevant to climate; just some $ for electric buses, EV charging. Climate action instead remained in a draft, mired down stuck BBB bill along with big social-spending programs; no breakthrough there at all.

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

Shorn now of restrictions, no sticks to cut coal, oil, or gas, those 3 could instead go on being burned pretty freely under a much-slimmed BBB without utilities having to scale back. Gone was $150 billion in clean energy performance goals & penalties on carbon; removed. Bulk of the plan to clean up US emissions were shorn off, a blow. Efforts to keep a few sticks, like needing fossils to use 'carbon sequestration' weren't successful: that 1 Senator recognized 'sequestration' was mainly just a marketing fudge. Nowhere was it actually cheaply reducing carbon from coal, oil or gas – so keeping it, wouldn't have actually helped fossils.

On the other hand, opportunities remained for some progress. Much could be done ***for*** clean energy like via tax credits; new incentives to grow clean energy faster via carrots alone. Still, just 1-2 Senators held back massive legislation. That implied if a liberal Party gained 2 Senate seats in future it could be disproportionately impactful ahead. But it's Not at all likely; traditionally, President's Party loses seats in midterms. Still, it's extremely likely climate emergency isn't going away. And public sentiment may change. Even a few Senators may one day break from other side of aisle, supporting some climate action. In other words, the future likely belongs, if only eventually, to acting on climate this decade. As wilder weather, and escalating costs of doing nothing, climate *inaction* – get more bitingly clear.

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

For instance, that 1 Senator had upended a proposed rule based on science that would have tamped down on methane at last – a greenhouse gas (GHG) being released to air like an open sewer. Methane is a far more potent GHG, than carbon dioxide/CO_2, so might have prevented 168 million metric tons equivalent carbon dioxide. That could have been like pulling 36 million gasoline-cars off roads. (We refer interchangeably - to 'carbon' - or to 'CO_2' - given latter's atomic weight is about 12 atomic mass units (AMU), oxygen is 16 AMU, so mass ratio one CO_2 molecule to one carbon atom is roughly 3.67). The point here is that just 1 person had killed a major draft methane rule and that big BBB bill. Plus, had killed off other draft GHG sticks too that had made scientific sense, and could have been impactful.

Trying to keep hope alive, revenue pay-fors were suggested to cover $1.5T BBB cost. Instead of eg, raising taxes, or capital gains rates, novel tax scenarios were discussed. One idea was a 15% minimum corporate tax floor for American companies, given some had avoided paying any taxes. That could help get to the revenue-neutrality moderates demanded. Also raised – and rejected was an unprecedented tax on unrealized gains of the very wealthy (could one deduct unrealized losses?); this idea might be unconstitutional given a 16th Amendment's requirement of realized income. Instead, that 15% floor idea had nicely steered clear of increasing traditional taxes, cap gains, or on unrealized income. In draft form it was joined with a proposed new surtax on very highest earners, maybe helping pay down the Debt.

1 US Senator had ensured at least in 2021 there'd be *No new sticks, hindering fossils left unfettered; *No traditional Tax Hikes passed to pay for climate programs, and *No Big climate moves in that year. Nor huge bill/s likely given 2022 elections calendar. Maybe a narrow lane for just piecemeal bits of BBB's tax-credits ITC/PTC in 2022 before Fall elections. Any bigger US green omnibus actions – might then be put off to 2024 or after at the very least.

Fury over how badly a reconciliation BBB had been eviscerated in 2021 was immediate. Hyperbolic-sounding criticisms fast sprung up, such as that just 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 visible influence on the geologic record, can normally be laughed at as no chance, just hyperbole. But climate is unique, and singularly different. Worryingly, such critique *ought to have had* zero chance of being right. Terrifyingly there was just maybe, perhaps, non-negligible, non-zero risk that it might turn out true.

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

Back to politics, biggest greenhouse gas emitter China said it wouldn't show at COP26 in Scotland. After prior outcry that China's 5-year Plan wouldn't start reducing coal until 2030, they'd upped ambitions aiming to peak coal sooner. But since then, taking initial steps away from coal - China was hit latter 2021 by severe energy crunch. It grew less certain they could keep to peak pre-2030 aims. Plus given rich nations had failed in their own $100 billion commitments to transfer funds & know-how to a developing world to help them reduce carbon emissions, there was this little reason, developing China, India, Indonesia etc felt to offer more. Besides leaders of Russia, Brazil, Mexico didn't even show up at COP in 2021: they likewise were hardly enthused then about COP26 calls for 'cuts' soon in carbon.

Anyway, most all nations remain fossil-addicted. Despite flowery words to contrary. Not just usual China, India, Russia, Saudi Arabia, Qatar – but rich G-20 polluters too that self-proclaim virtue like US, Japan, Germany, UK, others. All of whose addictions were at odds with prettier promises at G-20 events and Climate Conferences. As HRM the Queen of England so wisely and aptly remarked in lead up to COP26, it's irritating the way global leaders "talk", but "don't do." Private industries are more of the same. Like state-owned fossil firms offering vague promises, glossy blue hydrogen ads, talk of distant 'carbon neutral' in distant 2050 – all conflicting with pressing CO_2 reality. This COP26 that was only days after the G-20, and all failed regardless of any just in-draft and 2021 fast-dying in US, BBB legislation.

For 3 reasons, the 2021 COP goals, were tougher than an earlier, more-vague Paris Agreement. One, was rich nations' big 'commitments' of $100 Billion/year for developing nations were easy to mouth at Paris – but far tougher to actually start mobilizing at Glasgow. Two, making global carbon market rules was proving tougher than just talk, like a US Congress flailing on disintegrating BBB. Third, and most blatant, cuts big enough to keep to 'just' 2 degrees C heat – let alone to 1.5 C - were obviously far deeper than what nations were in fact prepared to offer at COP26. Commitments on offer were far short of 2 degrees C. And 1.5 C via 45% *fewer* emissions by end of this decade, that was a bridge much, much too far. Consider that simply adding up all 2021 commitments at COP26, meant emissions if followed would drop by oh … ahem, *Nothing at All!* Instead, they'd go Up, by +14% *higher* – even on best commitments of 2021. For example, while Canada had increased ambitions that it had offered COP26, its new 'tougher' goals remained so lax, they'd still mean 4 degrees C further heating.

Physics & chemistry give us a total carbon budget, for how much emissions can yet be spewed. If our climate crisis is to not go past 1.5 degrees C heating, then total future allowable human CO_2 emissions are 400 billion – 450 billion tonnes. Yet on current trends, we'll pass that max carbon release 'speed limit' in just 10 years. It's laughable to think we could go 10 more years – then switch off all our CO_2 emissions at once. Over a century ago, Svante Arrhenius (with Arvid Hogbom) had determined the How, and Why, a big then-forecasted 3 degrees C rise in global temperatures might result from each 3/2 rise in CO_2 (a ratio since refined, but principle is the same – along with more heating at poles than equator). Linear increases for the first, means by a power law for the second; temperatures vary as a logarithm of CO_2.

As for BBB, end of 2021 had brought it to a head. Either more compromise – or likely failure. Senate Parliamentarian would have to agree too all items are spending-related, a 'Byrd Bath'. But before that, its scoring/spending had to be looked at carefully by that 1 'moderate' Senator – whose vote was necessary. Things didn't look good at all. To cut big spending estimates some Programs were simply re-written pared back from 10 years – to a 3-year sunset (even 1) hoping some future Congress renews it. Reduced top-line costs, but those weren't real cost reductions that 1 Senator had demanded. Fearing social spending would stoke inflation, this defanged BBB also still could still hurt fossils, so dear to that 1 Senator's heart. Thus, it looked like that 1 smaller bill only, already passed, might be all there was 2021.

Even as eviscerated, a $550 Billion draft BBB would have gone farther than ever before on climate. Partly (though arguably not fully) paid for, it had firm revenue raisers that needn't have relied on raising regular taxes, nor capital gains as feared by moderate conservatives. Arguably it was a hugely missed chance late 2021. A loss, given what the bill might have been. And it might have finally started to take overlooked GHGs like methane more seriously.

What 2021 BBB considered, was perhaps a bit of a roadmap for attention ahead: *renewables; *EVs; *low-carbon-fuels; *tax advantaged Master Limited Partnerships (MLPs, once just for just fossils, here could be clean energy too). Low-CO_2 hydrogen might have gotten a tax credit of $0.60-$3.00/kg depending on carbon avoided, so not just green H_2 - but fossils-derived (blue) hydrogen too if carbon 'captured'. Electrolyzer-makers might have gotten hydrogen tax credit boosts. Provisions for smart glass in ITC for US OEMs (helping them with warranty accrual overhang). And if the BBB still failed late 2021, as in fact happened - it looked as if a narrow lane perhaps existed for some energy aspects to *possibly* be resurrected 2022. In all, draft BBB language though it died, helped show which way the wind was blowing.

That draft text had implied 10% more ITC help if a project had 40% US-manufactured content; more on US steel helping US solar tracker manufacturers. Residential PV could see a 30% ITC, renewed for longer periods; trackers, inverters also aided. Interestingly the ITC could grow if projects were located near former coal mine sites shut since 2000, or coal power sites shut since 2010. Maybe a 45Q tax credit for 'carbon capture & utilization', or for direct air capture. As for proposed Federal methane fees, those might have been mitigated by new EPA grants - even for big oil & gas companies (for an ever-unlikely flank of added support).

But late December 2021, that 1 US Senator declared BBB 'Dead'. No great surprise, as that Senator had criticized its size, scope, direction, especially huge social spends outside energy/climate, and Pre-K, from the start. It proved Progressives right; their Party ought to have kept linkages between smaller bill that Senator wanted - and BBB intact, for both. Still many objections voiced by that Senator were over costs of social aspects – unrelated to green-energy text. More about non-energy costs (and EV credits) in enormous omnibus-like bill. So, as in 'Princess Bride', maybe it wasn't all fully 'dead' – just 'mostly dead' 2022.

It's pretty easy to imagine bits of BBB text revived within limited legislation ahead. For example, tax credits for solar & wind could be put in separate bills or tax extender packages in 2022. Maybe old criticized text that singled out help to union EV makers – but did not help a big EV manufacturer in Senator's home State - replaced with more signable text helping all EV makers. For clean energy, arguably one path might be to Remove All energy Subsidies, including for fossil energy; maybe movement there much later ahead. But clearly, here in the US, clean energy momentum 2022 was hit. Think then of energy leadership elsewhere.

Think of carbon linchpin China. So wedded to coal it had resisted speaking at COP26 of a coal 'phase-out' – rather only of a 'phase-down.' Yet possibilities there ahead for solar power are immense. China, more than anyone, can make vast solar growth happen. Reminiscent of a US mobilizing in 1941 for war. By 2021 China already had 250 GW of solar power capacity, nicely 2x that called-for in earlier Plans. It could boast that 1/3rd of all global solar capacity being commissioned, was for its domestic China demand, reverberating benefits planet-wide.

Consider what's possible high end. In theory, if all China's areas that could easily have solar, had it, mainly sparsely-populated northwest (most people live in southeast), then a 'technical potential' of all its solar in 2020 was to make 100 petawatt-hours. That would be 13x all of China's then total 7.5 PW/hr electricity demand (2x then-Total demand all energy including heat). By 2060, as solar panel efficiencies improve, its solar potential might rise by +50%, to 150 PW/hr when China is planning for net-zero emissions. At least ½ its potential solar-area was already capable of PV being cheaper there, than coal in 2020. 80% can be cheaper than coal in 2022. As solar improves, by 2030, solar can be cheaper than coal across all China!

China's solar costs had averaged 4.93 cents/kWh in 2020. That projected cost can drop to 1.3 cents/kWh by 2030. Then, as solar goes on getting cheaper – down to 0.3 cents/kWh by 2060! And if a price is put on coal pollution, say carbon tax, that cost difference gets immense. So coal can't compete ahead; all sides know it. But coal has meant jobs, & it's been firm, dispatchable, uninterruptible vast domestic power that nation has needed. Solar hobbled by intermittency, dearly needs energy storage. Put the 2 together, storage + solar can grow 100% dispatchable and 2030 it's projected that 5.2 petawatt-hours of such solar-with-storage might be available in China. All cheaper than dirty coal too – vs. 7.5 PW total demand.

By 2060, solar+storage could be making 7.2 petawatt-hours, or nearly half China's electricity demand then - met by sun. Complimenting that, huge wind both onshore & offshore, geothermal etc that could meet all needs. Still, there's great challenges to such a ramp, especially in raw materials that pinch. Battery designs that need say, cobalt, may hoover up 36% of world known cobalt reserves (on older battery designs). Thus, if better new batteries don't need any cobalt, discussed ahead, it all gets much easier. Even huge lithium needs might then be 'only' 8% global reserves. Hence green alternative technologies, can be crucial – and myriad ideas are just beginning to blossom, requiring fewer costly raw materials.

Thus material availability & tech maturity, like cost & efficiency considerations, all impact choices. Look back some 6 years, it may have been propitious then to have 'gone into photons' – that is, to have invested in a solar theme that rose afterwards. Later, post-March 2020 surging inflation meant commodities such as oil & gas did relatively well afterwards by rising in value. Looking ahead, yet another P, here 'protons' so risky green energy storage & energy conversion (fuel cells, H2 etc) *may* turn out a bit propitious one day too - but it's unknowable now especially given their huge volatility. What's certain, is that this 'protons' theme early 2020s *is hugely risky*; maybe much more so than was photons/solar 6 years ago.

Solar back then, was already steeply cost-cutting. On modern manufacturing it got ever-cheaper, like making is computer chips. But energy conversion is quite different: surely risky. More uncertainties given many breakthroughs are still needed, for protons (energy conversion) - vs photons where extant solar tech was already sharply reducing costs. Batteries/storage, have seen persistent, annual cost reductions 7% - 8% a year. Very good and helpful. But work on 'protons' early 2020s like green hydrogen, ammonia, methanol, is far more a wild card.

Another "P' is maybe relevant, but less susceptible to analysis: 'Politics'. Maybe a factor as ECO hovered 150 – 200 in Q2 - Q4 2021 on whether BBB might pass. That bill didn't, and so on BBB's 'death', on new inflation, rising interest rates, Fed tapering – things did fall hard, fast. In Q1 2022 with no floor like a BBB to keep the Index from falling much below 150 – seeing it fall to 100 in Q1 was no surprise. Yes, there was an expiry date on hopes for BB passage. When California/Florida proposed cutting support for residential stand-alone solar, and then even war, a floor that once held things perhaps above 100 too, likewise could fade fast.

That was *politics*. As for actual *work* of growing clean energy fast, inflation/supply constraints vex. Input material costs were soaring. As supply chains stretched on demand, inflation was far stickier than a brief 'transitory' case initially laid out by the Fed. Steeply rising input prices have been & are thorny for clean energy. Going from efficient 'just in time deliveries', to instead 'what if worry'. Take solar. If the US, Europe, and Japan are to wrestle back their PV manufacturing leadership that had shifted away in 2010s to China (we recall 20 years ago, Japan, US & Europe had dominated PV manufacturing and China was nearer zero) – then big changes are needed – fast. To contain rises like seen 2021 when European wholesale solar panel prices inflated +19%, back to prices 2018. True, that was still -33% below where they'd been 2016. But panel prices of 2021 were up 50% seen in euro cents per kilowatt, from where they'd been in 2020. Polysilicon prices had gone up 4x over a brief period 2020 to 2021.

If US wants to grow its solar from a meager 2-3% of its power in 2021 - to grander 50% next 30 years to 2050, any hurdles to expansion loom large. Think then of materials used in solar. Polysilicon is discussed ahead. But there's other key materials in manufacturing solar.

To fast ramp solar, one place to start is cutting costliest inputs. Take silver so costly in making PV panels, thus ripe for change as a conductor in PV cells. How better to reduce, or to better yet, replace dear silver with much cheaper plentiful copper. Panels 2021 devoured 20% of global industrial silver supply. In inflationary times, silver can be 15% of total costs of a solar cell. *Could* be worse, say on 'slugflation' (sluggish growth + inflation) or stagflation ahead. So to grow solar more swiftly, think then of displacing silver's thorny constraint.

For comparison's sake, in 2021 silver had then cost $750,000/ton – vs. copper's $9,000/ton even after copper's price increases. But obstacles to switching include copper's oxidizing; it's also not easily used in PV cells. Note then an advance might make copper better than silver. Testing on a new kind of solar cell with copper, had slightly better efficiencies, 25.5%. Whether large-scale PV manufacturing is able to use copper ahead, in place of silver, is yet to be seen. But it's clear, that many other diverse sorts of greener changes lay ahead.

Take buses, likely to see change. Typically a dirty smelly diesel school bus costs $150,000. A quiet electric school bus, by contrast in 2021, had cost a dearer $350,000. So only 1,000 buses, pilot projects on grants were electric in a national fleet 480,000 school buses. Think then of the 'smaller' infrastructure bill which did pass: it had $5 Billion, half for electric and half for low-emission (like CNG) buses. That could mean, schools buying perhaps thousands of electric buses ahead. Driving costs down sharply too, for future new EV buses to boot.

A big school bus manufacturer is Blue Bird. Half its 11,000/year buses in 2021 were dirty diesel. Other half burned alternatives, propane, gasoline, compressed gas, polluting & awful for kids and climate. It only sold a tiny number of clean electric buses: 775 in 3 years to 2021. Understandable given high upfront purchase costs. Yet low-maintenance electric school buses *may* be afoot. Moreover, with greater battery storage, new fleets of EV buses could be excellent backup to grid. Made cheaper still by mass production. Used some days maybe Vehicle to Grid (V2G) selling back power, earning schools' money, or emergency community backup power. $7 Billion for EV chargers. $ for hydrogen demonstration buses (electric too, in a way) in passed 2021 $1B Infrastructure Bill, means they'll improve faster as well.

Yes, there'll be many obstacles to getting cleaner. Arrows to be shot at, rocks doubtless thrown at green energy. Some claims will be contrived, by renewables' opponents, seeking to blame clean (wrongly) for power outages. Like Texas 2021 where blackouts at first were blamed on wind power(!!) – described ahead. There'll be times too when renewables can be criticized this decade. But, as coal declines, as gas falters – solar/wind aren't then to blame. That's because there *isn't yet enough* renewables + storage to make a difference. Wind/ solar/ storage are just starting to displace dirty; there's not near enough clean - yet.

Wind, yes, is highly intermittent. So much so, a lack of wind some months ('wind drought') can be rough. Yet that's early 2020s, near no clean energy storage. This is changing fast. In 2016 the world had passed a marker: 1 first gigawatt of energy storage capacity. 5 years later, 2021 the world had 12 GW of new storage capacity – as much new coming each month, as had been installed all 2016 year. This new storage capacity is quickening rapidly. So much so it's estimated that by 2030 there may be 70 GW of new storage capacity being installed, each year. Maybe a 14-fold increase in installation rates over that seen in early 2020's. Mainly it is batteries now, but new tech could bring far more. A 400 MW battery installed early 2022, then the world's biggest, can/should soon be regarded as just 'meh'.

For why natural gas storage is crucial, consider say a cold Winter in Europe. An issue began mid-2021 as Russia suddenly began to export far less gas to Europe, than typical 80 million cubic meters (mcm)/day. Russia first lowered its gas exports to Europe in July to 49 mcm/day. Then August, it dropped to just 20 mcm/day. Gas levels were already very low in Europe - in UK & globally. Why? Prior months Covid-driven supply shortages + weather volatility dropped gas supply worldwide. US hurricanes compounded it, dropping output. Net/net on a sharp loss of gas supply, & less storage - natural gas prices jumped. Europe lacks big domestic gas supplies, so it long relied on importing (cheap Russian) piped gas for electric power. As natural gas & so electricity wholesale prices skyrocketed in 2021, Asia was hungry for gas too; in no time it gave way to bedeviling gas shortages. And thus eye-watering high electricity costs - especially in a prostate Europe. Thus deep cold, or 'other' event, could create a crisis.

Russia's gas profits grew. But another rationale may have been at play. It's been suggested perhaps that export shortfall 2021 by Russia to spot markets was to help it win needed OK for Russia's Nord Stream 2 pipeline to Germany. Europeans for their part need uncontracted, spot cheap Russian gas. Alternatives were more gas from Nordics (in decline) – or importing lots more liquified gas LNG from overseas by ship - though latter means competing with voracious Asia, so high prices - and Germany lacked LNG terminals. Europe thus needed all the gas it could get 2021. Especially on a colder than usual winter, say 2023 or 2024. If sparse winds so less wind power, nukes down for maintenance, coal shuttered by emissions permits – Germany aggressively targeting 80%+ renewables by 2030 – it can get very tight.

Sparse winds 2021 did hurt Europe wind output – nukes were down for repairs, drought hit hydro-power. And UK had opted to reduce its gas storage capabilities greatly – before Winter's cold heating demand. All that combined so that late 2021, unhappy records were set. Europe's natural gas benchmark spiked up +300%. Gas futures in a key Netherlands basket rose past equivalent of $150/ barrel for oil. Then early 2022, gas rose higher past equivalent of $500/oil barrel(!). This all made natural gas prices in 2022 become the dearest fossil fuel by far.

Ireland's electricity costs late 2021 jumped 10x in a 7-hour period on gas shortages. Gas there was so tight 2021, Spain & Portugal electricity hit $165/MWh, worst since 2002. UK electricity prices briefly spiked 2x, or 7x a year prior; next day UK power jumped to $395/MWh. UK imported 7.5% of its power from France so a undersea cable lost due to fire knocked out 2 GWs firm power from France. On good breezes, like seen early 2022, UK can produce most of its power from wind, cheaply! But few breezes, UK wind capacity 24 GW - can fall to 1 GW. Europe's natural gas power – once was cheap – and Russian, - pre-war. By Spring 2022 Russian gas was suddenly black-hearted; Nord I may even cease. Replacing piped 150 billion cubic meters (bcm) with LNG gas from Qatar, Algeria, US etc – started 2022; 15 bcm of new US LNG, more domestic coal, nuclear. Aiming to replace piped 50 bcm with LNG infrastructure.

Past-simmering European fears of over-reliance on Russian gas once was waved away by how bloody cheap it was (making up 40% of Europe's gas, more so Germany). Until that blew up in peoples' faces. Literally. Approving Nord Stream 2 was maybe an intent in Russia's cuts, to build support for pipeline; but paradigms shifted fast first on fears Russia may invade Ukraine – much faster when it did so 2022. Just before, China, Japan, and S. Korea buying LNG had pushed prices >$15/per million BTUs. US gas rose too as all pricing is interconnected, from $2 mm/BTUs - to over >$5 – unheard of in a shale era. Europe's Market Winter gas demand competes vs JKM (Japan-Korea Market) – yet geopolitical urgency meant Europe was able to fill somewhat its gas storage to 30% early 2022. That, and mild winter 2022, helped. But all became much scarier on war. And still to come maybe a cold winter 2023 or 2024.

Clearly, war had thrust Europe's debilitating over-reliance on Russian gas in a sobering light. Had underscored an immediate need for More Renewables fast, from 2022. GWs *more* solar/wind - plus long-term battery storage were all needed for firm power. Lack of extant LNG gas infrastructure & storage vexed too – because clean hadn't yet grown to be big enough. In particular as Europe tries to wean itself off coal and reduce gas & nukes (though latter 2 may persist a bit to let grow renewables much faster) - wind & solar 2020s are at awkward stage. Growing yes, but not yet big enough to be the Hero. In 2020, renewables had made up only around 20% of Europe's electricity, so not near enough to overcome gas' failures, yet.

And a new hurdle: solar's recent price inflation after years of relentless price declines. Solar prices 2021 *rose* first Quarter over Quarter, year over year, in residential, commercial, utility-scale - not seen since analysts had started measuring this in 2014. Inflation wasn't just in solar of course, but until lately it had been 'unheard of' here. Causes included: fast-rising costs for aluminum & steel in solar frames & mounts. High silver costs in PV cells as noted. Pricier special panel glass. Freight costs way up for shipping PV product. Labor for assembly despite mechanized operations. Polysilicon from sand is basic building block; yet it saw cost increases of late. Like Europe, global solar panel prices 2021 had risen 16% over 2020. Increasing costs for inputs 2021 reverberated, and were soon felt 2022. Accelerating clean energy demand also seemed to be heading higher about a same time as well.

For US solar manufacturing, a key deployment target was to hit 45% on solar power by 2045. From a scientific standpoint that growth wasn't only necessary, it was required on climate crisis – yet such ramp would also be unprecedented. US in 2014 had gotten only under <1% of its power from solar. By 2021 nearer 3%, just 15 gigawatts (GW) deployed that year. To ramp from there fast enough to reach 45%, would mean US solar must double each year. 30 GW more installed in US each year 2022 to 2025. Rising 4-fold/year over that seen in 2020. On to a fresh 60 GW of newly installed solar each and every year, from 2025 through 2030.

By 2035 the US, given climate crisis, needed 1,000 GW of renewable power on the grid! By 2050, 1,600 GW solar for a US zero-carbon grid! More coming from solar - than was generated by all sources including by fossils/nukes in 2021. To further Decarbonize heat too means 3,000 GW clean energy 2050. Greening US transportation, buildings, manufacturing, and industry. Zero-carbon power for every GW of needed electricity, each BTU of needed heat.

2022, 'only' a new 30 GW of US renewable solar was needed. For comparison each 1 GW could power 750,000 US homes, and is roughly like a smallish albeit firm current-generation nuclear plant. With proper support, solar & wind can do it – along with battery/storage critical for firm power. Or, all may stumble & fall. Especially if future bills, just like BBB fail. Partly too why there's such huge volatility seen here. And why across the Atlantic, small modular reactors are being looked at in UK - where its 7 big nuclear plants are being cut back, though they made a sizable 17% of UK power 2021. Smaller nuke plants may come maybe with standardized design (like in China/France). But, can they also be made 100% safe? Less costly? Much less risky? On early 2020s nuke state of art, that answer has been murky, dubious at best. Hence questions swirled around current-generation nukes 2022. Even so China, the UK, US and several others, are searching for needed baseload power answers. Let's consider ahead solar/wind/storage themes, and so ECO & global NEX as the oldest, and best benchmarks. We'll begin with the volatility here, that ever-dominates green themes.

After big gains seen in ECO/NEX in 2020, it was maybe 'unsurprising' to see the big falls 2021. From a plateau February 2021 it was then unknown of course if clean (& so ECO) might next fall in a harsh backslash shape "\" down all 2021 – maybe into early 2022 etc too? Or perhaps "L" shape: down, then sideways all 2021. Or given January, an inverted "V" or with ^ right leg going down much further than increase on left. For 3 reasons, 2021 and early 2022 could go on suffering headwinds for *1) No Clarity yet on whether a big BBB $550B reconciliation bill might pass in 2021 or at all; 2) *China's 5-year plan and its ever-greater energy demand might push its coal use on through 2025; in which case 3) *Europe seeing pause in green by both the US & China, might refrain from hoped-for even more aggressive actions in 2020s.

To those 3 worries 2021, 2 more were *Underlying green stocks had high P/E multiples 2021, plus *Inflation/Taper Risk. Thus perhaps Feb. 2021 was its soft ceiling? Hope for BBB was succor if one's felt a bill would pass; Billions *might* better justify rich Price targets ("P" in P/Es). But 2021 was maybe fated as an interregnum, a pause between Q1 hopes - & clarity on BBB's fate. Insight on "E" Earnings. Plus, inflation can mean big cumulative years of a Fed willing to let things run hot, over >2% inflation targets – or Rising Rates/a Tapering all 2022. Thus, tech stocks shifted fast towards lower pricing/expectations through a falling 2021 on Inflation discount of future values. Capital, unsurprisingly, went reflexively 2021 from growth - to value themes (thus not clean energy!). Though traders may get re-accustomed possibly to higher yet historically more typical non-zero interest rates as seen in past.

Valuations above 25x EBITDA (Earnings Before Interest, Taxes etc) might be seen again. But 2021 in this risky theme, few dividends, little positive "E" earnings – matters swung bearish hard. In Global NEX like in ECO, components fell hard that year – as one might expect macro-picture. Such a classic sell-off post-Feb. peak was maybe overdue: NEX/ECO had already spiked up by 4-fold & by 6-fold Q1 2020 to Q1 2021 – after their big gains too in 2019.

Recall too how Q1 2020, ECO had crashed -50%: Thus to see it plummet again by a same, neat -50% in 2021 as well wasn't too surprising. ECO went from 287 high close (286.89 intraday) Feb. 2021, down almost exactly ½ to 142.39 low December 2021. Given 2020 gains, this took it to levels seen not very long ago: ECO was 140s as recently as Nov. 2020; it was 100 in August 2020 - back to near 100 again February 2022. Or say, if NEX goes down say by half; it had been 315 as recently as Sept. 2020. Much bigger drops thus could thus be envisioned. And ECO that in 2020 had a -50% fall from 90 to 45; down -50% was a resistance level, thed rebounded. Just coincidence we saw a similar-sized, -50% fall again in 2021. *Coincidentally*, curiously a neat -50% decline to 2021 nadir. Much further falls could be envisioned 2022 or after.

In sum, much of 2021 was an interregnum/down: a rough patch, rife with uncertainty. Clean energy's theme spiked early in 2021 on just hopes following Presidential results and a surprise 2 seats gain by his Party. Maybe on unrealistic estimates of BBB passing – so understandably a Q2 – Q4 2021 pause was weighed down by high P/Es, steepening inflation fears, uncertainty on say if BBB could pass 2021 – then came certainty it had failed. There was an air pocket in Q2 - Q4 'twixt the election's outcome/hopes – then a tougher clarity. Frankly some skepticism is helpful once again on how likely it truly may be that green clean energy tax subsidies pass in 2022 (less likely in 2023 or 2024). Without a doubt, passive ECO/NEX themes could fall yet more on uncertainty. And that ECO fell near 100 in Q1 2022 was understandable. If P/Es are a metric (useful) & early 2021 figures had been very high, then chances of reviving tax credits ahead for solar/wind/EVs to justify such P/Es can be impactful – Down or up.

True, much happened lately in clean energy & climate. Some hopeful. Like a US President's aim to cut US carbon dioxide (CO_2) emissions near 50% by 2030, which was needed & doable. Yet renewable growth 2020s has been nowhere near swift enough, to reach 50% cuts in CO_2 by 2030. Solar & wind *potentially*, yes they alone are readily capable of doing it - but on current trends, we'll NOT be hitting 50% CO_2 emissions cuts 'til 20 years later, in 2050. Broadly this is due to 2 factors: 1) renewables aren't yet being grown fast enough to displace coal, oil & gas. And conversely 2) there's still a huge global inertia behind the fossils that isn't even letting up, let alone are these fossils being shuttered nearly quickly enough.

Solar & wind clearly are capable of it; they have the potential to power the entire world - many-fold over. On today's technology & available locations, these 2 alone could power the Planet more than 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 such vast opportunity, the world 2019 only captured 0.7 PWh solar power, and 1.4 PWh of wind. Even though free wind & sun could meet *all our power needs.* Forever.

So, no surprise they're expanding! Global solar growth was +39%/per year, last decade: it was roughly doubling in capacity every 2 years. Wind growth was 17%/year onshore; while new offshore wind booms might raise the wind's rate of growth much higher ahead in 2020s.

So clean energy's potential with its free fuel is eye-opening. Sub-Saharan Africa might generate 1,000 times its current energy demand from renewables alone. Australia, Chile, Morocco, could generate 100 times current energy demand. Voracious China, US, Europe, or India could all generate more than all their energy needs - from renewables alone.

US offshore wind starting from 'zero', will likely see big gains across this decade. But for 50% cuts in CO_2 to avoid crisis – all still fall far short. That ought Not dissuade. New energy *could* deliver abundant, affordable, change. Electric cars *may* go from a lagging 2% figure of US new car sales in 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 and plug ins there totaled 95% of all new car sales! If Norway presages a future, auto makers banking on 50% gasser lineups still 2030 are gambling with their own BK (bankruptcy). China, seeing this, was 15% electrics in 2021 – and rising fast to become EV dominant. Global EV sales in 2021 far overshadowed already puny US figures. China sold 1.1 million EVs in early 2021, Europe sold 1 million – both were far better than the US. And Europe leads in both clean power generation & EVs; meanwhile China is rising very, very fast from near nil. All as the US lags.

Western Europe's wind & solar are growing, coal cut back – except for a power crunch 2021, war in 2022 that fed dirty fossils! Natural gas can be reduced there - but not quite yet! Instead gas shortages made Europe's power prices jump. Yet, things change. Especially post 2022. Gas now a transition fuel, may be last pariah fossil, as socially unacceptable one day as coal or cigarettes. Europe's Climate Law may mean a border tax on imported CO_2-laden products. Clean energy should win out, EVs are on a cusp, but a keen need to *heat* buildings had no fast green fix in 2022. Replacing gas boilers in Europe with heat pumps, is costly. Renewable natural gas (RNG) blended with green hydrogen (H_2) years away. As is running ships & aircraft on green H_2, ammonia (toxic, so carefully) or methanol - green liquids, gases, or solids ahead. Clean too is vital – but only one-side of climate coin. Other side has got to be moves especially by China to also cut coal, CO_2/methane/greenhouse gases. Clean gains are for naught if the latter don't drop to near nothing. Still, huge populations in China, India, & in Africa all have much economic & energy development ahead, that will likely be driven by coal.

So, coal's fall 2020 in Western Europe/US – was regrettably a mere outlier. Elsewhere, in 2021 and worse in 2022 like in China, India, Japan, even parts of Europe, coal saw terrifying growth. China is growing renewable power + small EVs: great! – yet it's also expanding too its thermal and 'met' coal use at least 5 years to 2025. Notably China first half 2020 had added on 11 Gigawatts (GW) more coal, with another 53 GW of coal maybe to come. Of all the world's coal power added in 2020, China had made 90% of that. Plus early 2022 saw more of the world speeding up its coal-use, like India, given a war that spiked costs for natural gas.

Not only China is at issue: 33 of world's 60 largest Banks grew fossil fuels funding in 2020. Any & all hopes to decarbonize the world in 2020s are blown apart by coal alone. In 2021 world carbon emissions had spiked 1.5 billion tons, mostly on coal. 2022 looked worse. Instead of a big drawdown that's needed immediately, according to the best science to decarbonize - big cuts in methane too – all the fossils are instead expanding globally these next 5 years.

There are happier words. 'US commitment' to cut emissions by 50% from 2005 levels by 2030. COP 26 in Scotland had glowing blah blah. But look closer. Each Paris Accord nation sets its Nationally Determined Contributions (NDCs). Some are quite lax: China, Russia, Japan, Australia, Brazil. And games played; a UN baseline was 1990 – not later 2005 when emissions were higher. So, pledging say '50% cuts from 2005' is more like a 43% reduction. Worse, the US in say 2021 was on track for real cuts only 12% below 2005 levels by 2030 – nowhere close to 43%. Games are played too like counting *not*-cutting down trees. Or seeing oceans as 'carbon sinks' or 'reducing emissions' via offsets in a mockery of reductions. Some words inspire, but others mislead. Air traffic & shipping are kept out of emissions tallies(!), methane too, so the facts are worse. Aircraft, ships, methane; each means big greenhouse impacts and so ought not to be so pretended away because they're just 'too hard to reduce'.

There's a Huge Gap between big merely *promised* cuts to 2030, the 'blah, blah, blah' - vs. reality. These data show that fast-*growing* CO_2 & GHG emissions worldwide now, 2023/2024 etc are led by coal. With no real action. Meanwhile cuts pledged 'round the world' are failing spectacularly, and themselves are still not near enough, to make a real difference.

Consider: the UN in 2021 tallied NDC pledges from 75 of 191 nations signing the Paris Climate Agreement. Excluding China & US, it found fulfilling 75 commitments would only reduce global emissions by 1% from 2010 levels to 2030. So even if NDC targets from many countries are met there'll still be unprecedented, historic emissions driving climate change. And that is to say nothing (like we still do), of uncounted methane, threats starting to force heating too.

A Paris Agreement got fanfare, due to a supposed agreement that heating would be held to 2 degrees C (3.6 degrees F), or better yet to 1.5 C (2.7 degrees F). Yet assuming science is to be believed, then CO_2 emissions need to be cut now, in *this decade far more* enormously: by near half or 45% to 2030. Given ambitions & real actions worldwide are nowhere close to 45% required reductions, Paris arguably is already out of date. Far more bold dramatic action now taken by all 3 of the greatest emitters, China, US, and Europe, are essential. While war in 2022 may accelerate some change – it also doubtless takes the eye off CO_2. So, to be clear-eyed, recent fanfare over 1.5 C target wasn't deserved. Not as Paris lacks mechanisms to enforce necessary cuts to achieve it. Not when there's no real Plan to meet 1.5 C target in this decade. Not when leaders talk as if these (mostly meaningless) Agreements will head off a maybe, or quite likely(?!) catastrophe. Against needed 45% cuts in this decade – vs. a lack of action – the 'net zero' greenhouse gas 2050 targets aren't worth discussing.

We could squint, in hope. In 2020, plainly superior economics of renewables had meant 80% of new generating projects worldwide, were clean energy. It made dollars & cents/sense. That led to a 10.3% rise in carbon-free electric generation, globally. Also, nice to see then 91% of new renewables were wind & solar. Wind at 58 gigawatts (GW) 2019 doubled in 2020 to 111 GW. As a percentage of total global electricity production, clean sustainable energy grew by 2 percentage points – so went from 34.6% as clean power generation total in 2019 – to 36.6% in 2020. *Yet that's far from 100%, let alone 50%*. These numbers don't work, not as science implies that we're nearing a precipice, of perhaps irreversible changes.

So overall world electricity production pie is growing; yet a thing of it is, coal is growing too. Coal is vexing from mining to waste disposal, yet more is being built with new financing. Thus even as renewables' share of electricity grows overall, total greenhouse gas emissions have 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 coal uses for in other high heat industrial processes like making steel, aluminum, cement. Nor of its expansion post-war 2022. Nor embedded CO_2 in products often exported from China etc like out to the US, to Europe, and worldwide.

Greenwashing abounds. Ill-defined terms like 'net zero' or 'climate neutral', are bandied about. Emissions 'offsets' can be a shell game, using disingenuously trees, forests, oceans as a natural uptake. Coupled with distant target of 2050, words can be meaningless. 'Carbon neutral' is proclaimed – yet not same as true zero-carbon. Zero-carbon – should stand apart from 'net-zero'. So, words are important. They can inspire – or forestall stronger actions. What's clearly needed is to *decarbonize now,* in tandem with cutting all greenhouse gases: so less methane, black carbon, hydrofluorcarbons etc. Latter less-noted super-pollutants are more climate-forcing than CO_2. Shorter-lived they are also more potent at trapping heat - so are nearer-term drivers of global heating this century; or are quick fixes – if fast-ended.

Science & humanity in short, may require an unprecedented-swift transition to clean energy. Reducing all GHGs, even those that are less-now-notorious, if the science is believed.

Instead we hear words that dissemble. Much, as Greta says, is just 'blah, blah, blah' like 'ending coal' (only later-on). It follows: no nations yet merit praise. 'Twixt words & action, the void is huge. Gains so far have been necessary, but not sufficient. In short action to move away from CO_2 and GHGs – means enlisting capital to decarbonize worldwide. Arguably market forces shape energy choices – so markets matter deeply. Along with policy. Once, markets & policies together made coal King. Later on, they made oil near-exclusive in transportation. Later still, markets/policies had made abundant natural gas so common last century, that it came to dominate both in making electric power - and in both industrial & home heating.

Lately market forces helped renewables somewhat. But according to science, this transition isn't yet happening near fast enough. Shifts like from coal – to hydrocarbons oil & gas – once took half-a-century. We don't have a half-century now from what science tells us. And this transition isn't just flopping new energy – atop lingering old fuels. Instead, it's flipping over whole to new energy only; like solar, wind, green hydrogen. Policies can hasten it especially given clean is getting cheaper, better and is always healthier. Plus as we saw early 2022, gas was used as a cudgel of horrific war in Europe. In sum capital markets along with policy matter. They'll help shape our future. Time & pace of change in the 2020s are of the essence. It's simple. Listening to what science, and to what seas in fast decline now are shouting – perhaps matters like never before. We turn next to energy Indexes & financial markets.

More broadly let's look at ECO/NEX back in 2020. Given these Indexes/ETFs stood out as very top performers then worldwide, ECO in particular, was up +203%: why did these 2 do so very well then? Several factors enumerated next may help add a bit of colour. They also imply that in down years – these 2 volatile Indexes should & will drop harder/faster than most!

One factor perhaps, our long use of *decarbonization* as an organizing principle stood out. Another maybe, *Market Inefficiencies: our Indexes hold smaller & mid-caps not so known to mainstream analysts; fewer analysts in cutting-edge innovations like electric cars, Li-ion, green hydrogen, fuel cells, solar etc – may add sizable pricing inefficiencies. Fewer analysts in zero-CO_2 (and those that are, do excellent work!) on a flood of new attention & price discovery 'animal spirits' in tow, brings scope for gains. A 3rd factor maybe all-too human: *Disbelief! Difference of Opinion Is What Makes a Market; deep skepticism, even shorting - vs +12,000% gains in an equity impactful. 4th many 'clean' baskets are still steeped in greenwash; for example, they still have natural gas! Our truly clean energy focus has instead been unique & consistent for over 16+ years; that it's come into favor maybe is good fortune.

We'd seen a bit similar at ECO in 2004–2007 as green energy, long unknown, first grabbed a spotlight – with sharp rises in tiny solar firms, electric car startups, li-ion batteries, storage, H_2 fuel cells. Stubbornly-held (dis)beliefs maybe broke down, a bit - or not. Views oft heard 2004 had included that: electric cars could *never* be as fast as 'real cars'; nor see a 200 miles range, nor ever be pretty, nor fun to drive. Views oft stated that solar & wind 'weren't real' - vs. 'always cheaper' coal & gas. Future earnings estimates, on such short-term valuations resisted penciling anew. Importantly, valuations were based *on only future promise in 2007. Clean energy back then, was itself much too costly*. And all crashed on overcapacity, higher relative costs - and on clean being still just 'promise only' back then in 2007-2014.

So re-think 2020s what's maybe possible in this new decade, *maybe* more than promise only. Perhaps: 5-million-mile batteries; whole regions competing to make renewables & electric cars; solar-electricity costs falling to <penny a kilowatt/hour, perhaps green hydrogen – all causing new looks at valuations. Closing past inefficiencies in equity pricing. To more accurately value prospects is never bad: disruptions narrowing gaps are an engine of growth. Clean & new displaces dirty & old. Over & over so many ways, closing gaps from 'state A' – to 'state B' propels. At quantum-level scale on up to our own macro and visible, from a state A - to state B can propel. Going on up to our small solar system and local galaxy.

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

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

10 components in any Index theme with Gains of +1,000% from 52-week lows, even +2,600% is perhaps a bit remarkable. It may help explain ECO rising then 6-fold+. So, notable were a *Speed by which clean energy can shine as Best option, *Force by which policy can embrace zero-carbon, & maybe the biggest item, *Climate Crisis & Risk. This last factor: how much CO_2/GHGs can we afford, that's new to our species. Maybe a vital limit. Like *C* in Physics, other matters dance around it. All squarely within our theme here at ECO, NEX.

The Good

Digging deeper, just for fun let's call factors behind change, or 'delta': the Good, the Bad, and the Ugly. A Good factor was ***Huge Reductions in costs** of clean energy. Solar becoming **least-cost electricity* in much of the world; wind power better too. Solar should soon be the *cheapest electricity in history!* Unimaginable to many only a decade ago. Many models had long foreseen the dirty fossils instead, as definitively the lowest-cost power across 2020s!

Another Good driver ***unprecedented commitments*** by 3 economic blocs China, Europe, US. In 2020, China made statements on decarbonizing not well appreciated in the West. President Xi Jinping announced China's aim to become "carbon neutral" 2060, To be peak carbon 2030. Devil would be in details, to be fleshed out post-2021 when seminal 14th new 5 Year Plan publicly was then released to much anticipation. For China could be a 'solar superpower'.

Did that mean all greenhouse gases? Methane/CH_4, HFCs too for fully climate neutral - or just CO_2? How much disagreeably might a dismal state of art 'carbon capture & storage' (CCS) play a role? So CO_2 just temporarily stored? Monoculture reforesting? Can 'carbon intensity' to let fast-increasing natural gas use - be regarded as an improvement?! Or CO_2 be seen as a 'per unit of GDP growth'? That can/will distort true numbers around 'carbon-neutral'.

So it was a big disappointment its 5 year Plan released 2021 didn't take the steps needed to end coal. The world has needed coal to peak *before* 2025; for biggest user China to commit to peak-coal first half this decade. It did not! Instead, it saw CO_2 peak post-2025, presumably on steeper CO_2 cuts later on. In a fudge ocean & land were 'nature-based solutions', so CO_2 sinks. And it spurred on even greater coal production in an energy crunch in 2022. Yet pushing peak coal post-2025, ought to have been avoided. CO_2 sinks may fast become sources, even a great Amazon Forest. *Instead, China's renewables were always the best answer.* Glinda the Good Witch, knew Dorothy's ruby-red slippers could always take her home. But first Dorothy had to follow a gold/yellow-brick road to gain such confidence. China's own ruby/gold slippers, its solutions, its solar/wind plus vast new storage potential *could* have started to replace coal now/already. Fast becoming its 1st best choice, already 2021-2025.

Models by Tsinghua University have shown how China could reach net-zero CO_2 by 2050, all greenhouse gases 2060. It requires big, fast declines in coal power - and heat – plummeting from >70% – to <5%. To instead slowly cut coal, from a post-2025 time means sharp cuts 2030. Far better would have been to aggressively start Decarbonizing immediately: a pathway that would have been so preferable to so many worldwide. China instead may ramp up nuclear first, rising from 'just' 46 plants that had made 50 GW in 2021 - and no doubt some nukes worldwide will yet see tragic accidents ahead. Regardless of its exact path, China's new energy costs may well top $15 trillion! Far greater spend than contemplated by Europe, or by US: re-allocations to its economy. Most ambitious Plan the world has seen. There may yet be 10+fold increases in solar, 7+fold gains in wind. Maybe 10x-100x solar manufacturing capacity. Tremendous ramping storage – new energy technology like green hydrogen for zero-CO_2 high heat for steel and cement. Colossal challenges, all needing heroic actions.

Consider batteries: both in electric vehicles & energy storage. Apart from just Tesla in US, China had clearly most seized the opportunities. Too, Japan, South Korea, Taiwan. About 1 million EVs were sold in China in 2019: 54% of world total, 3x the US. And it's growing fast: EV growth in China could surpass 25%/year for 4+ million EVs in 2025. Maybe again a reason for volatile moves in ECO/NEX! Such demand helped push battery costs down 80% in 8 years. Maybe already was below <$100/kWh 2022 in some cases, as demand grew 5-fold+ plus.

America's battery leader in 2020 was Tesla, with 35 GWh of lithium-ion capacity, aiming to rise to 3,000 GWh (3 TWh) by 2030. That 3 TWh give or take, was about world battery making capacity in 2020, so change is happening! Ford, GM announced big goals, more reasons for valuation deltas. Make all vehicles electric maybe >10,000 GWh new battery manufacturing/ year. 2x+ that, for energy storage to replace fossils. In EVs maybe lithium metal at anode rather than graphite, one step towards solid state. Beyond lithium-ion, much more ahead. Perhaps nickel/zinc; or iron that's heavy but deeply discharges, no thermal management for longevity. Cooled EV charging cords, GaN, SiC fast charge. Vanadium/iron flow batteries maybe in grid storage that get cheaper, better resisting degrading over time, etc etc.

China's early battery focus was fruitful for it. In 2020 it had 80% of world refining material capacity: it could manufacture 77% of battery cells, 60% of components, had 72 GWh battery demand. No one was close! Europe's fondness for diesel once held it back, no more! EV incentives there are moving it forward. Europe's EV/hybrid numbers fast pulled it ahead of the US. A century ago, Des Moines Iowa had been a world capitol for electric cars. 30,000 EVs were then registered across US in 1912. Yet US is once again letting a world-lead slip away. Something that China, and lately Europe too seem very intent not to let happen to them.

All can = green jobs. China recognizing this has its foot on the accelerator. Yet its coal burning persists; China's big 53% share of global coal in 2020, was even more than its big 44% in 2015. Other side of ledger, China has led in clean energy growth: in 2019 China added 30 gigawatts of solar capacity, 26 GW wind - to total 204 GW & 210 GW respectively. In 2020, China added 48 GW more solar, 72 GW wind; 60-70 GW more solar in 2021. Then hopes for >100 GW/year in 2021, were dashed on NEA draft @60 GW. In thinking of what's needed now, given CO_2 levels over >400 ppm, it's why some **Climate** models call for 10x-100x greater, thousands of GW of global solar/wind power. Far faster ahead on purely climatic concerns.

Look Westward to faster-moving Western Europe; European Climate Law enormous. It laid out 'carbon neutral' by (too distant) 2050, but could get 55% there *this decade* by 2030. Little-discussed in US - it's still seminal – and was given more teeth 2022. Being fleshed out now it's a first legally-binding net zero Plan of these 3 blocs. Perhaps 2030 target of 60 GW offshore wind, 5-fold increase from 2020; 300 GW by 2050. Plus, unlike China, Europe is beginning vitally to start now – not years ahead. (China's green growth can/will be fastest in world in those areas to which it does commit, so note now where it's focusing on ahead).

Europe's Decarbonizing aims are voluminous, not just in energy: industries, infrastructure, agriculture, water, buildings etc etc. All subject to consideration and change. Broadly an EU Green Deal may mean new carbon tariffs and/or carbon taxes. Trillions of Euros in spending, carbon border adjustment mechanisms like on embedded carbon, affecting trading nations. Those details being fleshed out may start a path of a somewhat decarbonizing world.

There's ample news coverage of what the US really might have done. Could have been say, a whole government approach with strong unitary executive, green jobs in areas hit hard by coal, oil & gas losses – but only if the liberal political party had had a couple more seats in US Senate. It did not, so much less is possible near term. No chance soon for say a carbon tax, or National Renewables Standard. Nor say for US to start to out-compete say in solar module manufacturing. In 2022 China was making 2/3rds of world solar modules; 15% more were made in Asia often at plants owned by Chinese firms. So, no surprise the US reduced tariffs in 2022 - which can help solar installers (not manufacturers). At least low-cost solar can help electrify US. Better ahead, is to make those (Asia) solar panels with no embedded coal/carbon.

The Bad

Perhaps 'bad' factors too helped that 2020 gain. Bad in that the drivers, to some, didn't yet warrant such an exuberance; Hydrogen (H_2) & fuel cells 2020 come to mind. Not that these can't possibly sooner than expected - be vital. It's more 2020 maybe they hadn't yet justified the hype, not until breakthroughs occur. But then this is a passive Index – not active managed – so not active trying to predict rises or falls. And hydrogen & fuel cells in ECO/NEX baskets did outperform 2020. Yes, H_2 is burdened by sparse CO_2 avoided, low efficiencies. But H_2 may yet become increasingly green/relevant. If made from 'rock gas' (natural gas drilling) so inextricably tied to fossils, it's then not worthy solution. Such 'blue' H_2 on the fossil fuels & sequestration could only pass a very low bar, as it is polluting. Big Oil may embrace a chimera of blue H_2 – and it may compete with green H_2 in this decade only, if green scales up big. For neither ugly blue H_2 with 'sequestration', nor uglier brown/grey H_2 made from traditional rock coal or gas - are made in clean, green, truly renewable and scalable ways.

Far better is *green hydrogen* renewably/cleanly made by solar, wind or other ways ahead. In 2020, Spain hoped to see 9 billion euros spending on green H_2 ahead. France, 2 billion euros on green H_2. Germany looked at 9 billion by 2030. A Catapult plan for 25 GW green H_2 at <$2 per kilogram. Saudi Arabia was considering 4 GW solar & wind; UAE looking too. Different is to capture potent greenhouse gas (GHG) methane (CH_4) spilling from landfills, dairies, etc: maybe 'renewable natural gas' (though may be used to promote rock gas). Or a step further, drop-in replacement low-carbon fuels. Not immensely scalable but if made renewably – by *capturing spilling CH_4* and using it – that may be, somewhat a 'meh' transition bridge.

Green H_2 by contrast *can be* hugely scalable, and is now much more plausible than before. Demand for green H_2 *could* - just *perhaps*, grow enormously: >$70 billion by 2030. Europe might see €200–€500 billion+ invested by 2050 – *in theory*. Big oil's deep engineering bench lately touts H_2. Maybe too 'green ammonia' (H_2+Nitrogen=NH_3) easier to handle than H_2, say made on site eg by offshore wind. (Blue ammonia, undesirably, is using rock gas). Visuals of wind or solar making green H_2 – then 'green-ish NH_3' - in place of oil might be painted.

The rub is cost. Affinity of H_2 to react means much solar/wind power is needed for electrolysis to split water. And green H_2 2021 was too costly vs brown H_2 steam reformed gas – that brown costly in its own right. An inflection could be if: 1) solar/wind costs go on falling enormously; and 2) green H_2 goes <$2/kg by 2030, or to <$1/kg perhaps soon. Profoundly then no longer 20 years in future. On a carbon tax of $50-60/tCO2, clean H_2 *could* make steel, cement, or power ships, ports, planes and more. Manufacturers have reduced H_2 costs by 80% in 3 years. Going well <$2/kg is targeted; even far cheaper may yet arrive in innovative new ways.

All that was dreaming 2021. Green H_2 costs were x-times too much everywhere, seldom found anywhere. 42 hydrogen stations in California 2020 – vs. 22,000 electric outlets to charge. Worse, inefficiencies. Compared to batteries, H_2 loses half going from water – to H_2/O, then more going H_2 – to electricity at fuel cell. A case may arise *if* cheap solar/wind green H_2 'time shifts' intermittent renewables, a holy grail of abundant firm power & heat. Nearer term, green H_2 may displace rock gas <15% to not embrittle steel. Renewable natural gas a limited drop in fuel. Capture uncapped methane – upgrade captured hydrogen cleanly to renewable natural gas; or *truly* sequester C in stable form. Renewable natural gas just defense only, vs. climate risk. Not great, but of tiny help near term. In sum H_2 fuel cells are partly why clean so jumped in 2020 for equities are forward-looking. But it has to soon deliver. And a case for green H_2 – was far hazier in 2022 - than it is for solar, wind, electric cars. That said, green H_2 once just conceivable, *may be* plausible ahead - *if* renewables bring us cheap power.

The Ugly

Ugly factors even if tangential, can highlight how better are green solutions. Take a dismal state of the art now of CO_2 Direct Air Capture (DAC). Energy intensive, a non-starter needing gobs of power to burn yet more fossils & so on. But if DAC gets sensible, lower-energy = then *that* could be huge. Far less fetching (yet touted by fossil industries) is Carbon Capture & Sequestration (CCS). CCS might extend fossils by decades; it might inject captured CO_2 back underground, to briefly help produce more oil. But then a question to be asked is: Why??!! When burning *No* coal, No oil, No gas is where we ought now to be headed in the first place? CCS is a non-starter; that is completely the case if it's for eg enhanced oil recovery.

There's matters they don't raise. What if CO_2 leaks in centuries or sooner?? At Lake Nyos, in Africa, a CO_2 'burp' killed over a thousand people. Far better, stable, true CO_2 storage or mineralization mechanisms are needed, to be inert, safe, permanent. Solar's cheaper than coal anyway, so CCS for coal is No Answer; costs to capture CO_2 + pump underground renders coal 4x too costly!! It's why we've seen 'clean coal' ads (ha ha) only – but never for real.

Compelling DAC would need to *Remove CO_2 from air & seas, *Permanently, *Practical and *Economic Ways, *Scale up to Gigatons, be *Benign, Stable, and *Carbon Negative – and not just carbon neutral. Impotence of that technology early 2020s, boosts greener equities.

Truly Ugly: 'Geoengineering'. (Seriously, try to dim our planet's air, or dump CO_2 massively in oceans without knowing effects??!). It of course should be rejected. Yet even that hydra-headed monster, is overshadowed by immediate climate crisis. In the 2020s global heating is fundamentally altering our once-cool planet. This last specter should concentrate the mind: how do we now better, more swiftly and more sensibly avoid CO_2 in the first place.

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

Closing gaps, moving beyond past ***wrong*** views – helps propel clean equities here up. A few years ago, conventional wisdom held that EVs, like solar & wind power, were costly toys at best, to be always seated at a kids' table. Regarded in unserious ways. Rather than 'listening to the sea' or thinking holistically – electric cars were then dismissed as always slow, as silly golf carts vexed by small hills, their range forever under <100 miles. In sum a sad joke.

How wrong! Proving 20 years old beliefs wrong, sleek electric cars have become vastly better. They were fated to do so! Foreseeing such can favor the bold. Closing gaps between state "A" (older beliefs) – and "B" (the truth) – can be disruptive, innovative, and useful. Clearly, it can make for a delta/change in equity valuations – maybe an 'alpha' too in financial terms. Foreseeing these gaps, even if only a little before others do, may potentially be vital.

It's non-linear, plummets too. Think tremendous falls back in 2008/2009, when green themes crashed (or 2021/2022: they certainly could do so ahead again). A dozen years ago profit margins went non-existent, down years. There's a non-Euclidian curved geometry here. Like disjointedly compressed margins, few straight lines. Solar margins in time becalmed a bit; we've learned to make solar *least-cost electricity in history!* Learned cost-reductions led to virtuous circles. Electric cars got better in every way. Think by contrast of heat engines: unfathomably still all around us, spark plugs exploding, pushing pistons for power. For cars, trucks. Coal or gas making electricity by heat difference. Nuclear = world's costliest boiled water. Delta in that hot - vs. cooler. It's a difference of state, of temperatures "A" vs "B". But difference in heat engines, so brutally inefficient – oft unlike nature herself.

Mr. Babbage had captured delta via a difference engine. Mr. Turing's work, led to computers; a gap in '0's vs. '1's did work. Here, we don't know when razor-thin solar margins may crash. When equities again will plummet like they shall do. Growth *may be* possible on new demand – or on better affordability – or the top issue of all, perhaps on Earth's physical CO_2 limits.

This last issue is so significant, it stands out *sui generis* as a global climate crisis. Potentially, it just may devastate humanity, whole societies. It's perhaps an existential threat. One not yet well understood. With tipping points, feedbacks, methane bursts, clathrates, GHGs, things that can't be unwound. No matter how hard we humans may beg, may bargain with, or badger nature. On most topics, scientists will counsel calm. Soothingly they'll remind us things aren't half as bad, nor as extreme, as the non-scientific laypersons may paint them.

Not so, climate. Singularly, researchers are now shouting. Maybe conservative to heed science – unwise even foolish to reject it. This may one day hit us not in spirit of gladly looking towards smart solutions; not of boldly advancing our better natures. Instead, it may mean hastily saving what may be saved: remember Summers lasting only 3 months? Winters? Cool nights? Farther out, living Coral Reefs? Sandy Beaches? How better to prevent that as a future we all bequeath. Especially when sustainable, no regrets paths make us healthier, happier, richer, safer, more secure. Saving us from spiraling blood & treasure, diseases, and despair. This sea change may mean our intentionally embracing ahead, Prevention Rather than Cure.

NEX/ECO/OCEAN can help capture & track *possibly* more sustainable paths. Decarbonizing, electrifying everything, low-carbon fuels, efficient heat & cooling, green industry. Many more ideas will yet emerge, areas of particular advantage, certain themes, regions. Consider for instance, 14 of most volatile, upside constituents seen in NEX early 2021. These themes had been most up over past 52-weeks to early 2021, hence 14 biggest gainers then.

NEX in Jan 2021 was then near highs, so we'd avoided looking at a peak time. Instead, here are figures from March 2021 when NEX components, like most growth & innovation equities globally, were instead in steep falls. Hence these % up figures are moderated by a look from March 3rd amidst a then -25% YTD plummet. Nonetheless, here seen worldwide it's much like ECO's story where we'd noted big gains up +1,000% from their lows 52 weeks to March 2021. These were instances of rich gains globally. 14 NEX components/themes with big deltas as of March 2021, that then showed gains of at least +600% from their 52-week lows:

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%**

So 2019 & 2020 saw big gains in these green themes - but followed unsurprisingly by big falls in ECO/NEX 2021/early 2022. In 2021 ECO first fell with NEX and OCEAN; they then fell even more early 2022 – and could drop much farther yet! Should future climate bills again die – or equities crash on rising rates, inflation, the pandemic, war, etc etc - then these Index themes could plummet much farther, and swiftly. Outliers surely do happen: a US Debt default, terrorism, war, market crashes etc, these high-fliers could be far more seriously hit.

But 2020, what was maybe special about gainers? For sure the above were remarkably diverse. Some energy innovations were scalable, to go 'on offense' against climate crisis, like solar & wind. Names upstream in solar then had included poly & ingot/wafer/panel manufacturing. Downstream we saw inverters, PV sales, and installation. There's advanced batteries and materials. Plus, much more speculative themes like hydrogen & fuel cells. Biofuels were diverse too given that new energy innovation should reflect a range of possibilities.

There's 'defense' too on climate. Smaller steps, extant infrastructure. Capture methane – otherwise indifferently released to air like a sewer. 'Renewable natural gas' far from ideal; it may just turn methane to CO_2 – so combusted as a less potent greenhouse gas (and keeping rock gas going). Lower CO_2 or negative-CO_2 renewables, like aviation fuel, gasoline, diesel.

Past equity gains like 2019/2020 *in no way* foreshadow gains ahead as seen 2021. Indeed, such big rises may auger sharper falls later. Regression to mean, nothing's certain. Or, they *may* point towards better paths. Once upon a time fossils magnified human power many-fold. Yet we can't let past dominance by once-magic fossils now waning - mean what's bad for fading coal, oil, gas - is bad for humanity. We're wiser to set out for a once-more, stable climate. Towards broad sunlit uplands, carbon back again near 280 ppm: this choice is seminal.

20 years ago, paths forward were less clear. Solar viable, but could it be cheap enough? Might horizontal or vertical axis wind turbines win in red in tooth & claw competition? Electric vehicles sure on better batteries, but *when* might that succeed? Would green hydrogen *ever* be economically viable? Same, fuel cells? All were obvious questions – no obvious answers. Barely imaginable then; possibilities now electric jets, green H_2, ammonia, methanol MH_3OH for ships; how to scale DAC for sequestration to make carbon inert like mineralized rock? So much is yet to see in this important decade. All is open to debate. Inherently, unknowable. We recall this is rather like late in the last century, yet only some 25+ years ago.

Passively pooling diverse clean energy components into an Index basket made great sense then – & still does now. Victors, unknowable, which competing technologies will win the day. Mitigating against individual stock risk, via a basket was compelling then: it's more so now! One can't know *which* stories *may* survive among fast-changing storage, solar, wind, green H_2, fuel cells, electric vehicles, decarbonizing and more ahead. Which equities, all very risky – shall fail – and which may survive. Perhaps thrive. This vexed matter bedevils and helps to make passive Indexing like seen here arguably rather compelling.

Volatility, is a differing beast. We can say with great confidence oil & gas prices will doubtless jerk around at times very sizably ahead. Natural gas/oil/coal may be in long-term decline - yet events happen: lack of supply, or storage; accidents, attacks on infrastructure, drought, floods, hot days, bitter cold snaps, even solar weather or EMPs – making for big price changes. To not weatherize against extremes in a climate crisis = jumps ahead. Unpredictability is predictable, in that sense. Drought too stalks fossil & nuke plants; all need cooling water. Stratospheric heating in changing climate may occur one month, weaker Jet Stream lets super cold arctic air dip South so freezing infrastructure. Or a slowing Gulf Stream ironically, may mean dramatically cooler Europe alters weather patterns. Stability in both Streams: the Gulf + the Jet, is crucial. Less temperature contrast 'twixt the poles vs. equator may mean wind droughts. Fossils are in long decline – yet we'll certainly see price spikes ahead.

Perhaps foreshadowing, a deadly disaster hit Texas in 2021 when a freeze took down its electrical grid. That US blackout showcased too battles going on in messaging. What will it take to build a stronger, more reliable grid going forward? Key fossil fuel natural gas has long been dominant – yet lately it is finding itself at times a bit on back heels.

Case in point amid that crisis: an argument was hastily put out during this blackout that it was due to clean energy, due to wind turbines freezing! Whether promoted by uninformed, or politically motivated opponents to renewables – that tale was widely circulated especially by certain media outlets. An image was spread of a helicopter & vat above a frozen wind turbine – claiming it was a recent photo of flailing Texas attempts to use chemicals to try to unfreeze turbines. They claimed it was proof that wind power alone was ***the main / or only cause*** of terrible grid outages right then in that freezing Winter February 2021 in Texas.

Was that really so? Let's start with that frozen wind turbine photo shown by so many. In fact, it was an old 2013 photo from a Swiss helicopter company demonstrating tests using hot water lifted off a truck boiler (no chemicals) in Sweden – on a turbine lacking usual de-icing features. That compelling photo shown at a 2015 conference – was made into a powerful fictional 2021 false narrative. That meme shared widely by a publicist, website, & others was memorable, but clearly not true. Yet it definitely stoked misinformation and was seized on by wind's opponents as 'proof' of wind's failures. Truth in Texas was very different - but it only arrived days later, after this memorable photo & tall tale were already long-played out.

Let's dig a bit into what really caused that awful Winter freeze grid-collapse disaster in Texas. First to begin with, Texas' electricity grid early 2021 was not at all mainly powered (yet) by renewables; but instead, by natural gas. 52% of its grid power was natural gas in 2020 – vs. about 39% gas in grids on gas nationwide. What's key, is how well Forecasted energy Supply – matches Demand. In that week an Electricity Reliability Council of Texas (or ERCOT) expected 82 gigawatts (GW) of power would be available, in Winter. Greatest expected supply percentage was expected to be natural gas. A huge projected 50 GW availability.

An excellent review of just what happened that Monday February 15th – Wednesday Feb 17th is laid out in Texas Monthly (3/3/21). As recounted there, the key problem was a fast loss of massive expected 20 GW of natural gas-fired electricity generating power, due to hard freeze. Reasons included inability of power plants to even obtain gas; also some plants that got it weren't winterized to operate in such conditions: gas lines froze. So regardless of how much gas was 'given', the fuel couldn't be utilized, so many couldn't make any electric power.

Some plants didn't – or couldn't - find enough natural gas at any price, anywhere. While early, premature criticisms were leveled against wind power by both Governor – and Texas Railroad Commission – they were barking up the wrong tree. Hence a fascinating image and tale of helicopter hovering high bestride frozen wind blades confused matters. It made fascinating Kabuki false theater, a one-time narrative for Texas' political opponents of clean power.

To be sure a sizable amount of wind power did go offline. From peak pre-freeze to worst on February 15th wind dropped 8 GW. But importantly very low wind output was forecast for that time of year: dead Winter is regularly near wind power's lows. So ERCOT's models expected a puny 1.89 GW from wind. Thus, as wind output went as low as 0.65 GW nadir, that wasn't very far off forecasted models. (Wind soon spools up enormously in later months).

A relatively small underperformance vs expectations in wind, was narrower than was for coal. Latter was off a larger 5 GW from where it 'should have been' due to freeze. Even supposedly unflappable current-generation nuclear, was down roughly like amount to wind – off 0.7 GW. In all 55% of unplanned capacity outage was in natural gas. 22% was wind. 18% was coal. Plus, nuke losses too. Thus each source of electrical power was hit. Truth is wind's power shortages were but a fraction (nearer the least) of all disruptions in that crisis over 3 vexing days.

Key shortfall was natural gas. It suddenly fell short by a huge 20 GW less than expected – for a gap 16 GW lower than very lowest-end case models by ERCOT. How? Why? Texas is a global hub of shale gas drilling! But when temperatures froze, about a third of its own gas production simply 'froze off' Normally it's a warm, or often hot place; much equipment was thus left unweatherized, so the tanks that divert oil, water, and gas, became solidly blocked off.

Unfrozen, they could have spooled up enough to 'oversupply' gas-fired electricity to a tune of 45 GW. More than enough to make up for all losses elsewhere. As laid out in that article, many gas producers did Not financially benefit though. They simply didn't have product to sell in this acute shortage. Worse, some couldn't meet their own contractual gas obligations for volumes promised. Hence some were forced – like other gas producers – to suddenly compete for meager amounts of available unfrozen gas supply as prices were skyrocketing.

Normal days, gas producers might sell product around $2.50 per million British Thermal Units (BTUs). Contractually obligated to supply gas which they couldn't, instead they had to buy (to give elsewhere) at ridiculous prices like $200/BTU. On a trading Exchange where gas prices hadn't gone up to $200, they'd added a digit. Nearby in wealthy Dallas the price of natural gas right in heart of super-gas-abundant Texas(!) suddenly went to $1,000.

Power plants need continuously supplied gas – to sell electricity – so were flummoxed. They'd anticipated of course ever-ample feedstock gas. And were expected to hit normal wholesale power rates of $24 per megawatt-hour. But because gas was unavailable on freezing temperatures, in chaos sandwiched between needing to find gas right away at any price, their prices they charged shot up for each MWH – from $24, to in some cases a crazy $9,000!

Power producers needing gas to make electricity, competed with gas producers needing it to meet contracted obligations for available unfrozen supplies. All getting hurt. That gas trading expert well described how differences in trading normally just concern one penny amounts; instead, they were dealing then in gaps of $50 & $100 'deltas' in gas prices.

In retrospect, understanding how to do better, means lessons to be drawn. Lesson 1 is that *more* natural gas would have solved nothing. But, *winterizing - or better yet *weathering for Cold – and Summers too in key gas facilities & infrastructure can make a difference. Texas has a long history preferring very light regulatory touch to its electricity supply, natural gas even less burdened. But this, arguably is a matter of public safety. Plus, more unregulated power markets like this one, as it turns out, may surprisingly not always be cheapest.

So the cold wasn't at fault, *per se*. Plenty of gas infrastructure works deeper-freezing places, because facilities were 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, not all of it needs to be winterized. There are 100,000 Permian Basin wells, 250,000 are active in the State; many are just marginal of little consequence. Hence there needs to be some balancing. Or, the State could continue being fully hands-off, like before (with such consequences).

More *storage* was suggested, but instead, of *natural gas*. In Texas' crisis, its *gas Storage* was a Hero. It didn't freeze like gas *production* did. Another idea, *winterize the key power plants. A multi-billion-dollar nuclear plant down on a pump freezing (inexpensive to prevent in first place) is a no-brainer to fix. So key *critical infrastructure gets power in crisis. Harder to protect against, is drought. Thermal coal, gas, nukes all may *have to* shut down on low water – not only hydropower. In Texas, Arizona, much of West, a drought threat is worsening.

If most above feels like playing at edges of a teetering system bound for scrap ahead, you're probably right. What it shows too, is what really went wrong in 2021 Texas crisis. It wasn't a small loss of wind! Wind turbines can readily be winterized; that may add 10% to turbine costs but is done round the world. Wind works in the Arctic and US Midwest far colder than Texas; in fact, wind prefers colder, heavier breezes. (Natural gas too prefers cool, but no claims to contrary are made about gas – like it was for wind power!). After Texas' freeze it came to light that a campaign was fast mounted to call renewables 'unreliable' – to deem fossils as 'reliable energy'. Even though natural *gas* plants *were the most responsible*.

Texas' disaster, bad as it was, was minutes away from being far worse - if frequency stability was lost. It fell from 60 hertz – to critical 59.25 – near a crash of the whole system. Had grid transformers caught fire, high voltage lines destroyed, it could have been weeks or Months, not days of no power. We don't realize how dependent we all are on electric power 'til it's gone'. Only by shedding 7,500 MW of demand (effectively turning off about 1 in every 8 homes in the State), were they able to take a first emergency step. That's was twice 2011 emergency shed, which had lasted 8 hours, and that was 4x longer than the blackout of 2006. There were in total 3 emergency load sheds/rolling blackout – and frequency stability was near lost.

It boils down to: How ready are we for a changing climate? Honestly, not at all. A sole key oil fuel pipeline from Texas to US East Coast if shut – could paralyze the Southeastern US. Glance at a weather app like Ventusky; it shows swirling arctic polar vortex each Winter. Bitter arctic air drops at times in Winters towards population centers, yet remains just North of the US, of Europe, Asia. We're saved by historic wind patterns of the Jet Stream. Those can change. Sudden stratospheric warming high in the atmosphere can weaken this 'fence' protecting us. It doesn't take much to envision Jet Stream shifting, wavering, weakening, bitter arctic cold descending more south. While it may not sound especially harsh to the ear, consequences surely would be. Floods and droughts too increasingly imperil big thermal power plants.

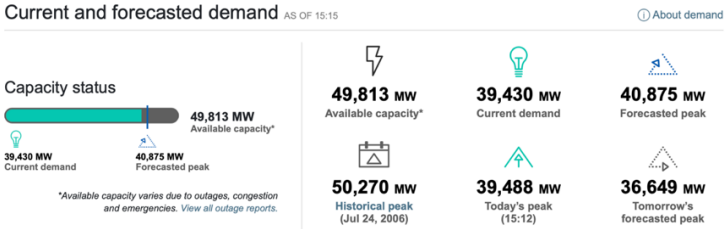
Perhaps 'Climate Change', 'Global Warming' are too benign as words for a possible Calamity. Better might be 'Climate Crisis', 'Global Heating', even Global Weirding for decades and centuries plus of blazing Planet. An uninhabitable equator, yet not too far different from hot Poles. It does Not mean getting there will be incremental. That we'll experience just linear, pleasant, 'nice' warming along the way, with gradual and gentle changes only.

A slowing Gulf Stream *could* paradoxically mean bitter cold. Trace a finger on a globe from lovely Britain/Northern Europe either westward or eastward. Quickly it becomes frozen and barren away from North Atlantic warmed by the Gulf Stream. Should non-linear global heating cause a warm Gulf Stream to slow, or cease, that change may alter much we know today. Science is still unsure there: is it cooling, or warming? But unlikely is no change at all!

For solar & wind, storage of abundant clean electricity is what's needed. Together making electricity cheaper too on renewables. Storing clean power, is where we'll need to focus and grow. It can be done in myriad ways, but it's ***Storage*** where attention ought be turning.

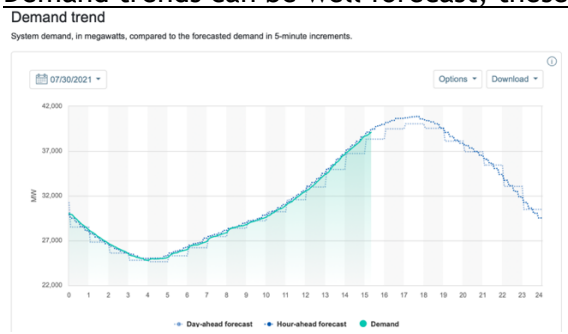
That was one circumstance. A purposeful (terrorist) attack on grid's hardware, or cyberattack on its software could confound all attempts to remain above a critical 59.3 hertz. Once the whole system goes down, a black start is needed – and whether it can be done in just a week if entirely unknown. And like bitter cold, other weather threats include extreme heat, etc. So in sum, better storage is key. Looking forward, that along with and tied to more renewable generation is what can best Decentralize the grid. This is what will improve resilience.

To illustrate, let's consider for example Summer day heat, say end of July 2021 in California. On a typical expected hot day – here July 30, 2021 shown below, situation in that State's grid around 3 pm is not great. As it looked that day, all power sources were generating some 50,000 MW (49,813 MW). Demand forecast to peak soon that afternoon at 40,000 MW:



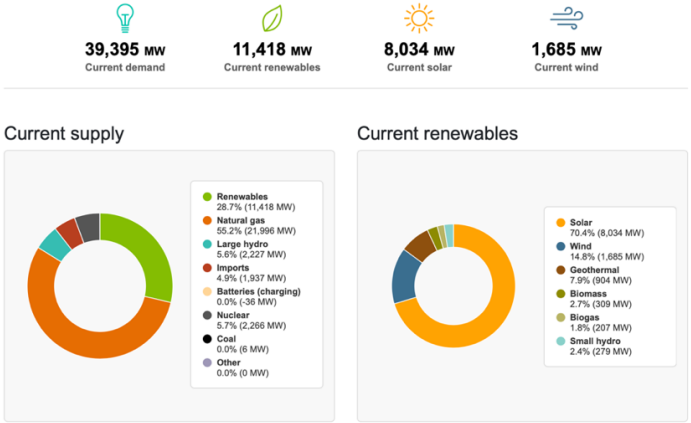
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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



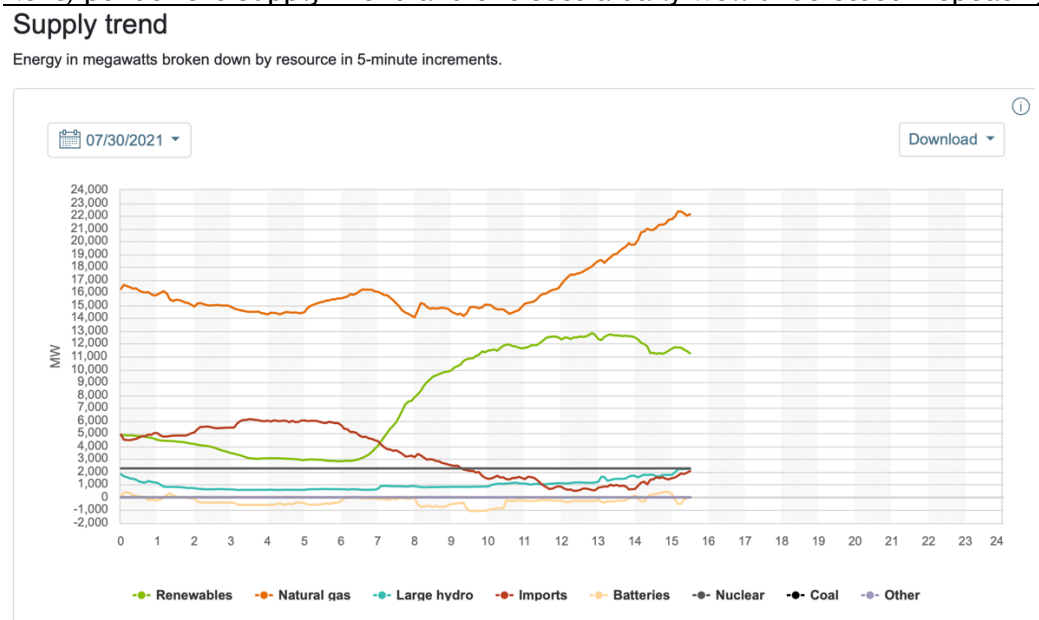
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

<u>To meet that readily-forecastable 3 pm Demand, all Supply sources were producing as follows:</u>
huge 55% of electric power coming from Natural Gas, 28% was from Renewables (other than big Hydro), 5% large Hydro, 5% from Nuclear; and 5% Imported from Out of State:



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

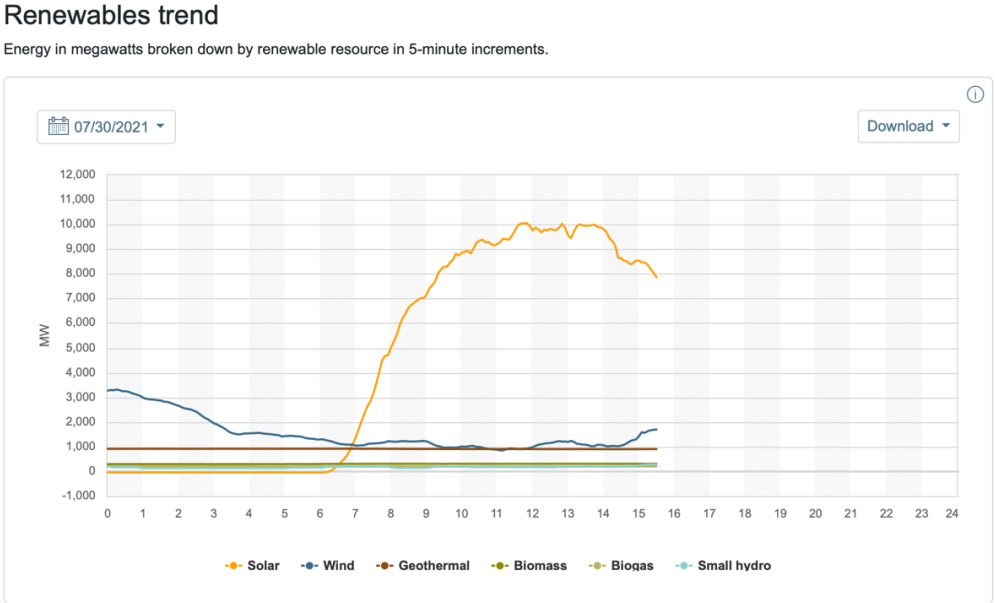
Next, ponder the Supply Trend and one sees a daily well-understood 'repeating issue':



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

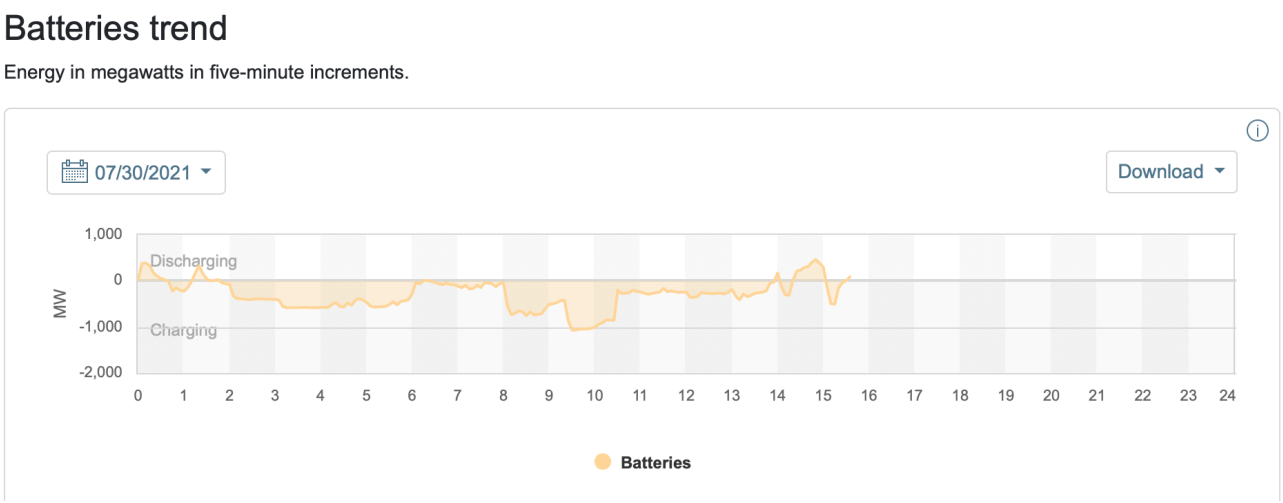
Solar power making up most of renewables' contribution in green above, is about to drop hard, as sun begins to set. Of course, eminently forecastable! So, this 11,000 MW from solar at 3 pm above used to help meet 40,000 MW of demand – will fall very hard. Firm, dispatchable natural gas is generating 22,000 MW at 3 pm (orange top line) and about to be called on to scale up fast to replace that 'lost' 11,000 from solar (green, 2nd from top above).

Next chart shows Solar just past its daily peak, starting to fall hard (in orange). Wind *can* potentially make quite a lot of power, at times – but generally it's at night (here in blue) and not on this day. Certainly not on this hot mid-afternoon, which is quite foreseeable:



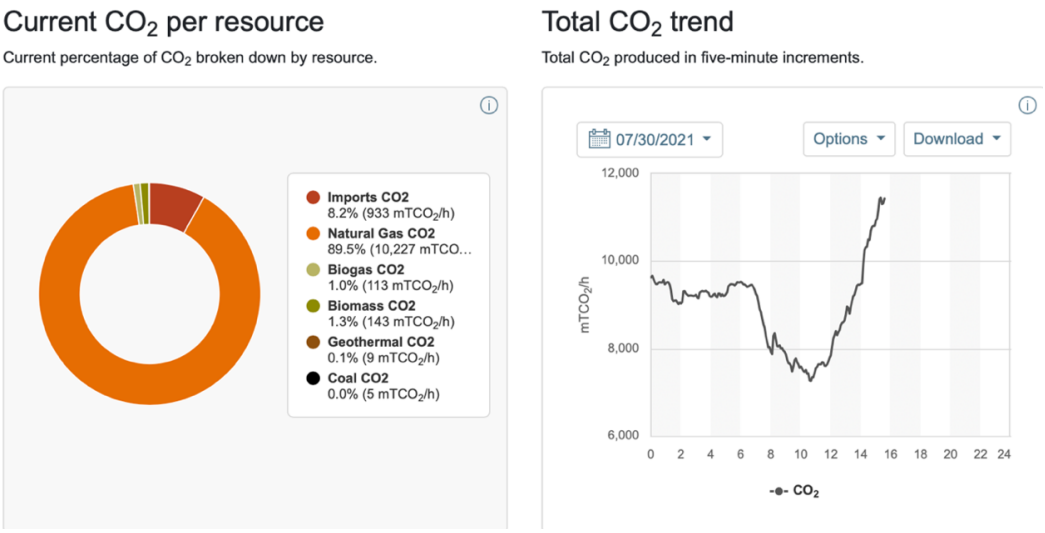
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

In theory one may think Batteries & energy Storage will & should kick in hard. Foreseeably to readily make up roughly 11,000 MW lost solar after sunset, using green power charged in day. They might replace 22,000 MW that was generated from natural gas. But ... reality in 2022 is that energy storage is almost entirely non-existent, still. Batteries can help in temporal ways (delivering renewable power at times when there's no wind/solar) but only over brief gaps now like 4 hours. More Grid transmission can instead help in a spatial way – but it lays ahead. So batteries now, below, show meager 1,000 MW at play – when we need some 50x that – 50,000+ MW of storage! Thus, it shows negative here this day (charging) – scant power soon in a temporal way that's available (today) when the sun goes down by discharging:



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

On insufficient storage early 2020's, we all suffer from ongoing dependence on fossils. Mainly on natural gas like in California, Texas, much of Europe etc – producing huge carbon emissions. Big hydro can't be scaled up more; indeed big reservoirs like Lake Powell, Lake Mead may become 'dead pools'. Natural gas may not be as odious as CO_2 coming from coal per ton, but methane leaks badly vex Earth and climate nonetheless. About 90% of this *measured gas* CO_2 (and unmeasured leaks make it worse) is but one GHG. There's many other GHGs too.



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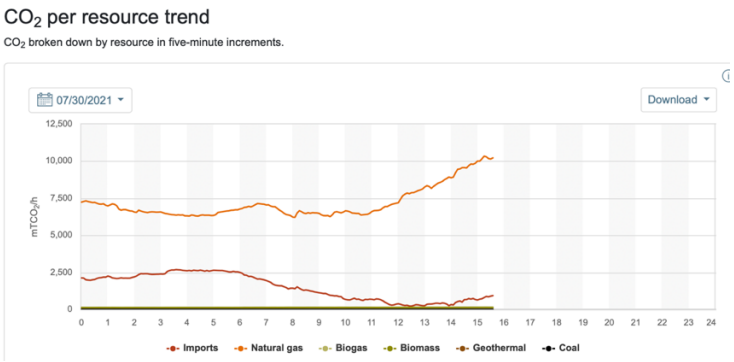
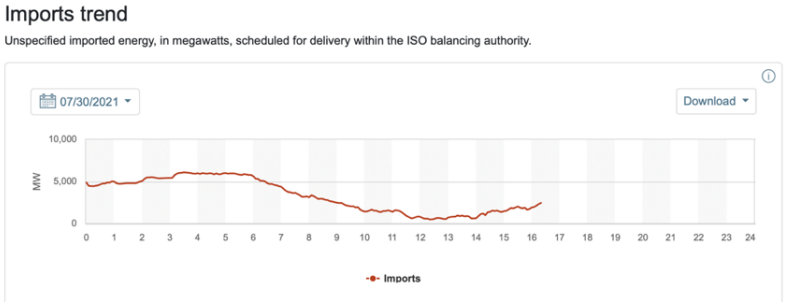


Source: CAISO.com Today's Outlook – On July 30, 2021 at approximately 3:30 p.m.

That same day California's Governor gave an Emergency Proclamation to shed load – and up generating capacity. Shedding power to 3,500 MW industrial customers for whom losing power will be paid handsomely. And dirtier backup generators then used more freely. Ships allowed to burn dirtiest fuels in port, rather than to use far cleaner shore electricity.

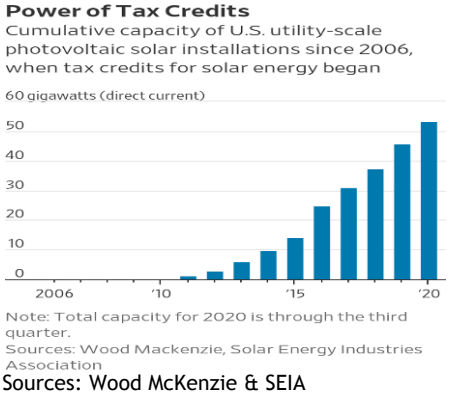
It gets worse. Issues in California's grid early 2020s included **that i**n a Flex Alert, CO_2 Emissions could spike to get Supply as high as possible, over >50,000 MW to meet demand. Natural gas+peaker plants could max 100%, no maintenance, much power imported from out of State. Demand for example in a Heat Wave eg Sept. 5, 2020 had outstripped capacity. **B**lackouts threatened. So California's Demand History has shown both a need for more Renewables + for much more Batteries/Storage that should grow very, very, very fast, given huge efficiency strides already were made. And California is also ever-adding more electric vehicles. That swiftly means more demand – while shuttering its lone, older technology 2nd gen nuclear plant. That closing means a big 5% loss of its overall firm generating capacity, and very soon.

To date the State's been 'solving' this conundrum by Importing electrons it needs from power generated elsewhere in West in times of insufficient supply. But that dirty *power may be generated by carbon-laden sources like gas or coal - maybe by risky costly current-generation nuclear. And those sources all suffer more than renewables from heat waves, or drought and lack of water needed to cool their systems. As Texas showed in Winter 2021, cold can knock out both fossils & nukes. Imported fossil power may have been a band-aid for California in 2021, but isn't an answer long-term. What could help: new grid links to windier Midwest US. Their profitably exporting a wind bounty as to California & Texas via new grid boasting links. Especially if better protected from Wildfires. Built with storage, more wind/solar, a resilient grid makes sense 2020s. Especially as drought is now threatening hydro, gas, nuclear, coal. All hit hard too by increasing weather / climate extremes that must be expected.



Source: CAISO.com Outlook – On July 30, 2021 at approximately 3:30 p.m.

So what to do in a 2020s decade? Changing tack, let's recall past possibilities of Tax incentives for energy storage. Back in 2020 proposed pro-storage tax changes had passed in the House – but failed in Senate, nor were they supported by a President who had opposed green. 2021 did see a new President but reconciliation BBB failed in Senate. By 2022 it was possible parts of text might be attached to broader bills, or tax extenders, or simply narrower stand-alone legislation. Such tax credits, once so crucial to starting solar – could again, possibly, grow vital to storage, batteries, grid. A big 'omnibus' BBB bill had failed 2021. But piecemeal tax-credit language carried over from BBB was maybe possible in spending or tax extenders say 2022 and onwards. It's a chicken & egg problem. Solar had needed both ever-cheaper panels – & favorable (tax) policies to light a fuse, prime a pump. Both were needed. This chart shows how fast solar then grew afterwards partly on pro-solar tax credits post-2006. Solar stands strongly on its own now – but like all else energy, earlier tax policies had mattered:



Sources: Wood McKenzie & SEIA

Tax credits for Storage, required before links to solar, so often were of little help. Unleash storage alone, by allowing investment tax credits, or better yet, cash in lieu and much can change. In 2020 there was just MWs of deployed storage – we need hundreds, thousands of gigawatts. No doubt storage will scale up with right policy. Repeat for batteries & storage - what recently happened in fast-growing solar. That would be of great benefit to and for all.

Just one upstream example: tax policy could help bring about at least moderately greener 'low-CO_2' lithium for batteries that's cheaper to boot. Where naturally hot lithium brine occurs, geothermal power from hot brine might make lithium hydroxide without water waste; freed from intensive evaporative ponds like lithium, no sulfur. Co-locate battery/EV makers – like polysilicon plants/solar panel makers - and to decarbonize as an organizing principle can promote lower-costs and efficiency. Ever better circular zero-CO_2 solutions.

Tax credits are important, change is possible. Maybe like seen in drafts extend solar ITC credit to 10 years at 30% plus storage, though prevailing wage goals may make it onerous to apply. Domestic content >55% rules could go to 40%. Near-term, WRO and anti-circumvention dominate 'in the weeds' issues but work here could mean helpful 30% ITC to 2030. Ability to make use of the PTC (besides ITC) in solar would be helpful. For Wind that PTC extended 30% for 10 years, better than annual threats of termination; direct pay option for parties not able to avail of Tax Credits. PTC again of 2.5 cents/kWh + a new base rate. Domestic content requirements to get greater tax benefits. Maybe diverse tax credit programs of past can be replaced by 3 for clean power, transportation fuels, efficiency. Perhaps possible: more equity for the one side and more rural jobs for other side especially in places coal was shuttered. All top line priorities in new energy policy (with maybe line items for West Virginia?!).

Last Few Years … and Indexes

ECO/NEX/OCEAN have all shown a vivid non-correlation vs fossils energy. What example of diversification! They have robust non-correlation: sometimes clean (alone) gained or goes the other way too, clean well down - dirty energy well up like 2021! Themes are all in *energy* – yet clean marches to distinctly different drummer versus coal, oil, and natural gas.

Before a 2020 vantagepoint so looking back from there, an interesting thing had happened. Dirty energy was then to 2020, recent worst performing sector of S&P500 in 4 of prior 6 years; down -30% in 2020 while clean energy roared. (In an S&P500 'energy' is mainly fossil fuels). For a sharp turnaround, fossils then jumped 2021 after very long in doldrums as noted. In sum last few years were remarkable for all energy – so let's look more at this recent period.

Consider what transpired when Covid-19 crash first hit everything hard. First it dropped most all markets worldwide, to a then nadir mid-March 2020. A thin slice of S&P500 that was within energy (mainly there, dirty fossils) was strongly off -51% in Q1 2020 – while the S&P500 was down 'only' -19%. Partly this gap was due to that 500 Index's cap weighting methodology. Just 1 very big component in an S&P500 that's based on market capitalization weighting, say Apple, might be potentially heftier than all its (dirty) in 2020 fossil energy combined.

That major Index has been slowly greening, albeit at snail's pace. An electric car firm was added to the 500 in 2020 – already America's 4th biggest company – yet curiously marked in that 500 as 'consumer discretionary'. A solar inverter firm was added 2021. As for energy in general we'd noted back in 2020 that (dirty) energy then was just 2.5% of S&P500, but was far bigger going back: 7% in 2015, 11% in 2010; 16% in 2008; and in 1980 dirty energy was 7 of S&P's top 10 by market cap, 25%! By contrast 28% was technology in 2020 was up from 18% in 2010. Some observers early 2020 hoped a big EV maker's addition to 500 might have come say mid-2020, to be 1.4% of that Index. That would have been significant given $4 trillion in Index trackers. But it was then still passed over, and was only added later for Q4 2020.

Drilling deeper let's consider US oil & gas behemoth Exxon. In 2020, Dow Jones announced it was dropping Exxon from its leading 30-stock Dow basket. Why? Apple was splitting 4-1 so that price-weighted Dow needed to find new component/s to better keep up with other baskets. (Dow had significantly lagged performance of late). New representation was chosen - but it wouldn't be from dirty energy like oil. Instead, they added 2020 3 tech-heavy names. Dow Industrials dropped Exxon that in various incarnations, had been in since 1928. Once a long-serving Dow component, no more. Only Chevron in oil, stayed. (Due to last decade perhaps when dirty energy fell – vs. a big coming rise 2021; indeed energy became big in an S&P500 as 9 of its 11 sectors fell September 2021 - while energy gained +14.3% - so in retrospect they should have kept in the dirty fossils – which really jumped at last 2021).

Thus make-up of financial baskets matters. Battles are quietly going on, influencing hundreds, even thousands of billions of dollars. Back in 2018-2020, a then-Administration on Dept. of Labor on ERISA law had wanted to know if there were 'discernable trends' in how retirement funds were investing in energy (FAB 2018-1). There'd been sizable outflows out of fossils – and into sustainable energy themes. It's been reported that fossil industry & climate skeptics were an impetus trying to slow inflows to ESG (Environment, Social, Governance) investing. They'd perhaps hoped to see 'non-pecuniary' goals, like climate change, get subverted. Afterwards a new Administration from 2021 soon moved from prior Labor Dept aims, and even explicitly pointed towards green themes as important. Still, it's useful to recall how a stealthy attack from top recently occurred (and failed) against clean energy in 2018-2020.

Real-world Returns for clean energy in that 2018-2020, up by hundreds of percent, are hardly 'non-pecuniary'! For that period, clean was up +300% (ECO), while broader traditional Indexes were well up too by a more modest +85% (Nasdaq), +40% (S&P500), +25% (Dow). And fossils oil and natural gas were then *Down* some -60% - though they soon spiked hard up in 2021. Interestingly, fossils & clean energy both nicely non-correlated vs broad Indexes last decade. Thus it was maybe no surprise at all to see billions of dollars flowing then into ESG, breaking records. 2020 ESG assets more than 2x that of 2019, reached $246 billion end of Q1 2021. In Q1 2021 inflows reached $55 billion, vs. $41 billion Q1 2020. Assets in ETFs/ETPs topped $6 Trillion for a first-time 2021. As ESG in particular has been growing, it may be very volatile at times like 2020. And yet that attention to climate (IB 2015-1) seen in some baskets, has fallen under attack such as 2018-2020, reportedly by fossil fuels interests under ERISA.

So if proposed rules in 2018-2020 had sought to prevent a look at climate solutions, deemed as 'non-pecuniary', that's a bit curious given these glaring Performance facts:
2018-2020, Clean/Climate theme (at top) vs Traditional Indexes had left them far behind:

Source: finance.yahoo.com

Or in a window from 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. Like nothing in old energy. As was said then of clean equity's gains in 2020 by a brilliant man, "How strange…. Well, back to work". Doubtless future falls like seen 2021, lay ahead. Yet in 2021, China aimed to go from 11% solar/wind power generation – to 16% by 2025. Wind developers jumped on spurt of activity of expiring subsidies – they'd installed 72 GW of wind 2020, 3x that of 2019 (solar up 60%). But because that government's fund for subsidies had early in 2021 reached cumulative 320 billion yuan (near USD $50 billion) shortfall, its government briefly proposed writing-off some owed sums. In response a big wind developer's stock fell -30% over 4 days, soon rebounding afterwards once that proposal was dropped. Regardless, even with drops to come, sure ongoing volatility, new decarbonization has begun to figure prominently and with good reason.

Over 2021 that was smitten by diseases, wildfires, temperature extremes, and blackouts, we're increasingly seeing mounting evidence that the economy is a wholly owned subsidiary of the environment. And if newer Infrastructure package/s ahead, get yanked away 2020s decade – then ECO, NEX could all well fall *much* farther ahead! In what may be soon to come: one item getting lately growing attention is battery & metals production – where China's has clearly been 'eating our lunch'. Well, not just beating us us in the US, also many would-be competitors worldwide. A question for lawmakers therefore next years this decade: how to shape US innovation policy so that American battery & minerals production may again better compete across the 2020s. Having fallen so badly behind these past many years.

One key problem 2021/2022: the US was lagging badly in lithium, nickel etc for batteries. And in producing rare earths minerals which in fact are not very rare, yet needed for motors & strategic uses. As Sen. Manchin observed 2021, "We don't produce any of the rare earth minerals, or very, very, very little of any rare earth minerals that it takes to make a battery. We depend on other sources of the world … that we seem to want to be out of sight, out of mind, and we just say, 'Well, we have an electric vehicle." Nickel, for instance critical for batteries, electric cars, grid; yet March 2022 it spiked on short squeeze from $20k - to $100k/ton as Russian exports of nickel may be curtailed too due to sanctions from war.

This 'ain't our first Rodeo' in seeing the US fall badly behind, when it needn't have. We saw solar manufacturing decamp from Japan, US, and Germany - to China 2 decades ago - then on to cheaper Vietnam, Malaysia, Thailand. By 2020 the 3 biggest PV makers were all based in China. In 2022 the US lowered tariffs on PV, as it made little, just a few nascent PV makers. Problem is, this may be happening again for crucial batteries. Such needn't occur. But the US in 2021 had then only 3 big battery factories. Tesla's Gigafactories can point a way ahead yet we may see only say, 10 total big US battery factories 2030. There should be many more. 'US' factories here includes S. Korean etc owned factories, merely built in the US.

By 2030, so in less than 10 years, China's smartly on track for 140 big battery factories! Europe is ramping quickly too; it looks to have 17 big factories. On projected US demand for electric vehicles, there ought be 20 or more battery factories in 2030. Not inspiring, in 2021 there was only half that, 10 – that were on track. To be up & running say 2026, such factories should have been in their initial planning back in 2021, with construction starting in 2023.

All underlines a need to act pre-2025, to *Cut CO_2 emissions - where the world is failing badly. US is clearly far behind China - even behind a more committed Western Europe. If the US has as is expected 200+ electric & hybrid car models 2024, it should be producing more needed rare earths minerals for their motors. Rare earths are necessary in still greater abundance for wind turbines too. Lithium for batteries is a different beast; rather abundant in Earth's crust and not to be confused with rare earths (again, not so rare). The latter rare earths are necessary eg for magnets generating electricity from wind turbines spinning – or for taking amps of electricity and turning that into lovely electro-motive power pushing EVs, etc.

As said by Mr. Nikola Tesla, foreseeing later amazing inventions like potent magnets, wind turbines, AC electric motors, more, *"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 electrical parlor tricks by comparison, rotating fields exhibited by rare earth's possess awesome traits making possible unmatched blue-sky advances. Like batteries needing lithium or even basic iron, so too do clean energy's applied technologies often need rare earths for their magic.

Yet for all that, mining clearly means a range of environmental and social impacts all to be handled solemnly. Ideals like 'greener lithium' are tough, but at least 'greener' lithium made from hot briny waters & zero-carbon geothermal power is better than using water-intensive evaporative ponds & sulfur. So too avoiding mining company bankruptcies upending cleanup. Ecologically sensitive places surely must be protected from all mining. Meanwhile, some places are more amenable. And US states like West Virginia welcomed sourcing minerals from their ample disturbed sites, extant waste piles and old mines – creating good jobs.

Sens. Manchin, Capito, Murkowski have written bills to get rare earths from coal wastes, of which they've got rather a lot. Recent studies showed more greenhouse gas methane may even be coming from Appalachia's old coal areas – than from all of Texas' active & abandoned oil/gas fields! Places unemployment is high like coal country, arguably should merit special attention in local jobs for key minerals. Legislation considered 2021 had included incentives for domestic US solar & semiconductor manufacturing, a proposed LIFT America Act that could include domestic battery-making incentives and support for US critical supply chains. But given how far ahead China is already now, how much faster Europe too is moving, it's doubtful the US can get to what's needed in producing batteries, minerals, rare earths without a big push. Sadly the US is likely to stay dependent near term on importing these strategically-vital materials, and often from more ambitious (and at times goals-conflicting) China.

Possible changes could lay ahead. Cutting say the subsidies bizarrely still given to fossil fuels. A 2017 Report found $20 billion was given to oil, gas, coal in 2015/2016, more subsidies there than for clean renewables. Oil & gas can write-off expenses like intangible drilling costs, benefits from lost royalties on deep-water drilling, Master Limited Partnerships for fossils. G20 has advocated eliminating ALL dirty energy subsidies; a study says their removal could cut CO_2 emissions 0.5 to 2.0 gigatons, like removing to 2030 all annual emissions from Japan. An initial Covid relief bill initially had $8 billion in tax breaks for 77 fossil firms. Given it's all from a public purse, public health burdens of fossils are massive, it's sensible to end that. But, that would be stridently resisted by those industries and so in the US House & Senate.

Oil & gas will have a fight ahead, as coal can attest. In 2021 the International Energy Agency (IEA) had predicted to be climate neutral by 2050 would mean: No new coal mines; no new oil & gas fields; un-sequestered coal use cut -90%; oil demand cut by -75%; gas use cut -55%. An IEA that's funded partly by OPEC nations, still predicted per capita fossil earnings there may fall from $1,800 in 2021, to $450 mid-2030s - if fossils are so slashed. No surprise several oil-heavy nations and entities called the IEA's 2021 findings "fantasy" – not realistic.

Yet IEA criticized too Developed nations behind much cumulative emissions, & their Pledges nowhere close to what's needed for 2 degrees goals. Calling them out too it states: "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 the typically vague pledges by corporations, combined with often very distant target dates.

The IEA says annual low-carbon investments must rise 2x+, from $2 trillion/year, to $5 trillion by 2030. It expects that in <30 years, 2/3rds power from renewables. It sees in 10 years EVs going from 5% on to 60% of vehicles on the road (China's vehicles boom is mainly electric). Planes run on biofuels, ships on ammonia - *green hydrogen* H_2, or ammonia NH_3, methanol CH_3OH, or biofuel. Carbon pricing worldwide including China to be effective; subsidies ended for fossils including the US to be effective. Green hydrogen for high heat in industry.

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

We'll discuss ahead, but a point is that oil's crash in 2020 was a *crisis* for it (until rebounding, only then could OPEC restore 2 million barrels/day production). By contrast, the green themes like solar - can & do move very differently. And future for clean is thankfully different. Key drivers differ too for solar, where there's ongoing consolidation & growth. For instance, in 2020, one US solar maker sold its operations & management arm to another O&M. A big integrated solar name split in two. Vertical-integration was once seen as positive: before it had both made panels/and installed and serviced them. Split by spin, newly specialized, parent refocused downstream on just selling PV in North America. It's a big market, with thin margins: new storage allows it premium branding and can get bigger. That in-country work can't be outsourced, nor done overseas by cheap commodity competitors elsewhere. While there was rising PV inflation in 2021, longer-term, solar will see more *declining* prices.

It all shines a light on tight margins downstream & consolidation. Post-spin, that parent *may* see better valuations in a heated space. US PV installs are rising; a separate merger 2020 had brought 2 US solar installers together as 1 behemoth. Post-2021 the latter *may* see robust valuations, more comparable to that other standalone solar name (less dependent on Net Present Value, NPV). Meanwhile, everyone is seeking lower-cost access to capital.

Upstream, that spinoff premium PV maker 2021 enjoyed China patent protection & pricing power (2-4 cents/Watt commercial, ~4-8 c/W residential). But margin pressures unrelenting; so shipped cells, rather than panels to shave costs. There's a huge commoditization across PV upstream ('just get good panels, least cost') module pricing down ~80% in 2012-2020. Module capacity then well up from 2019 to 2022. Downstream, selling say efficient premium, back contact panels may help hurdle razor thin margins. 2021 module prices were near $0.20/watt reflecting price inflation - but spikes *may* be subsiding. It will be interesting to see how performances of these two 'cousins' unfold. In 2022, their mutual exclusivity softened. One a 'new' premium solar product maker - the other, now separate, for solar sales & installs.

A roller-coaster recent past, exhausting & thrilling. The stock chart remarkable, nothing like it, now 100 pages in an ECO Report. Overshadowing much was the pandemic, now endemic. Job losses jumped in Great Lockdown. Many markets cratered – and may do so again ahead. Oil imploded to places not seen in 100 years, then bounced back hard. Attention paid climate and clean energy solutions – briefly derailed by pandemic – has again resurged especially in light of new and ongoing weather extremes. And some action 2020s on infrastructure.

Moving on, let's consider a past 5 years. Fossil fuels stand out here for their long declines, then rise hard from 2021 in 5-year chart. Until a few years ago, ECO in past 5-years periods had generally often been down. Breaking that from end of 2019 ECO left a long spell negative past 5 year timeframes; at first clean energy was up, positive, returning +50%. Then, end 2020 past 5 years was even more striking divergence: clean then up +300% as green jumped – even as dirty themes were down by -30% to -70%. By end 2021, dirty was instead jumping.

Last 5 years to end 2021 by a mathematical coincidence could have improved – even if ECO had been flat-ish 2021, due to a declining. That was a mathematical fluke without much significance; just please do be aware of it given steep slope up all 2020 – then the sharp decline as 2021 became all about drops. At any rate 5 years captures a small sliver of time. Corrections happen, trees don't grow to the sky. Clean once long *down* past 5 years in prior Reports in the mid-2010s, had shifted. A once more monolithic early 2010s with 'All of energy far down' (clean too) - lately has been changing in the early 2020s, by a lot.

In this 5-year Chart below clean ECO/NEX has left a down 2014-2016 period. It also reflects 3 positive up years 2017, 2019, 2020. So, gains in ECO, NEX, OCEAN were big absolute ways – plus more so relative to major Indexes too. With clean ECO peaking at over +500%, it left all dirty fuels & major Indexes 'in the dust' even with its 2021/22 falls, and jumps in dirty energy. Past 5 years here, ECO's tracker is strongest of all, up +180%; and global new energy NEX is up +100%. Performance by a best major Index 'bogey', NASDAQ is below NEX at +83%; while Dow and S&P500 are both near 'just' +55%. Normally anything up +80% in 5 years is a 'Win'. So, in an absolute sense, 3 major bogeys – especially NASDAQ, did well. Just relative to clean themes of ECO/NEX, did z major Dow and S&P500, flail – only NASDAQ nearish NEX. Far at bottom are two fossils: oil & gas themes, each far *down* dropping some -17% & -40%.

ECO/NEX trackers vs. fossil fuels themes and major Indexes, Past 5 years March 2017 to March 2022. Once, last 5 years had been 'tough' for all energy; here now, Differentiated - Clean ECO/NEX are at top – moving differently vs. traditional fossil energy Indexes:

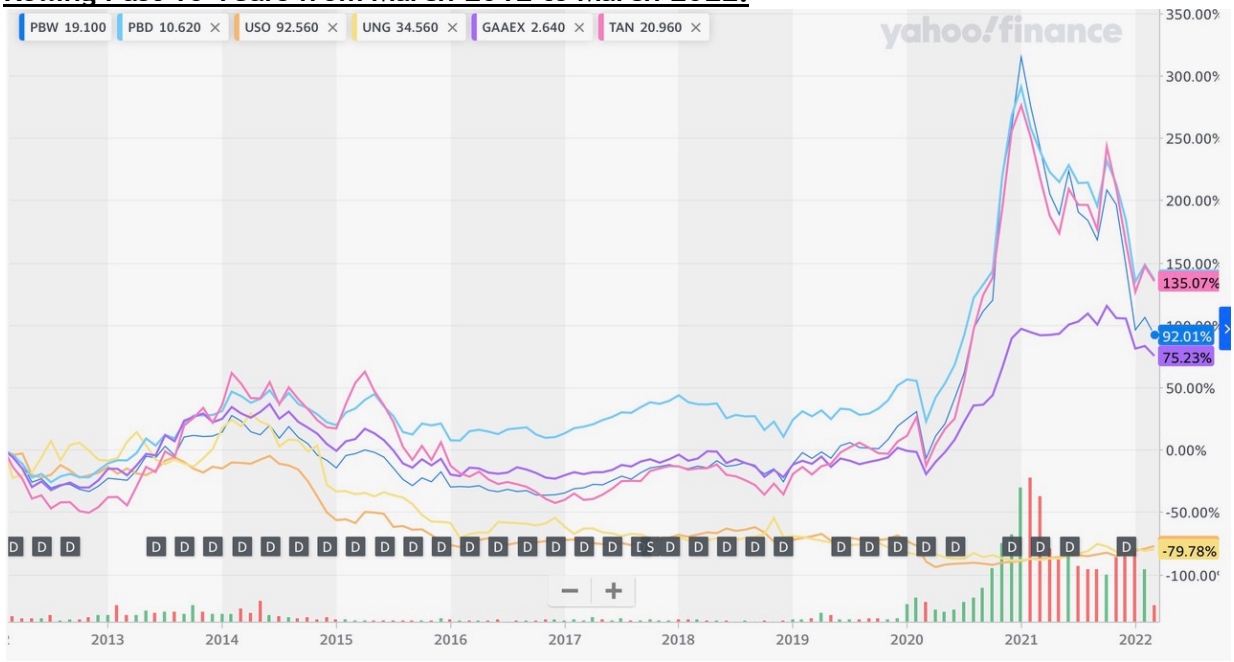
Source: finance.yahoo.com

Clean clearly, can & does plunge at times. So after tremendous gains for 2020, big drops in 2021, and early 2022 weren't surprising. Plus on the other hand, clean's gains may at times outpace broad Indexes, going up more. Consider August 2020: Dow gained +7% in its 7th best August since 1984. S&P500 was up +7%, its 8th best August since 1986. Meanwhile same month, ECO was up that August +20%, NEX was up +15% (nor was those their greatest monthly gains in that year: Nov., then Dec. 2020 next saw larger gains, before a Feb. 2021 peak).

Next page is a past 10 years rolling, here well positive for clean. Until recently, the clean story last 10 years had been a relative 'dog' (our apologies to all dogs). What changed? From a strict charting sense, it's partly due to leaving steep declines long ago, late 2000s and early 2010s. Those near then-final legs of a steep renewables plunge. So including any bit of those years had bent performance downwards. Clean at times relatively outperformed big vs. dirty since (but Not in 2021/early 2022!). Still, clean had plunged which warrants attention. Thus next is a rolling chart for rough past 10 years, March 2012 - to March 2022.

Here for past 10 years *Global* NEX tracker is up the most at +135%, a solar-only theme is nearly tied, while ECO is 3rd best, +92%. The start leaves behind a Great Recession that thunderously dropped all 2008-2012. That had put in bottoms at many tech stories, many moving well up afterwards. But not so energy, which got hit harder, stayed down longer. Especially seen in dirty themes, much in energy went on falling those 2010s, no immediate rebounding up.

Rolling Past 10 Years from March 2012 to March 2022:



Source: yahoofinance.com

Hard to see as so far down, oil and gas in orange/yellow are down -80%. Here's 2 new energy themes: *an excellent solar-only index basket capturing that theme; and *an actively-managed global clean energy mutual fund added too showing its very tough to beat passive ECO/NEX! 3 major Indexes' lines are removed, for better visual clarity. Of note 2010-2019 was tough: an independent ECO tracker start of 2010 was 55: it later ended 2019 at 34 so down. An independent global NEX tracker in 2010 was 16: it ended 2019 at 14 so down.

Globally, NEX is most positive of these 5 themes the last 10 years, as noted is +135%. Tied with NEX in light blue, is that excellent solar-only basket in pink above. ECO in darker blue is positive too for past 10 years, at +92%. Next is that active-managed alternative energy fund in purple up +75%. Meanwhile oil & gas are plumbing depths, far down -80% even after recent gains. A tale of two cities for the Past 10 Years: there were Big Declines in Dirty energy – vs Clean being all Well-Up to varied degrees. Until of course 2021/early 2022's gains for both oil & gas, while clean plummeted - that *might*, *possibly* begin to create a new narrative.

So very highest here are Global NEX/tied with solar-only independent Index, and ECO Index - outperforming vs. other energy here – and showed yet again it's very tough for active funds to beat Indexes. And all the clean baskets trailed broad Indexes not seen here, like S&P500. Fossils far down. As time rolls on, past earlier tough years in green Indexes like global NEX *may* begin telling a new story. As shown next, just how an NEX captures the global new energy story, thus the theme's definition is no backroom matter; it's very consequential.

The NEX as first for Global Clean Energy – consider it vs. a differing younger theme:

Consider next major differences between our Global NEX plus trackers in US and in Europe – vs. a different, younger, other global clean energy Index plus trackers in US and in Europe. That other global Index has several characteristics which set it well apart from NEX. One, has been that other Index had before been maybe a better choice for a highly concentrated basket made of biggest caps only, with little/no exposure to energy storage, electric vehicles, fuel cells, H_2 more. Because that other basket was so very concentrated, not-so-clean - it differed from the clean global clean energy NEX that's more diverse with solar, wind, EVs, energy storage, hydrogen, decarbonization etc. There are many other contrasting differences.

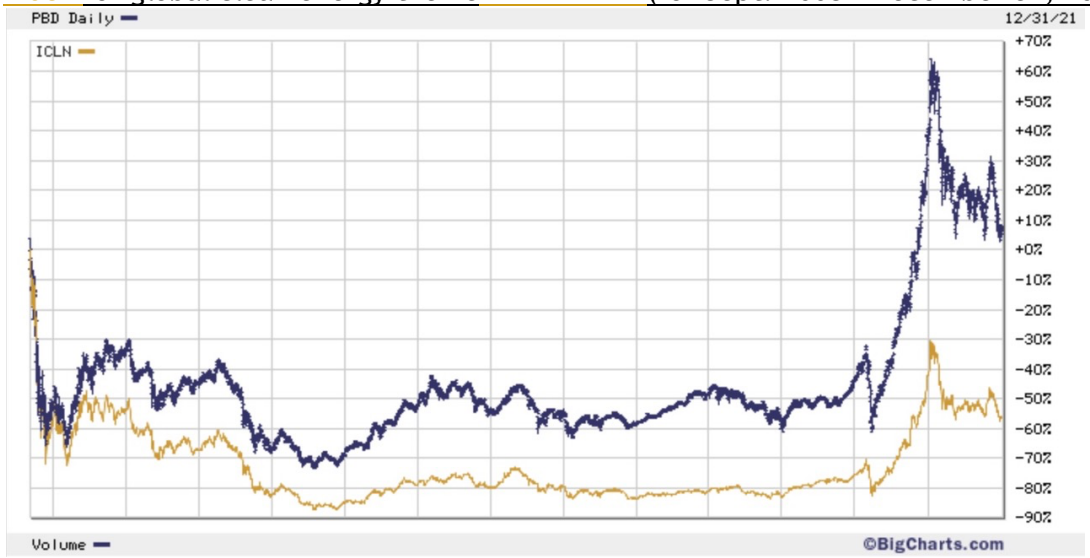
For example, late 2021 the green NEX's rating on carbon was far better/and more deeply green – than that other Index. The NEX is also steeped in diverse new innovation, unlike an old GICS (Global Industry Classification System) built on 1999 nomenclature. One result has been that other global basket has long fallen heavily within what GICS calls "Utilities". So, if aiming for not-as-clean, narrower concentration, just biggest names only, sparse or nothing in key energy storage, or in EVs – then that other basket had maybe been a better choice.

Consider too that their key divergence, has been Performance. In briefer periods, NEX vs. other Index traded leadership back & forth a bit. Shorter-time-horizons, one Index might lag the other, either way. Briefer time frames only, was mostly a wash, no clear leader.

But most longer periods, this key fact stands out: **Global NEX (seen here in bold)** has mainly well Outperformed that other Index that's also for global clean energy **(seen here in brown).** This is for most lengthy periods: the past 10 years, 12 years, since their inception etc.

Here's a Chart below for global clean energy as captured by both Indexes via their live trackers for over 13 years, Sept. 2008 - to end of December 2021. It's interesting to see how divergent their performances are for these two Indexes/ tracker funds. *In sum the **global NEX tracker (bold)** clearly shows far better long-term performance in global clean energy:*

NEX (bold) is the first Global Clean Energy theme and Up +10% here – vs a separate, other Index for global clean energy theme **Down -55%** (for Sept. 2008 – December 31, 2021):



Source: Bigcharts.com

As seen above clean NEX far Outperformed, by well over +50%. Why might that be? 4 factors may help to explain why that other global theme trailed so far behind the leader **NEX** for global clean energy. Perhaps it's because that other non-NEX basket has/had been:

* Heavily Restricted to just not-so-clean, biggest-caps – far fewer themes & stocks;
* Very concentrated too in top 10, or 30 names total (now it can be more post 2021);
* Heavily skewed by having to use modified-market capitalization style and weightings;
* Unable to hold very many stories – eg misses new storage, EVs, alt. fuels, efficiency, grid;
* Less Diversified across stories, and nations – with relatively fewer clean themes represented.

Nothing wrong with that other *per se*. Also provides a good contrast as between 2 clean energy Index themes! For other differences as between global NEX – vs. other global energy basket, the NEX launched/went live first in 2006 – well before that other Index. At Q2 2021, the NEX had 125 components. That other global basket instead and for years since inception, had only just 30 components up to 2021. Just 30 hadn't allowed it much clean energy scope at all. So wasn't possible for it to as well capture stories across EVs, hydrogen, fuel cells, etc etc.

Weighting styles matter greatly too. That other basket based on market cap weights, modified by a 4.5% cap, at times exceeded. Generally, at any rate, just 10 names in that other tracker might make up half or more its total Index weight! In truth global clean energy reflects far more than just 10 huge names of course. Yet concentrating that way has meant a biggest few, might push it up if momentum there narrowly did well up – or might pull that down.

As seen in shorter performances like last 1 year or 5 years, while the 2 Indexes at times trade leadership back & forth short periods - over very long periods, NEX does significantly better. The equal weighted NEX early 2021 had a much greater 125 names with far wider reach. And helpfully, its equal weighting style let more & smaller names be included and heard: each has a voice. Given such big performance gap over longer periods, it seems equal weights *may* allow passive NEX (& tracker) to better capture more - especially the smaller & mid cap stocks and inherently clean purer plays. *Please note though, neither approach is 'right': they're simply 2 differing methodologies*. 2 varied ways for clean stories to be captured. One's been highly concentrated, some dirty, biased to big – the other's been clean and wider-ranging.

As a practical matter that other Index's tracker has had a moderately lower expense ratio (though oft swamped by performance difference). And its heavy-trading has meant good liquidity. Overall, then, 2 takes on a fast-growing theme. Equal weighted NEX is truer to clean theme - vs. that Market cap weighted, less-clean, other emphasizing its Top few. Probably quite useful in the real world having 2 differing benchmarks in an-emerging global story. But: that other Index has faced vexed issues given how it was designed/built. One, arguably, was its excessive concentration. Tracker thus faced liquidity risks given design. As big & increasing sums flowed in, only a few concentrated names in its tracker, could overwhelm even its ('smallest') big stocks. That in turn, might *distort share price/s, and/or *take far too many days for its tracker to 'fill' at rebalance on regular or far above average volumes.

After a useful public consultation early 2021, that other Index made numerous understandable changes for Q2 2021 & going forward. Having always before had fixed 30 only components, it was first adding 52 more – and could go towards 100+, total unlimited. With unlimited ceiling it was again growing more like NEX; that made sense as new energy's story may grow ahead. This allows too for that other Index, to reflect the evolving story over time.

However very problematically, the other then could & did then, add *Non-Pure-plays* - outside of true clean energy. That *can* mean less closely adhering to a *clean* energy theme, instead to be only 'kind of global clean energy' basket, *less pure*. A big new difference then 2021 and after – vs. clean and purer NEX. That other Index was previously closer to clean; before it had aptly had very little fossil fuels like in natural gas or diesel. That changed after 2021.

After mid-2021, that other Index then can/did hold non-clean names. For just 3 examples 1) that other Index added at big 5% weighting late 2021 a utility getting only 8% of its earnings from renewables: it's instead doing fracked natural gas with enough gas pipelines to reach New York to Paris and near back again: it won't be clean nor sustainable decades at soonest. 2) They also added another dirty energy name, that again can't be in NEX as it is heavily in natural gas and has long been deeply in nuclear too; neither can be in clean NEX that's purer and true to clean energy. And 3) that other Index added in 2021 yet another electric utility also ineligible for clean NEX as it's generating electricity from oil & even by burning diesel (among last US Utilities to do so)! In 2020 only 35% of that dirty utility's power was coming from renewables, though in a region blessed with sunshine & wind. Later on, that other Index in 2021 did a market consultation to allow more changes, but notably, it explicitly allows much gas(!) just weighted then a bit less. And it kept unfortunately carbon 'intensity' as a scoring metric. That metric may allow inclusion of dirtiest fossil fuels, by a distorted false numeracy. Clearly, no doubt, fossil fuels don't belong in an ESG basket. Nor should they be in any genuine global *Clean Energy* theme. So that theme by seeking to fix distortions, had arguably moved post-2021 to allow itself to become instead 'kind of' clean energy.

We recall how years back, as small caps grew popular, big inflows had made it hard for active funds in general to hold smaller equities. Even under $1 billion(!) market cap. There was liquidity risk from inflows. So 'small cap' range inched up, maybe towards >$2 billion market cap or more(!) to accommodate growth. Some definitions got thinned out, or were diluted out of target concept – not pure. A ramification of fast-rising popularity of 'small caps' then was that it got harder to hold smaller equities as inflows grew. Whether active Funds – or passive Indexes. Consider now, ESG thinking today; green goals see tremendous interest. There's been an upswing of activity. Of 'net creations' especially in ETFs in ESG themes. One result may be that as investors open their Prospectus to see holdings, what's in ESG funds, they'll be very surprised by what's inside! Confoundingly many ESG funds today hold oil & gas companies, perhaps even names steeped-in-coal(!). That failure can, should & will be addressed. Greater understanding of ESG arguably ought to prohibit dirty inclusions.

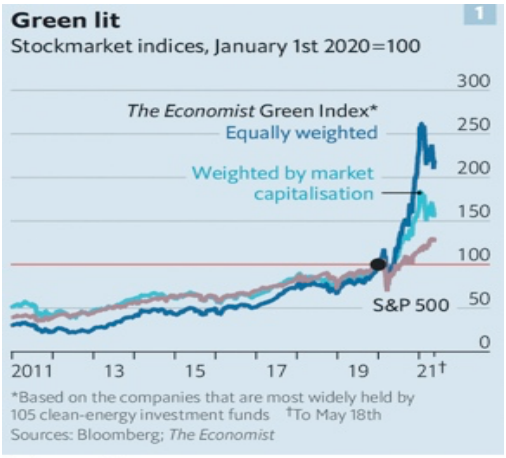
Arguably, priority should be staying true to clean/green. Not get pushed out to brown energy. Otherwise, prior focus on good targets (like robust zero-carbon) might get pushed somewhat off-theme. How in the world can oil & gas ever be included in a green ESG basket? Or, make any claims to be green ESG leaders? They shouldn't. But, one unfortunate way has been via a 'carbon-intensity' metric. It allows a big fossil producer, say on revenues of 70% oil & 30% natural gas – to massively ramp gas production to say 60% natural gas, 30% oil, 10% biofuels – and claim it's 'clean'! As CH_4 /natural gas spews somewhat less CO_2 - vs. oil or coal – higher revenues/profits might misleadingly lead to green claims. Nothing of the sort is true of course. But, that 'carbon-intensity' scheme lends false numeracy, seeming quantitative rigor - when opposite is true. Left side of equation, is correct: carbon footprint measurable in tons of CO_2 - Scope 1, 2, 3. But right side of equation, 'intensity' grafts on 'value' or revenues in Dollars, Renminbi, Euros. Yet the air cares not a whit 'how *profitably*' each CO_2 molecule was made, whether more *revenues* - or less! But an (intended) upshot is dirty fossils are given a pass.

What 'carbon intensity' wickedly can do, is lend fossil fuels a fig leaf. Seems quantitative, yet lets polluting firms claim green in going from oil/coal – to gas. Clever for its marketing, it also enables fossil firms an entry even into a few 'clean' (brown) baskets – or ESG funds. Ill-conceived notions like 'profits' per ton/CO_2, makes this 'intensity' slippery indeed.

So subtle, it's pernicious. Consider a startup solar firm, so tiny CO_2 emissions, negative revenues; it won't score well in 'carbon intensity' on few sales. By contrast a big fossil name massively growing fossil gas, with gobs of revenue, scores well. Its CO_2 is eclipsed by swelling profits for a better CO_2 'intensity'. Something's patently wrong with that picture.

For how instead a passive green Index, performs vs that, return to Weighting Methodologies. Interestingly, we've seen equal-weighted NEX has outperformed the last 10, 12 years etc – vs. a Market cap weighted Index. For how that may be relevant, consider a Chart below.

For how much better real-world results are for equal-weighted NEX - vs a market-cap weighted Index over long periods, note the literature. *The Economist* in 2021 wrote on their clean energy Index portfolio models. They'd constructed a Green Index, as seen at right: straight Equal-weighted, it very nicely doubled and so went up swiftly from 100 to over 200 in 2020, thus up over +100% … But a market cap weight version, instead had gone up by less, from 100 to about 160 or by '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; 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 inflows in 2020s are increasing into green & ESG themes, they also state:

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

The Economist makes a good relevant point: it's a surprise & dismaying to see any brown fossil fuel names - in an ESG fund. Likewise in any global clean energy Indexes or funds.

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

So, *global* itself, probably doesn't = volatility. But here clean, new energy *innovation*, may somewhat. There's much risk in solar, wind, EVs, H_2 or 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). It's been overly-dependent on Russia. It may thus seek green H_2 on security, climate concerns too. Says nothing of how equities may perform (maybe *down* like 2021, or up like 2020). Just reflects a very risky theme. Clean themes are volatile, uncertain; whether domestic (US) listings - or listings worldwide in new energy innovation.

Of maybe interest ahead, contributing to more volatility: in 2021 the International Renewable Energy Agency stated a startling $131 *Trillion* might be needed for clean energy by 2050 to avoid heating >1.5 degrees C. Nothing to do with war in Europe. Gas spiked early 2022 in Europe on horrific destruction; yet gas *may* peak there late in this decade. Global electrolyzer capacity *may* go from puny 0.3 GW 2020 – to 5,000 GW. Green H_2 may be feedstock for 'green ammonia' - or methanol/CH_3OH, - but that isn't true green if from fossils; that's greenwash. Europe potentially, *may* latter 2020s become a green H_2 leader. And China may soon ramp its nuclear – while regrettably only reducing its coal a bit (if at all) before 2025.

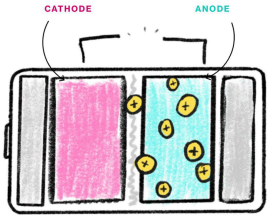
So great uncertainties abound, giving rise to volatility & tremendous risks. Myriad sub-themes *may* see advances, some incremental, some maybe non-incremental. Perhaps disruptive jumps. Advanced energy storage & batteries plainly merit focus all 2020s – and ECO & NEX have had exposure to that since 2004. New attention also needed to the Hydrogen Economy, and Wind Energy. And China has been a major presence across all themes in the 2020s.

Energy storage is a big deal, as the world needs far better, cheaper, and much more batteries. A fine piece in Bloomberg Businessweek was useful and well-illustrated ('The Hidden Science Making Batteries Better, Cheaper and Everywhere.' April 27, 2021; we side note Bloomberg New Energy Finance had been 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 a 'lithium ion' battery may have a constellation of materials besides lithium, such as Iron, Nickel, Manganese. And there's much effort at using little to no cobalt. While different chemistries favor varied characteristics, all batteries will basically consist of a *Cathode, *Anode, *Separator, *Electrolyte. The anode was once partly settled: graphite and maybe some silicon – maybe nickel niobate (NiNb2O6). But that changed with war in 2022 and shift away from nickel; maybe pure lithium anodes ahead can also replace graphite.

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

a) 4 basic battery parts:



Source: Bloomberg Businessweek

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

Source: Bloomberg Businessweek

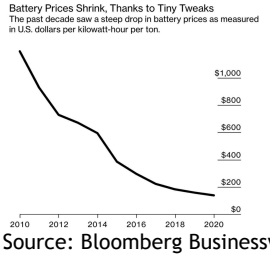
c) NMC as seen in a Nio:

Source: Bloomberg Businessweek

d) Tesla 3 has used NCA:

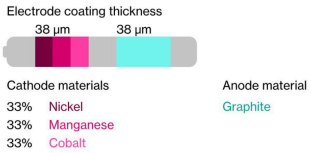
Source: Bloomberg Businessweek

Battery prices are falling hard:



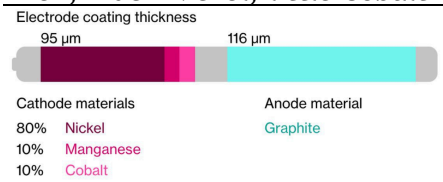
Source: Bloomberg Businessweek

NMC Composition back in 2012:



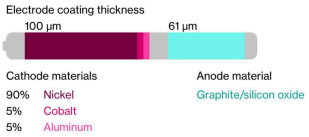
Source: Bloomberg Businessweek

Then, much Nickel, little Cobalt = thicker:



Source: Bloomberg Businessweek

NCA, light strong battery, no manganese:

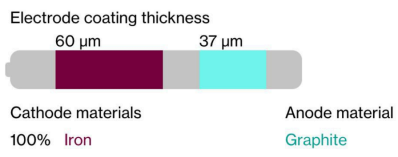


Source: Bloomberg Businessweek

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

e) Electric Buses using LFP lower-cost iron:

Source: Bloomberg Businessweek



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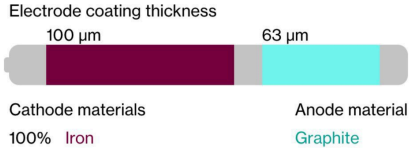
f) Modern LFP, a bit less-energy dense:

Source: Bloomberg Businessweek

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



Source: Bloomberg Businessweek

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

Figuring out how to add a bit more silicon at the anode, without swelling, may show promise. Farther ahead exciting metallic lithium batteries could be – should be - very impressive. Fire risk was untenable in 2022 since 'dendrites' can penetrate electrolyte. But new-generation solid-state batteries later this decade may be tantalizing. Drumbeat of wistful ever-on horizon solid-state batteries hopes, in past so-elusive, *may* be getting closer. Possibilities of non-incremental advances towards solid-state batteries this decade may make one hopeful.

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

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

Iron is so key in our planet's backstory that most likely life was fated to use it abundantly. A star like our Sun, burns by fusion. Start with lightest element, hydrogen – it fuses to 2nd lightest helium, releasing both light/heat. Over billions of years fusing, stars create helium atoms and then in turn fusing on towards the heavier carbon, oxygen atoms, and silicon. In supergiant stars, iron is their terminal stage as stars age. Given it's such a stable atom, once that star's core becomes iron, it begins to die (giving life in turn, after death). On reaching a terminal iron core, no further energy can be released by fusion. More energy required than released, thus it may go supernova. That great resulting explosion spews immense amounts of iron, oxygen, carbon atoms etc out into space. If and when gravity later coalesces those elements into what may become planets, asteroids etc, that iron is again easily found.

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

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

Expect battery technology advances. Fundamentally, these differ from greenwash that only dresses up carbon-laden fossils with spiffier-sounding names. Beware of greenwashing; without cause, it perpetuates dirty. Please be aware too some phrases mislead just a bit. As noted, lowering 'carbon intensity' isn't actually same as lower actual CO_2 - but instead, is based around rather duplicitous profitability. Or, say strongly-scoring E Pillar ESG number - doesn't correlate necessarily with lower-CO_2 emissions. Or a big oil & gas producer may say 'lower emissions' intending that as its own operations (scope 1) only - and ignore scope 3 emissions; or it may regard efficiency as the responsibility of buyers. Or 'carbon credits', or 'offsets' can game true emissions reductions. Artful dodging like 'net zero', 'sequestration' or 'offsets', coupled with vaguely distant promises like 2050 - divert from more-pressing goals of real decarbonization now. At once, first half of this decade according to best science.

Lest that disappoint, gaslighting, greenwashing, or dissembling, are oft last gasps of a waning industry. Fossil interests can/do see writing on the walls. Solar & Wind vs older coal – like Electric Vehicles vs older gassers - arguably are already known as the Superior Technology. They've 'won' in a sense. Next decade+ important but more granular is filling in the blanks. Mid-term incumbent natural gas now faces competition from batteries/storage, especially on gas' 2022 price spikes enabling competition in just a few years. Longer-term, much riskier, just maybe: green H_2 *might* be viable for heat in buildings and industry. And as always these are all very risky in baskets here capturing dynamic evolving themes. Looking ahead, we're at start of an innovative new decade, a future entirely uncertain. Let's briefly look back now at a past decade+ in Indexing, for brief elucidation on time frames and Charts.

A little point about Charts. An issue with **rolling** Charts, past 5, 10 years is years ahead, these *may* show very different returns ahead for ECO & NEX. As charts leave falls like 2008-2012, tough energy times 2014-2016, and 2021, then with relative drops removed, ECO/NEX *may* show far greater relative gains. For that reason, a view is needed too with great ECO declines like 2008/2009, and 2021 preserved: hence this Chart below. From a fixed (not rolling) 2008, it looks onwards. Longer-running ECO+tracker could have begun in 2005, yet other trackers didn't commence until later – so an earliest feasible start was 2008.

Over now 15+ years & growing, this *non-rolling* chart shows Very Big declines. This period fossils lag behind green sizably too. But relative to rolling 10 years, one vibrant difference is those global green plummets in 2009, and in 2021, are highlighted and forever preserved.

Farther back we'd note too an ECO predecessor in the WilderHill Hydrogen Fuel Cell Index had informally calculated 1999-2007. Given this ECO chart below picks up from 2008, we've uniquely been capturing hydrogen & fuel cells for over 20 years now since 1999! For H_2 and FCs one can visit our 20+ year-old 'predecessor site', the Hydrogen Fuel Institute, http://h2fuelcells.org So, this chart below preserves as in amber, some big drops after rising in early-2000s. In 2008 some trackers commenced, near peaks, all soon plunged. That first 2009 crash hit countless themes globally. A bog & deep mire afterwards that stretched across all clean and dirty energy for years mid-2010s, is brightly preserved below forever.

Starting from bottom we can see the fossils oil & gas are far Down here, some -90% or more(!). 'Above' them/down less is an excellent solar-only theme here off -75%. An active managed alternative energy fund, is off some -60%. 'Above' that/still well down yet rising steeply at times with big falls is ECO at -50%. Clearly 'highest'/least down energy themet is the global NEX though well down at -24%. The broader major Indexes (not seen here) all did *far* 'better' – yet they differ sizably - energy is only a sliver there. Generally speaking volatile ECO/NEX may really rise in climbing markets - and can/will plummet really hugely in declines:

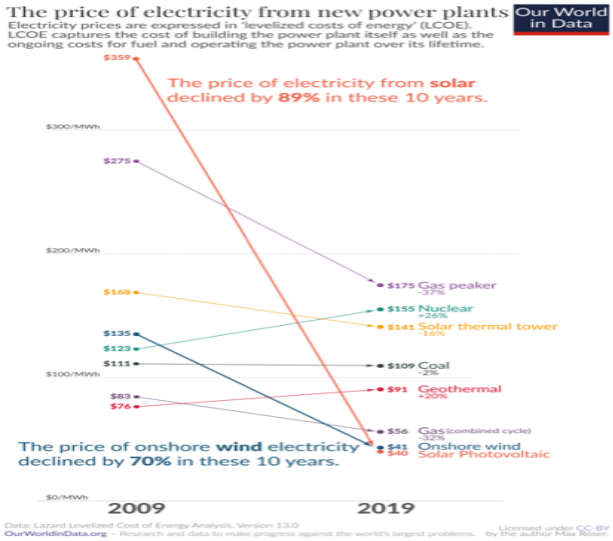
<u>Roughly Last 14+ Years starting from a Fixed June 1, 2008 to March 2022:</u>

Source: yahoofinance.com

So that's looking backwards a decade or more in the past, when clean energy was just born. A flip side to America having had so-near-zero-green power in 2010 - is despite some growth - where we stand on renewables in absolute figures 2022 was *Awful*. By 2022, offshore wind 'should' already have been hundreds of GWs, instead it was near-non-existent. US had total only 7 offshore wind turbines in 2021; Europe had 5,400. Solar in 2021 made but 3%, wind 8% of US electricity. When solar & wind *should have/could* have met all US electricity demand. Instead, electrified cars, trucks, ships, airplanes still were but a tiny rounding error in 2022. It may feel like we've come a long ways – *but only given how dismally we began*. Our World in Data figures show that fossils made up 79% of energy production worldwide in 2019. Vexed dirty fossils were the bloody cheapest option of all then, so no surprise. Low-cost meant all. Plus, they alone, like nukes offered firm, dispatchable power. But not much longer.

Solar is forecast to wallop dirty on cost ahead; its price plummeted 89% in 10 years to 2020 as costs for solar, like for wind & storage too dropped hard. (2021 was an exception given inflation) Coal, oil, gas by contrast all grew relatively- (much) costlier: they all pay for fuel. Fossils are bound to be costly to operate, plus they must pollute, and are powerless to reduce their cost follies 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 is 6-fold more than all annual war deaths, terrorist attacks, and murders combined!!

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



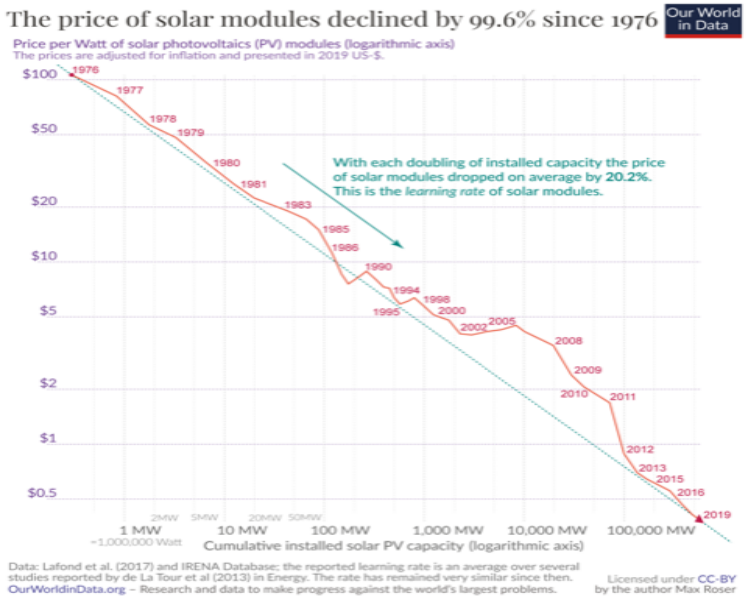
Source: Roser, Why Did Renewables Become So Cheap So Fast? Our World in Data (Dec. 2020).

Thus fossils & nuclear are poorly-situated 2020s as long-term ways to make electricity ahead. They're vexed by eg *Fuel costs, *Wastes (and nukes must store for centuries!), and *High Operating Costs with hundreds+ of employees for costs that won't decline. And of course, CO_2. Even for less-GHGs nuclear, each new non-standard US nuclear plant costs yet *more* to build on risky 2022 technology – exact opposite of cheaper solar/wind/batteries. What they had going for them was a firm, dispatchability, but renewables will have that ahead too.

In a coal plant, fuel costs may eat up 40% of operating costs. Natural gas fuel costs declined 7 or so years to 2020; that trend was broken 2021, when gas spiked, Natural gas has spiked far higher in Europe (and Asia). Coal did too as carbon trading meant significant new costs. A downside also was China backed off ambitions when it too faced an energy crunch in 2021,

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

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



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

Solar prices fell enormously -99.6% since 1976(!) on technology. In 2022 US tariffs on PV made in China were further reduced so that it enters US freely, cheaper still. Fossils – by contrast - are Not all about technology; they may be doomed the long-term even apart from carbon. Costs declines in wind too are impossible for dirty to catch. How can coal, oil, or even gas hope to keep up for decades with this lovely curve? They can't if economics is the metric. But fossils have inertia, influence, capital, lobbying are deploying it all. No doubt they will Not go gently into that good night. Natural gas & nukes have notable roles yet in this 2020s decadal energy transition. In sum, it's no wonder solar & wind power make up most power plants built today – along with growing storage. Plus, here in green basket/s, storage is crucial. How an Index is constructed, where it aims, as we'll next address – is very significant.

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

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

But not very much, really. Initially its 100 companies in 1984 had a market value about £100 billion – and that Index started at 1,000. By end of January 2021, it stood around 6,400. That annual gain over 37 years was just +5.1% (or +7.6% annually including net shares issuance).

This (not so great) return was No straight climb. As noted in MoneyWeek in 2021, it had peaked in 1999 earlier at 6,930. Later it passed that in 2016, next 2018 at 7,877. But in Jan. 2021 at 6,400 it stood out as being only +11% higher than where it had been some 15 years prior. Then in March 2022 it was at 7,500, but that was up a mere +3% from where it was 5 years prior. Much stronger growth rate was seen from 1984 to 2005 when it'd had a much better return compound average growth +12.5% (real terms +8.5%). But 2005 through 2020 annual growth rate had been much slower. Only 2% ahead of an inflation that then was at +4.7%.

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

What can account for such a lugubrious showing by FTSE 100? One is its biggest components at start was BP – oil & gas. Recall how poorly US oil & gas energy companies fared say in S&P500 many years. Terribly, is how they'd acquitted themselves - before 2021. Hence, it's not been BP per se, but rather maybe was just partly a bit about oil & gas in that regard.

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

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

There's been some names related to health/biotechnology like AstraZeneca. Some tech like Aveva, Rightmove in web-based real property. But last 15 years, or obviously 5 years to 2021, the FTSE 100 returns clearly have lagged behind Wall Street/ US broad Index baskets like S&P500, Dow, or Nasdaq 100. And FTSE 100 was absolutely crushed last 5 years to 2021, by the two trackers for our own global new energy innovation NEX Index, and ECO Index.

As pointed out, part of FTSE 100's issue is an absence of organic growth in its components. Sage plc has enterprise software, Next plc has clothing retail, but much had entered top 100 by mergers & acquisitions – not a good long-term ramp for growth. An innovative Nasdaq 100, Nasdaq Composite - or S&P500 are different. As noted in MoneyWeek, the S&P had 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 are reflecting considerably more tech. A mid cap/smaller FTSE 250 had enjoyed more momentum in 2021 with innovative-equities, than FTSE 100.

In a 2022 chart below, clearly the bottom performance recent 5 years is FTSE 100, light blue. It was up relatively little this 5 years period though end of December 2021, a very puny +5%. Next up mid-cap FTSE 250 in purple did better, +21%. But tech-rich S&P500 in pink has doubled here up +102%. And **NEX in blue** is up about +140%; Tech innovation **Nasdaq, in orange** is most up +165%. To be sure innovation themes are always very risky: at times they'll drop very hard. Conservative = less risky. Yet in recent periods, tech, energy & innovation outperformed by far. So much so, one must be very wary of a bubble – and recall that the NEX – same as the risky very volatile ECO & OCEAN baskets - can and will at times surely 'drop like a rock':

5 years, 1/1/2017 through 12/31/2021; FTSE 100 & FTSE 250 at bottom - vs. the NASDAQ & **NEX** at top:

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's put it well ahead of large cap FTSE 100 that was up too, but 3.6% less per year.

Of course, all in hindsight only. It's impossible to say, beforehand, what Indexes, like which companies, will do well ahead. Some factors may be additive like emphasis on small cap/ innovation was recent years - big/conservative can do better in down years. In the FTSE 100 those big older energy firms in 2021 were 9% of it, plus mining/materials 13% - for 22%. By contrast those 2 old themes were just 5% of US market; 10% of Europe. In the US, tech was 28% and healthcare was 14% of S&P500; in a Europe-wide Index (ex-UK) they were 10% & 16%. By contrast those 2 were just 1.3% & 10% in UK. To quote The Economist from Nov. 27, 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." In sum, Index rules & construction, like definitions can vitally shape a theme. They matter. Next, let's look at a few possibilities for clean new energy ahead here in a world that's fast changing.

Recent Changes – and perhaps possibilities ahead:

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

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

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

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

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

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

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

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

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

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

Problem is, BP paying so much at a start makes it harder to reap high returns later. Arguably 10% returns are a very tough target anytime, especially aiming for no-risk. Too, oil & gas had earlier shown 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 once earned $100K+ working part-time: that bubble is largely now gone. Hard to think of a new job that matches what fossils had once paid, letting workers stay same place their whole lives. Today in green energy a worker in wind, years of experience & training may make good salary around $80Ks/year. Geothermal with drilling, $80Ks. Solar with some years of experience, $70Ks. But unionization rates have dipped everywhere including fossil production. Areas like pipefitters, unionization rates are relatively higher and it come with sizably better Wages and Benefits. Hence the fossils have been hard for anything to beat.

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

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

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

4% cap ex spending at BP for its new renewables & clean tech might not be terribly inspiring. However, an ExxonMobil in the US spent much less, under 1%; same for Chevron. And big Oil hadn't even made net-zero pledges until 2018. By 2021, the pace had 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 much talk of 'carbon utilization' & 'sequestration'. Shareholder actions will likely see some increasing success at prioritizing climate action.

Following huge 2020 cuts in supply, then only modest spending there as demand rebounded, oil/gas/coal leapt up in 2021/2022. But look back, further, and Big Oil stock valuations Declined big past 5 years. That's important. Perhaps the more fossil behemoths like in the US defy change, the more they *may* head long term towards becoming 'Not-Such-Large-Caps'. Those most wedded to high-CO_2 models might, possibly (Ahem, no polite way of saying this) go towards Irrelevance some 30 years from now. Like coal & steam before them. Take for instance, last 5 years to late Q1 2022. Even after rising, here's **BP in darker blue** in Big Oil at bottom, down -14%; hardly up near nil is carbon-heavy **ExxonMobil, in yellow**. In sharp contrast is Orsted, light blue, highest at around +200% (once in oil & gas, but sold & instead is in clean renewables like offshore wind). Well up, too, is a tracker for the decarbonization themed **global new energy innovation Index (NEX) in orange**, 2nd from top, up near +125%:

Source: GoogleFinance

Denmark's Orsted is rather a posterchild for past oil & gas firm, fully transitioning to clean new energy – successfully so. Growing more profitable to boot! No half steps, not dithering with 'sequestration' to prolong fossils. Orsted, robustly, launched into wind, solar, bioenergy. Benefits since showed up in its fast-rising market capitalization (above) - as BP & Exxon lose. Results are underscored in its Scope 1, 2, 3 rankings for emissions. Scope 1 means direct emissions by a company's own operations. Scope 2 indirect, is say power suppliers; these can be reduced even if a firm goes on selling fossil products. So Big Oil could stay in its dirty fossil lane while reducing Scope 1 & 2. But, Scope 3 refers to customers' carbon footprint using their product. Hence only green transition (like Orsted) to sustainable energy will satisfy this measure. Even if US Big Oil is determined to stay in dirty energy with facile CO_2 accounting. Or by claiming 'offsets' an oil company may pretend its rock gas is clean or 'green'. It may make dubious marketing claims – yet its Scope 3 nonetheless grows ever-tougher.

Big Oil in Europe has moved towards offshore wind well ahead of the US – on differing aims. Europe's BP, Shell, TotalEnergies arguably are right to do so: wind power is clean/green, unlike oil & gas. Big oil has cash, experience, engineering know how – like BP's with Equinor of Norway for US wind. What's needed too, besides wind, floating or otherwise and potentially in big oil's wheelhouse, is magnitudes more energy Storage. Big oil here could help accelerate storage: like by pumped air in existing caverns (not a CO_2 sequestration!). Weights for gravity storage mounted on old rigs, so much more. As noted, geothermal at lithium-rich hot brine can make cleaner power – & 'lower-carbon Lithium' for batteries. Lower CO_2 'greener lithium' may help displace hard rock mining, water-intensive evaporative ponds and sulfuric acid.

UK lessons learned offshore can assist US too on infrastructure like undersea cables. Facilitate offtaking power in a first-place. In this and more, the US has badly trailed behind the UK in offshore wind. In 2021 there was just 10 GW offshore wind in UK – yet it was a world-leader. The UK since aims to quadruple this decade, 40+ GW offshore wind - enough to power much. They could do more. The US by contrast even in 2021, had pathetically near-zero offshore wind power, despite being a vast country with bigger, windy, much lengthier shorelines.

Data from Bloomberg New Energy Finance, BNEF (our long-time prior NEX partner) - and US National Renewable Energy Lab in 2021 showed how badly America lagged Europe/ China in offshore wind. All can use big turbines – GE Haliade 12 MWs, Siemens 14 MWs, Vestas 15 MWs, 16 MWs from China - so consider a key obstacle has been US regulations. All of America in 2021 had but 2 tiny offshore wind farms. One was a 30 MW site, so equivalent to just 2 big turbines! That figure ought to be, and it is growing – but still happening much too slowly.

Breaking down the US Pipeline there's a Project Planning stage (developer or Agency initiates site control), then Site Control (lease/contract), Permits (plan+offtake agreement), then Approval (regulatory OK), Financial Close (sponsor investment), lastly Construction (build) and Operations. This doesn't include myriad lawsuits along the way. Nor political opposition, and sparse infrastructure to offtake power that's all halted offshore wind before it begins. Perhaps little wonder then that wind power had been so very absent from US shores.

Now changing like a 'pig in a python' are projects bulging near start. Projects in site control, or offtake stages increased +200% from a small base in 2018 – to 2021. In 2021 some 28 GW of various US projects were mainly early development stages. As slices of pie, already-installed US wind hardly visible at 30 MW, a tiny 12 MW in final approval – which was 0.1% of 28 GW planned in 2021. 6 GW more US offshore wind was advancing towards permit offtake, or 22%. It's a big ocean; some 60% of 28 GW pipeline, or 17 GW was in lease/site control steps. And there's many years to go yet in this decade - but progress is finally starting to be made.

US states farthest along 2021 in Site Control/Permitting were Massachusetts' 8 GW to come; New Jersey with 4 GW perhaps ahead; New York 3 GW; North Carolina 3 GW; Virginia 2 GW. Only one State had offshore wind in construction in 2021, Virginia's 12 MW then energized. Overall, the US is 'progressing' but still too slowly, although the 2020s are ramping.

Confoundingly all but 2 of 11 US States in its wind pipeline in 2021, were on the East Coast. Despite great Pacific Ocean/Gulf wind resources! One might've guessed there'd already be tens of gigawatts off Texas/Louisiana coasts - yet only California & Hawaii 2021 then had potential projects. Mere 1 GW in planning – and much needed submerged cabling. That said BNEF has raised estimated offshore wind projections by +70% from 11 GW by 2030 estimated in 2018 – to 19 GW estimated by 2030 as projected in 2019. It's been growing since.

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

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

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

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

Most crucial in wind, is pricing. Like solar, it was falling (to 2021), wind more modestly so than solar – but falling nonetheless. Both renewables growing favorable too, vs. costly current technology-nuclear, or coal, oil & gas. Once enough energy storage enters the scene, older energy although firm won't be able to compete with similar price declines of their own.

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

Once *offshore wind* gets a better toe-hold ahead in 2020s, regulations in place, new *floating* wind might have far greater presence. America's 1st floating ocean wind project only began in 2020. Meanwhile China already started growth in its offshore wind. Of course, China's solar is fast advancing too; China confounded expectations of a slow solar year in 2020 due to Covid. Instead, China's solar manufacturing *gained* speed in pandemic. First half 2020 China had produced 59 GW of solar panels, which was about 15% greater than in 1H of 2019.

Europe too saw early gains in its solar & wind, despite Covid. In 2020 EU made more power renewably – than by fossils. Nations there with **more* renewables in 2020 – had enjoyed *cheaper* electricity prices – obliterating a 'high cost' argument oft leveled against green. Critics ding renewables as 'suffering' from intermittency. Yet there was good power supply in 2020 in Europe - unlike power interruptions then in California & Texas. And a crunch late 2021 in Europe/UK – was mainly once again due to fossils, especially natural gas issues.

Back in 2020, in the EU-27, wind, solar, hydro, bioenergy then made 40% of electricity overall. Fossil fuels were 34%. With some notable standouts: Austria then made 93% mainly using its renewable hydropower, Portugal had 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 was continuing then to build enormous growing fleet of renewables - with pretty big moves away from coal. Its wholesale electricity prices went *down* near just 3 cents per kilowatt/hour (kWh). By contrast in neighboring more coal-dependent Poland, wholesale electricity costs burning its dirty coal were higher - more near 5 cents kWh. But that was Before the horrible war that erupted in 2022, throwing German energy into disarray.

So, Wind & solar can grow. From making just 13% EU electricity 2016, to 22% in 2020. Yet in a more pressing perspective, there's a long way to go given what's needed on CO_2. More renewables, more flexibility, ability to export excess power, transmission, batteries: all fast needed! Faster needed post-2022, immense moves away from Russian gas that put everything else on the table. US is making less progress. Renewables were just 18% of US electricity generated 2019, fossils were 62%. Recall again how European nations with *more* renewables, often see *lower* *Wholesale* electricity costs, rewarding green. The EU chooses to add more Taxes, rendering Retail power costs higher than the US – but that's a differing matter.

One surprise in 2020 was US extended 26% ITC tax credit by 2 years for solar & fuel cells; PTC $0.15/kWh for wind by 1 year. Yet a hoped for 'in lieu' cash from Treasury didn't then materialize. Batteries alone also couldn't get credits unless bundled with solar. Nor was a $7,500 credit re-extended for 2 big EV makers. But things change fast. And consolidations have continued, as solar has gone on maturing. In China, a solar maker sought dual equity listings on US & on China Exchanges, another in 2020 moved towards dual listings, a 3rd too. All with intent to unlock low-cost capital for growth; those were 'grown-ups' moves in solar – a commodity business where low price is all. A long way from just very few, only small solar listings possible for ECO and NEX as we well recall, back in 2006, even in 2012. Yet in 2022 fast rising cost inflation across solar inputs – had meant projects were being pushed off.

Facts reveal an energy landscape changing so fast, it challenges all we 'know' about energy. Clean energy oft now betters fossils on price and compellingly will do that soon *no subsidies* – growing more affordable than fossils & current generation nuclear. Economics is changing everything. And yet. Low natural gas storage has, and will cause crises - in electricity, heat. Coal, oil too seeing knock-on rises. And then, strong inflation, maybe 'slugflation', even stagflation. Not our Grandparent's energy world - or maybe, one simply different!

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

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

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

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

As we'd learned 100 years ago from Mr. Einstein, later in quantum science, flat to increasing entropy (disorder) gives us Time – a second law of thermodynamics – and Time moves one direction (centered on basic C, velocity of light). What's notable is time's arrow here, given entropy means that what we've learned in past, generally isn't unlearned.

In work for which Mr. Einstein earned his Nobel Prize, we saw light acts as both wave + particle in discrete quanta; we've learned to harness photons in solar panels better over 50+ years. Researching wavelengths, new solar panels might enjoy maximum efficiency ceilings higher still, vs. silly heat engines. And since fuel (sunlight) is free, doesn't much matter! On time's arrow, gifted by entropy, we've learned how to harness Mr. Sun's free photon packets at ever-lower, better costs per watt. Unlike fossil fuels, there's now a learning curve here. Profoundly it pushes ever-downwards on solar costs, often very rapidly.

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

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

Yet like older Newtonian Physics, what was once 'known', had misled. Semiconductors nano-scale display a bit of quantum strangeness: we make use of that. Smallest scales around us, space/time and gravity differ from past Newtonian suppositions. Weirdly different Quantum theory once bizarre increasingly explains reality. On greater understandings, other worldly weirdness (the truth) usefully-gets-harnessed by new technologies. Like how quantum entanglement mat allow charging EV batteries hundreds of time faster in the future. That physics is already essential to cell phones, GPS, Lasers, MRI Imaging, LEDs. Ubiquitous computers rely now on quantum effects not-heretofore known prior centuries. Revolutionary ideas, superposition of objects 2+ states at same time. Einstein-Podoleky-Rosen paradox of 2 entangled particles, though far distant from one another, seem linked real-time so appear to share information - inconceivably faster than light! (Entanglement & Copenhagen interpretation solved a latter thorny quantum puzzle). We've progressed as we learn. Space is not truly a complete vacuum; virtual particles may briefly snap in & out of existence. Photons may act in 4 possible ways, 2 are observed, other 2 options cancel each other out. Wonderful Mr. Richard Feynman's Rules of probability are weirdly, profoundly deterministic – or there is Hong-Ou-Mandel effect. (If interested in more, see for example Quantum Centre at the UK University of Sheffield, https://www.youtube.com/watch?v=ld2r2IMt4vg).

A point being for clean new energy too, we're learning novelties that at first had seemed so strange. Fresh ideas that may be embraced in energy – given *this is how the world actually works*. A few sacred old ideas maybe thrown out, progress! Jarring yes, but leverage for how we can advance – including new energy innovation. Especially as we move (one hopes) faster towards zero emissions for CO_2 and methane/GHGs, for softer, natural energy paths.

Lashing new lithium batteries to AC motors, to create electric cars, was one recent example. So too ahead, novel thinking about solar: Oversizing renewables may actually save money. This might seem weirdly brain-spinning, oversize solar farms. Yet there's room: just 0.3 per cent of the world's land, 450,000 sq km of 150 million sq km could power globe with solar. That's less land than used by coal, oil, gas infrastructure; dirty energies use 126,000 sq km. If solar grows super-low cost, over-sizing solar PV may easily compensate vs. costs of adding storage. 'Oversizing' solar – given the fuel's free – may not mean a big penalty like over-sizing any coal, or nuke, or gas plant. Moreover, solar power may in time be shared widely via grid, or green H_2. Ever over-size say, a nuclear plant? 'Fuggetabouddit'!! That nuke would be so costly, so inflexible, vexed by its wastes needing to be stored for centuries /millennia, that is a cul-de-sac of an idea for fossil fuel or currently 'old' 2nd generation nuclear.

Intriguingly solar *will* get very-cheap. Since electricity must be put to use immediately as generated – so we learned to avoid oversizing, including by curtailment. But in a new world, possibly 'wasting' some solar by overcapacity sunniest days, may obviate need for (costly) storage. Nothing like oversupplying dirty-brown electrons that carry all kinds of downsides. If clean abundant renewable electricity is ready at no cost, then H_2 & fuel cells ('fool sells') so once staggeringly foolish, only a few years ago, *might* just begin to make sense.

Leaving academic musings aside, let's return to practical: to markets and decarbonizing. ECO/NEX/OCEAN all saw sharp equity gains in 2020 – oil, gas & coal flailed by comparison. Thus, clean energy 'beat' brown that year. Then in turn, fossil fuels did much better in 2021. And solar even with green credentials, like much new, suffers from unneeded undesirable risks. We'll address a sad, unneeded risk next, one unnecessary and shocking of late. This is a possibility of unneeded/unwanted forced labor within a unique region.

An issue lately come to light, is allegations of forced labor in Xinjiang Uyghur Autonomous Region of desert in northwestern China. Of note, Xinjiang is big for silicon in manufacturing solar panels: that processed polysilicon is in solar PV that's made worldwide including in US. 'Poly' prices have plummeted for years to where it's become a cheap commodity, and 3/4s of the 2021 global PV polysilicon came from China. Of that originated in China over ½ of it in 2020 was co from that unique Xinjiang region. There was in 2021 no clear evidence that forced labor was actually involved in silicon manufacturing. But this matter is grave enough to be looked at very carefully; it's extremely serious – with a legislative response.

A few companies were noted by a firm in 2021 as having perhaps Xinjiang-region supplied content. A couple with US listed shares, widely found in US and global Indexes – and in a great many active funds. One of them in 2021 was in some 135 mutual funds; the other was in 165 mutual funds. Again, without any doubt, this issue warrants serious attention.

What's so tough is there was no independent confirmation yet, one way or another. Solar companies themselves strongly denied any connection. There's No need for any forced labor. In the US, the Solar Energy Industries Assn. sought to 2021 to ensure no forced labor was in any part of the solar chain. The SEIA aims for a protocol ensuring there's zero such labor.

Nonetheless one firm named was downgraded in 2021 to a Neutral rating on just a possibility. Again, no evidence, but without clarity the US and others can act given the gravity. 2 solar firms emphatically stated they condemn all forced labor, they do not use it in their factories; it is called "morally repugnant" and that they have "zero-tolerance" for forced labor both in their Xinjiang factories and across the supply chain. While US did not in 2021 call out specific solar manufacturers in Xinjiang, clearly just a notion of even-possibly abusive labor rightly raised warning flags. Just the possibility of such labor, has to be of great concern.

Side-note, separate issue: China' Rare Earths was also raised by that source elsewhere – but for far different reasons. (And besides mining's myriad ecological challenges). Given Rare Earths are vital in clean energy's spectrum: solar, wind, electric vehicles, batteries etc - another one of its reports looked at China's dominance in mining strategic rare Earths. Relying on just China alone for Rare Earths, maybe has placed the rest of world at a disadvantage.

US in 2021 imported 80% of its needed rare Earths from China, including for defense systems. That dominance may give China great tactical and strategic advantages & leverage, as clean new energy innovation gains steam. End of 2021 US rebuttable presumption language (of 'guilty until proven innocent) got passed law in UFLPA (Uyghur Forced Labor Prevention Act) – but with long lead time giving industry the time needed to prove no forced labor. They could say adopt traceability protocols, or move all sourcing out of the Uyghur region.

In conclusion, a burden for Xinjiang-based solar, wind, quartz, textiles etc – may be proving Absence of forced labor. And if evidence to contrary arises, that's enough to lead to changes in an Index. It's an unnecessary, unwanted risk, and one to be watched closely with moral implications as well. Possibly all suppliers, products from Xinjiang may face some burden to prove No forced labor. Some firms may relocate from that dirty-coal powered region. Others may move to listings off US exchanges, to China Exchanges. Likely traceability services, 3rd party Independent Audit Verifications. There's no call for unacceptable practices to seep into solar supply chains. Important too, moving to *non-coal* green manufacturing. Decarbonization may begin now with using clean renewable energy like say in a Northern Nordic region.

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

Musing on dynamics in 2022 and onwards, backdrops change. Mainly it's incremental. And yet new Trillions *may* be spent globally in this decade on new climate solutions. Infrastructure improvements, to grow green. In the US, utility-scale solar for example might grow by over >100 GW/year. US battery storage could grow by >50 GW/year, in time approaching today's total installed electric generating capacity. Here the US has long been a laggard.

This decade, 2020s, new attention is being paid to greening in Europe. Past stolid economies, once-long dependent on foreign gas imports, being reassessed. Yet 2 things seem certain short-term. One is, as Europe/UK moves early on away from coal & natural gas, will see repeat energy crises there in this decade – *but not due to a fault of renewables*. The UK for example, had earlier shut much of its gas storage capacity several years ago. Little's now left. On less natural gas supply coming into Europe 2022 engendering high gas prices on little gas stored – this meant heating, cooling and power generation there can at times get very costly.

Resulting spiking gas costs on sparse gas storage, is much more of an issue about gas – than renewables. Such crises would have happened anyway, had solar/wind not existed. However, the clean renewables will be blamed – rather than the vagaries of gas markets. So a gas draw-down – with little energy storage – risks price spikes and populist backlash when all energy prices spike. And yet around the world, people are on a steep energy learning curve. Mis-directions like in Texas when blame was put on wind *when natural gas* froze - face the truth. Still on China's voracious demand for coal, oil & gas, on Europe's early moves from fossils - whilst it can't yet set energy prices - means energy crunches & crises are certain ahead.

Also certain, will be new Opportunities. The Northern Nordics for example may turn their own cheap wind & hydro baseload power into green manufacturing. UK could ramp exports of wind-made power. Morocco, Namibia its solar. Iceland, geothermal. Spain & Portugal export solar across EU. Ukraine may try to modify pipes to export greener H_2 – vs brown CH_4 in Nord Stream 2. New undersea cables, could allow green power to be exported to grids far afield.

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

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

First, where did the US power grid stand lately? What will it then take for 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: much power or 38% came from natural gas plants. 23% was from coal fired plants; 19% nuclear; 7% wind, 7% hydropower. Only roughly 2% of US power as recently as 2019, was coming from solar power(!), 2% from miscellaneous other sources.

As noted, when US coal waned in Covid-19, gas & renewables became cheapest power – with some reduced CO_2 at first resulting from simply shuttering highly polluting coal plants in US (and Europe). But it produced only an awkward, short, unintended blip of reductions.

It implied what a huge slog lays ahead to get to a zero-CO_2 American grid. That said on pure economics of it all, to start early/now & to go hard will actually be the most profitable path. Current-gen US nuclear can't offer very much help; unlike solar & wind that each year get cheaper & better – this US nuclear instead has only gone up in cost. And it's impossible without enormous subsidies like a Price Anderson Act to limit liability. Nuclear plants once cost 'just' ~$7 billion each. Now a ridiculously-costly plant in Georgia cost $25 billion+! Their inflexibility once touted as an asset, instead has been flipped to become an issue vs. renewables.

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

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

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

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

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

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

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

If action occurs soon, note how plunging solar, wind & energy storage costs *immediately can change everything*. A US grid with 90% (or in our case, 100%) less/no CO_2 is not only feasible, it is reachable in 15 years – on *cheaper* electricity. Competing analyses differed on last pieces of 100% zero-carbon puzzle. Yet models often *agreed* on 90% – (we're using 100% as a goal), so a 2020 Report blueprinting how to get there from U.C. Berkeley is important. Also, a 2020 Report, Larson et al, 'Net-Zero America: Potential Pathways, Infrastructure and Impacts' by Andlinger Center and High Meadows Environmental Institute. Additional Reports have since bolstered this case. But we'll cite here to this Berkeley Report, and one from Princeton.

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

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

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

The study allows for all known 'zero-carbon' generation options. As expected its focus is on the cleanest: solar, wind, energy storage. Yet baseload with 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 nuclear, nor sequestration). In contrast to Zero Carbon path, No New Policy is merely the state & federal trends status-quo ante. That latter model reaches only to 55% clean by 2035 so would fall far short of what's required. Crucially this better clean plan means reliably all firm fully dispatchable power, as needed. It meets all demands in every hour of each day. There's no compromise on performance.

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

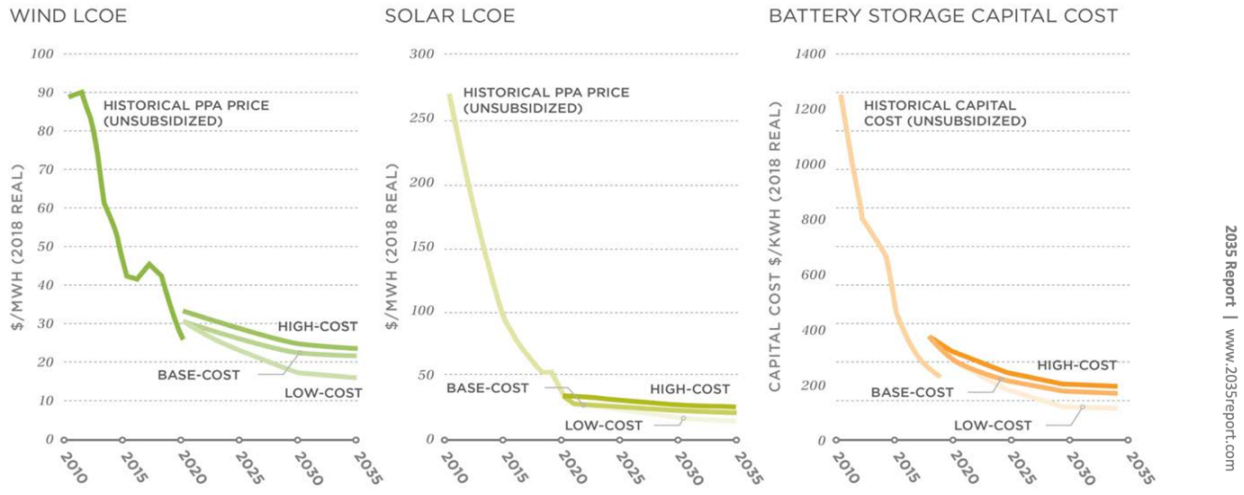
US energy generation growth had gone big before; natural gas grew by 65 GW in 2002. Now what's needed, changed: *energy storage* is 3rd leg triad to solve intermittency of renewables. Key new storage deployment needs to grow by 25% each year. Starting from a measly 523 megawatts storage in 2019, it should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

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

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

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

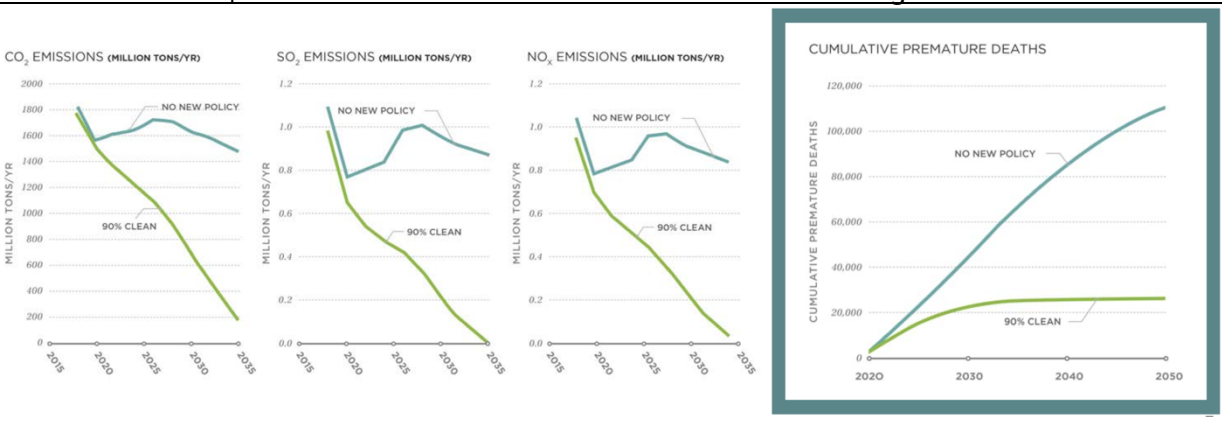
<u>Dramatic Declines in Costs Have Arrived 2020 Far Sooner than Expected:</u>



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

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

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



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

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

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

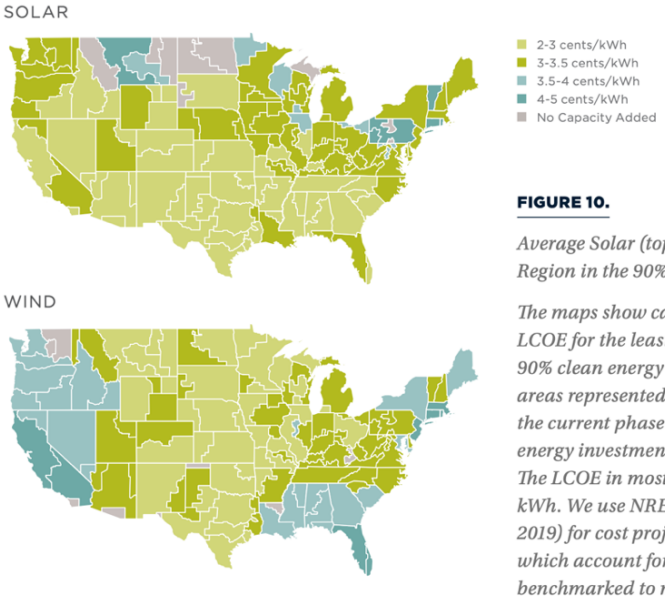


FIGURE 10.

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

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

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

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

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

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

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

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

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

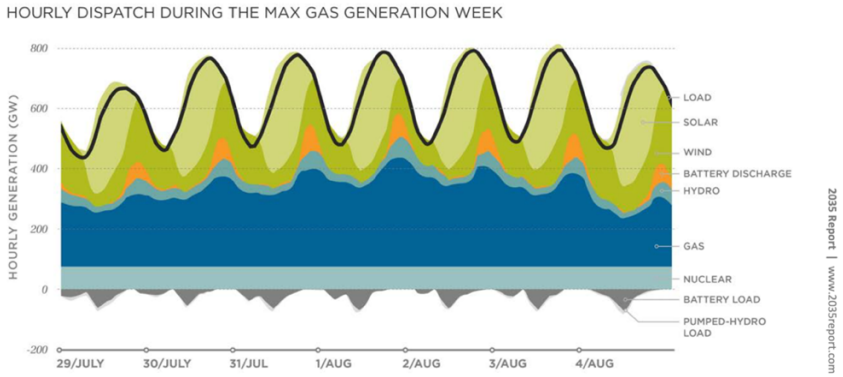
Over 7 weather years modeled, in normal conditions, wind, solar, battery storage generally, regularly provided 70% of annual generation; hydropower & nuclear provide 20%. But when there's very low generation by renewables solar/wind – and/or unusually very high demand, existing natural gas plants, hydro,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

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

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

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

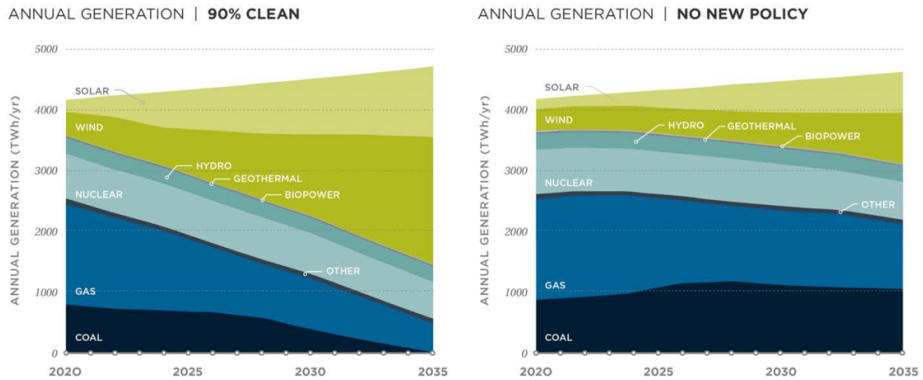
A Worst-Case Generation Period for Renewables: Still Moving Off of Fossil Fuels/Nuclear:



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

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

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



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

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

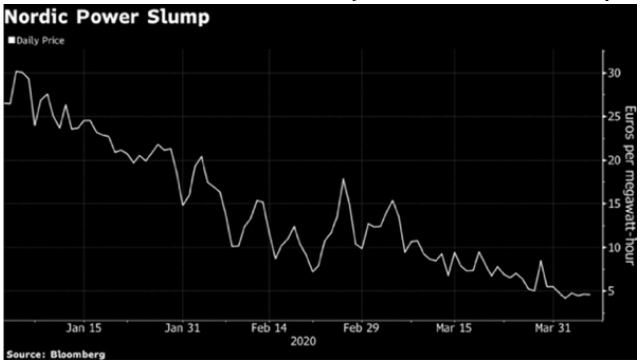
Recall some 'normal', pre-Covid, *applied* clean energy trends back early 2020. As renewable prices were falling in good & snowballing ways (unlike oil/gas). Start with Solar; costs had then hit a new record low: *only 1.35 cents per kilowatt/hour* at a big 1.5 GW solar farm going up in Abu Dhabi! True,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

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

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

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

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



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

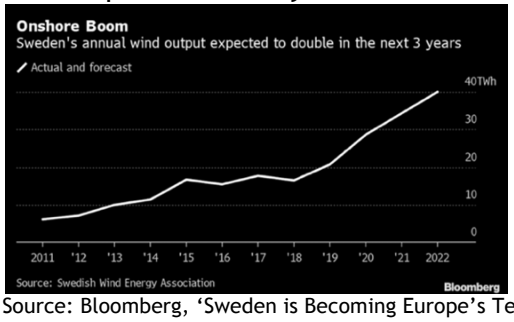
Yes, the renewables wind/solar are intermittent. Winds not always blowing, like if no sun, or no rains for hydro. Yet at such times, then other renewables too may be tapped. For instance, geothermal might possibly grow well as firm power. Especially when oil rig counts drop, geothermal may then grow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

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

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

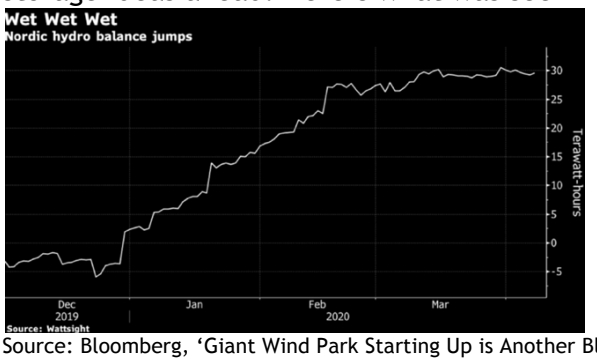
Dirty cheap northwestern China coal, had long attracted industries like PV; cheap electricity eg Liuzhou was an incentive to make EVs too. Yet Northern Nordics may potentially do it one-better ahead! If cheap/er renewable power can make green steel, aluminum - industries shall welcome that – as low embedded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

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



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

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



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

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

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

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

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

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

Mid-decade, new wind power hit a marker in 2015, when more renewables were installed, 150 GW – than all fossil plants added that year. Diverse kinds of renewables were growing common in Europe & to a lesser extent in US. Various clean power together on good days, so began to briefly even meet 100% of demand on occasion. Thus in 2016 all of Portugal ran just on its new renewables alone - solar, wind, big hydropower for some 4 straight days.

By generation type, renewables were pulling ahead of nukes. A first in its industrial history, the UK made more renewable power in 2019 – than from fossils combined. Unsunny, yet it still made renewable power on wind, hydro, & solar - plus not-so-green biomass. April 2020, UK solar made 9.7 megawatts meeting 1/3rd of its power demand; a one-off 10 times what it normally produced in a day there. Oh, what a change! 2010 its dirty fossil fuels met ¾ of demand, 10x that of renewables. Yet renewables next jumped to 40% by 2020, gaining since. UK coal-fired power fell from 70% in 1990, to under 4% 2020: coal may end in UK by 2025. Meanwhile, the EU has aimed for climate neutrality by 2050 – or likely much sooner.

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

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

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

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

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

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

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

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

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

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

Solar manufacturing capacity worldwide back in 2020 was then less than $1/10^{th}$, maybe nearer $1/100^{th}$ what we'll need - to be building PV fast enough. In 2020 we'd made a little over 100 GW/year worldwide. (Better than a puny 0.250 GW in 2010!). We've seen PV manufacturing becoming a low-margin, commodity business. Decade of consolidation, wringing out costs, growing capacity, PV growth steepening; yet 2021 and then 2022 also saw rising inflation.

By 2021, 9 out of every 10 PV panels was being made in Asia. Planet's biggest PV solar module factory in 2020 would be in Anhui, China: perhaps capacity for 60 GW modules by end 2023, each & every year. But given the economics, it's going up in 4 phases, to $2.5 billion. From a standpoint of where we need to be on CO_2 in 2035, that's but a start. Just a beginning. Still wildly small, if we'll 'need' 60% of global electricity demand to be met from solar.

Without vastly ramping today's trends, on current growth rates, global PV capacity may be 'just' 400 GW/year ahead. That may seem strong – yet it's only an incremental increase in global PV installed capacity. It means we're growing far too slowly. On that rather steady incline, it would simply take too many decades to get to 60% of all electricity from solar.

Given where we need to be on CO_2 and climate - solar must become very, very cheap energy. Wind too. So arguably, we also need Policy Changes now as well, for still faster ramping. It's a hand that CO_2 forced on us all. On carbon levels already over >400 ppm, and in the 2020s, nowhere near enough installed solar, nor manufacturing capacity to ramp solar and wind fast enough to 2025, hence policy changes are needed to speed matters. A growing China recently had the world's greatest existing installed solar capacity; the European Union was 2nd and growing; the US third. As emphasized, none are yet anywhere near where they need to be.

Think then of wind. Here, Europe may soon lead. And wind power can be crucial.

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

Texas' grid also intentionally lacks US interconnections, left antiquated. So its wind power growth shall be crucial ahead to Texas. Outside Texas, wind is rising fast too as a percentage of US power across the Midwest. In 2020, Iowa once an EV capitol had made 57% of its power from wind; it's not hard to envision a conservative Iowa going over 100% by 2030! Conservative Oklahoma, Kansas, the Dakotas, all had made >30% of their power by wind in 2020. Like a more Liberal Colorado, New Mexico, Nevada, Vermont. Offshore wind may come to Great Lakes too, US Gulf coast, Western US coast: maybe all offshore wind powerhouses ahead.

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

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

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

> "It's possible for the EU to become fully climate neutral by 2040, complying with the ambitious 1,5 C Paris Climate Target, and without any tricks, like carbon sinks, but just by going 100% renewable. ….
>
> … Solar PV and wind represent the two main pillars of the energy transition, supplying over 90% of power demand in the long run. …
>
> Clearly the transition to a climate-neutral energy system comes at a cost; however, perhaps surprisingly, moving slowly does not make it any less costly. The most cost-effective way of achieving climate neutrality by 2050 is a 100% renewable energy system. According to the modelling in this study, total cost of achieving 100% by 2050 is 6% lower than the cost of inadequate action in the less ambitious … scenario, which only reaches 62% renewables by 2050, thus missing both the targets of the European Green Deal and the Paris Agreement.

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

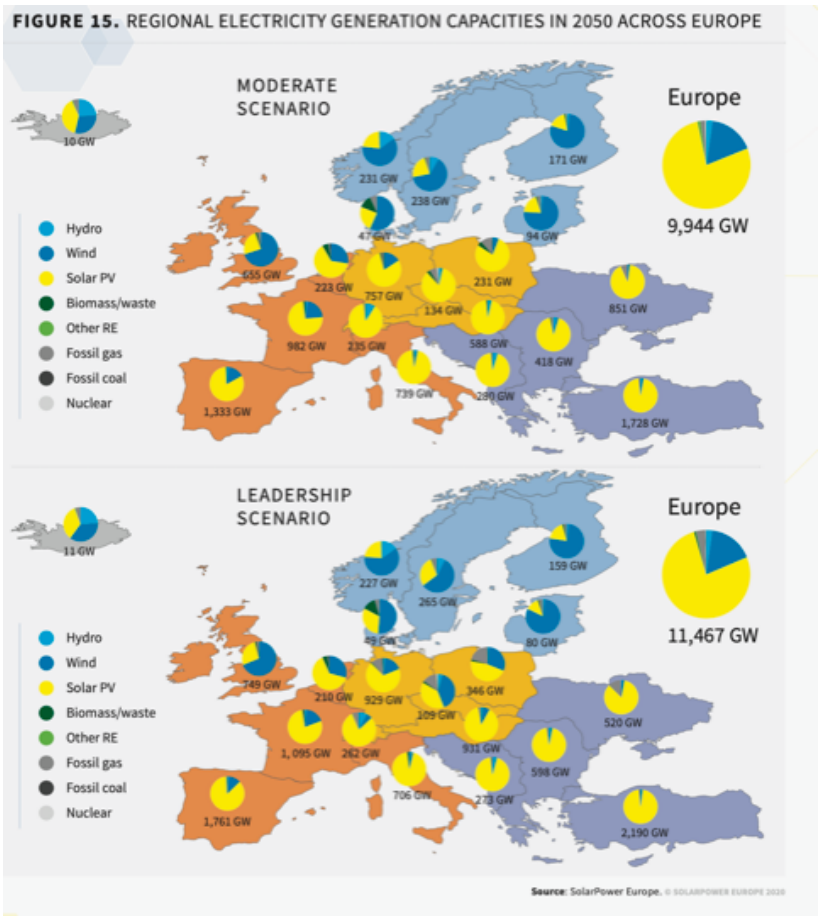
This Report recommends that policymakers should begin immediately creating a framework targeting installed 7 TW solar power – plus 1.7 TW of wind to be reached before 2040.

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

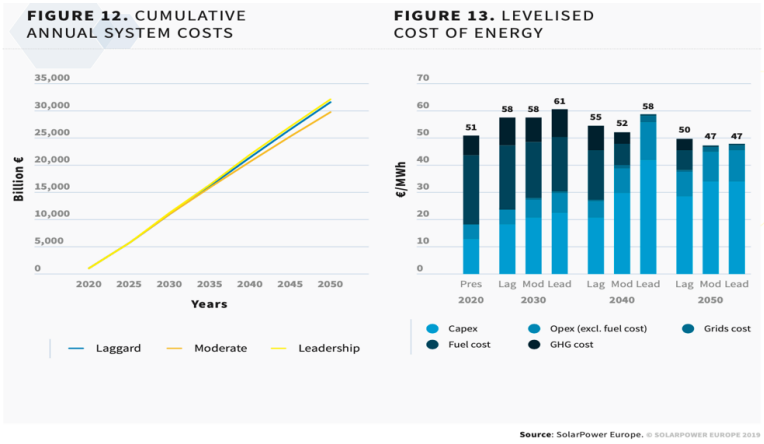
2 scenarios presented were Moderate approach – and Leadership one that's quicker. Former meets only 2 degrees C heating goal of Paris. Latter meets a more robust, better 1.5 degrees C goal. Again, it's a matter of when this ramp begins, so the angle of departure. But interestingly, the stronger and sooner the action, the more $$ is saved over time!

Moderate path doesn't achieve 100% renewables 'til 2050. By contrast Leadership path gets to 100%, 10 years sooner, by 2040. Better to move fast. Under it, Southern Europe makes vast amounts of solar power, in Spain, Italy, & Eastwards. Northern & Western European regions mainly use wind, given natural resources of Denmark, Norway, Sweden, Finland, etc. Similar approaches under both Moderate and Leadership scenarios, just differing rates.

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



Source: Solar Power Europe 2020.



Source: Solar Power Europe 2020.

Or, we continue as is – let vagaries of Coal, Oil & Gas throw markets, in loops over and over. While also making an eventual turn to clean – get to be much tougher than was needed. For recent proof of how volatile those fossils (always) are, look at oil in 2020/2021, next.

Why a Major Crash in Oil Happened in 2020 – followed by Oil Spike Up in 2021

Intriguingly, 2020 saw a remarkable, huge world oil crash. While some call that crash illogical, it arguably unfolded with rather explainable oil logic of its own. It started when Oil Demand collapsed with an onslaught of Covid-19. Businesses froze globally. Very quickly, surplus oil began backing up worldwide, just as we'd forecasted in a Q1 2020 Index Report. That Demand Destruction swiftly grew so large, as anticipated, where to store 'excess' oil soon was a real question (especially because, oil prices, as then expected went briefly negative).

Start of 2020 the world was producing 100 million barrels/day, well-matched to needs. Demand & production were then expected to (only) grow. Indeed in only just 2 of a prior 35 years, had demand for oil dipped – and then only a brief bit. Yet suddenly in March 2020, a monster demand collapse from Covid had loomed large; perhaps down some -25% or more.

Normally on slightly slackening demand for whatever reason supply can be slightly curtailed. Excess is stored, soon mopped up. But instead Saudi Arabia & Russia had *ramped* production up in wrestling for market control. On an important day, March 9th, crude prices plummeted by -30%: a greatest one-day 'fall off the cliff' in oil for roughly the past 30 years. In March US benchmark West Texas Intermediate (WTI) crude had fallen -60%, for an historic drop, from $60 down to $20. One big factor was Saudi/Russia ramp; also the *Demand* was dropping tremendously by -25% or more as world economies gummed up. A fear by the Ides of March 2020, was America's crude might yet drop well under $20/barrel absent intervention. There might then be 1.8 billion surplus barrels of crude, yet 'only' 1.6 billion of storage capacity.

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

May 2020 front-month WTI contracts would expire late-April. So, if -25% less demand was not met by great production cuts, fears grew of 'tank tops' like in landlocked Cushing, OK USA. Those May contracts would need to be unwound fast by traders with neither a desire, nor capacity to take crude delivery; that 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 at all! Not too much should be read into -$37 close. Contracts more months out were less distorted than May contracts, expiring as storage was evaporating. But WTI oil near $20, still showed that oil markets were in distress. Even a better global benchmark, costlier North Sea Brent crude briefly dropped down to near $20 by late April – but never nearer zero.

Oil near $20 meant further production cuts worldwide. Perhaps 1 million oil patch jobs & their expertise might potentially disappear. Rig counts fast dropping, capacity tightening, wells shut-in, bankruptcies – some wells perhaps might never be (expensively) re-started. Maybe forcing the US shale producers to shut in was perhaps an initial aim like 2015. But this time, oil's ramp in supply had begun just before pandemic's sudden demand destruction. That on Covid, made for disorderly consequences greater than was maybe initially expected.

Perhaps all was down to timing. In 2014-2016 opening spigots had failed: in that thriving well-lubed oil hungry world, impacts were muted. Oil then dropped near $50 briefly. Excesses soon were absorbed. Not enough to kill off America's shale, and shale reserves which might one-day bounce-back strongly, put something of an upper cap on prices WTI oil might fetch.

A playbook might have been, world awash in oil lets low-cost conventional producers survive, later raise prices, post shale bankruptcies. It's long been said that the cure for cheap oil, is cheap oil – seen again & again. More commanding market-share could be re-captured by those able to lift oil from ground the most cheaply by conventional means. Once competing shale capacity were well-gutted, 'too-low' prices might disappear. (That's all very unlike clean energy where lower prices go lower still, without the floor seen in oil and coal).

Then, in 2020 on pandemic + tank tops, oil unexpectedly went <$20. To quickly revive economies & get oil demand back up, was essential. Oil-wealthy nations might ideally seek higher crude prices nearer $70 - $100. In theory it lets them better balance their own books and national budgets. But now, regaining firmer demand came first. Proposed conventional new oil projects are anyways oft uneconomic, without oil at least well above the $50s.

Plus for nations it's important to realize crude's intrinsic vitality, while its still richly valued. Vast underground reserves if held too long, look increasingly like maybe stranded assets. The assets might in time become of sharply diminishing value, whether due to CO_2/ climate crisis concerns, perhaps an ascent of electric vehicles, or simply changed economics.

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

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

But the U.S. can't cut production by diktat. Anti-cartel laws mean apart from say, a Texas Railroad Commission (rather like a mini-OPEC, long before OPEC) ordering rare cuts as in proration, it's not an option. So, with wink and nod, Saudi & Russia agreed to 10 million cut. Even that unprecedented big move, was just a (necessary) patch-up fix. Yet it made headlines. Concerns of some technical oil-watchers, was it was 2x smaller than hoped-for. And didn't start until May 2020 - so made possible the April 2020 scenario when lower-grade crude went narrowly, briefly cost-negative, at less than zero. Even at desirable light sweet crude, cutting 10 million barrels/day did Not match up exactly to ~25 million barrels/day suddenly no longer needed. But it was hoped demand would rebound hard in 2021. And WTI Index with its landlocked Cushing fears, proved not as useful as Indexes for Brent Sea Crude (stayed positive with $20 bottom then) – and new 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 inevitable heat waves or cold snaps. Free markets are how the US and its prices work, rather than by fiat, so paths were envisioned to stimulate rebounding. If say US States begin re-opening 2021. If Covid-19 grows increasingly endemic more like a seasonal virus; even if immunity is conferred only for one flu season, if effective vaccines arrive, or better yet, robust vaccines for Covid ably can treat new variants too, there were thus hopes for some return to demand rebounding towards normalcy.

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

Thus when a benchmark Brent crude fell Q1 2020 to near $26/barrel, Australian coal at $57 /metric ton roughly equivalent by analysis to $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 light sweet crude for gasoline, heavy sour for asphalt. Levelized costs (includes fuel) of solar & wind had fallen too, as they became relatively more attractive vs old coal or gas. In sum, dirty energy was briefly getting both less desirable, and relatively costly.

It wouldn't last. Surest path to oil rebounding in 2021 would be if economies revived, demand returned. Production cuts could linger, eating up slack. Yet oil's crash had uncomfortably gotten near to upending far more in the oil patch. Key hub Cushing's 4 huge tanks nervously had grown full-ish. Pipelines to forward crude, had slowed to be like storage that could have meant a kind of oil constipation backing-up to producer. Had 5,500 miles of pipes for refined product from Gulf Coast to mid-Atlantic, stopped accepting gasoline, no contract-buy off-taker, a fascinating and scary April 2020 - might have yielded to a much different 2021.

It didn't: for as many in the oil patch fervently hoped, oil demand rebounded latter 2020. That on fast-reviving economies, as well as production cuts by OPEC+ largely complied with (Iran pumped rather freely). So Spring 2020 that had begun with oil tops on everyone's lips, gave way to Fall with tops largely unnoticed – or at least prior excess no longer much concern.

Renewables (among energy more broadly) were rather unaffected by oil's crisis. Instead, to grow more clean energy/storage fast enough, was at issue. Storing electricity can be simple, if little is in play; push water or weights higher up, release it if power is needed; or inject air in caverns etc. But more vast storage might mean maybe new '5-million-mile batteries', infrastructure for innovative flow batteries, H2, etc. For immense scale of what's needed, consider Texas. In 2019 it had 5.5 GW of solar, that was only 1.35% of State electricity supply; a healthier 17.5% wind power; that 5.5 GW of solar in 2019 was only a start. Nonetheless were Texas a nation its PV would have ranked it 5th - after China (30 GW), EU (16 GW), whole US (13.3 GW), Japan (7 GW) – and ahead of say, Vietnam which had 4.8 GW of PV in 2019.

Very generally think of fast needing 20x more US renewables capacity than now; needs too to convert industrial processes like heat in steel & cement to green energy. Roughly that's a dozen-fold plus increase in solar capacity – more wind capacity. One nice 1,300 MW (1.3 GW) Texas solar farm going online in 2023 is just a start. Far more energy storage is needed, starting from scratch: That's so enormous, those needs aren't readily measured by 'x-fold'.

Consider CO_2: A Topic Gaining Importance

For 20+ years our emphasis here at the Clean Energy Index® ECO has been on the *Solutions*. Not on CO_2, nor on Climate, *per se* – but helping to move solar, wind, electric cars etc towards ecologically & economically better paths. Global heating has been one key driver here - but CO_2 hadn't been a focus in Reports. Lately however, climate crises have come in at worse ends of what models foresaw. In short CO_2 increasingly matters, so let's address it here.

For just one acute sample of the remarkable science here, a 2020 article in the Proceedings of National Academy of Sciences warned: in a span of just a "coming 50 years, 1 to 3 billion people are projected to be left outside climate conditions that have served humanity well over the past 6,000 years." On current trends in CO_2 and population, a narrow temperature niche that our species has long required is projected to change more in just the 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

Hence a brief excursion in these Reports as climate is so relevant to clean energy's story. And a consideration too of Environmental, Social & Governance/ ESG factors (especially 'E'). First note: CO_2 has been a hero to our species – in moderation. Earth without CO_2 may have had zero degree C surface temperatures. Instead, warming thanks to CO_2 in small concentrations well under 400 ppm, had meant greenhouse gases naturally gifted average temperatures near ideal for us 59 degrees F. We'd habituated to that over ten thousand years plus.

In the late 1950s when regular CO_2 monitoring began, modern readings had already risen from what long prior had been near 280 PPM, to 315 PPM. By 1988, scientists became alarmed by planetary warming given increasing CO_2 had reached 350. Worried, a world conference held that year called for reducing from that very high 350 figure, downwards by -20%, by 2005.

In 1992 a global compact was reached. Signed in Rio, that UN Framework Convention on Climate Change lacked specific cuts. Looking back that nebulous agreement to try to act was a real failure – nowhere close to task. CO_2 continued rising sharply. For Rio only implied *cuts,* like calling for global emissions to be -20% lower in 2005. Instead, CO_2 as it turned out only grew - going +34% *higher by 2005*. Looking back, it went on rising another +22% higher by 2017 - to over 400 ppm in 2020s. That's higher than in at least last 3 million years. Maybe highest of last 12 million years. So merely more aspirational words, absent real acceptance & robust action, has woefully not achieved what's needed on decarbonization for climate.

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

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

And nearer-term just to 2100, intercomparisons of some 56 climate models indicate some most awful possibilities *may* be a bit less likely. Barring say, methane feedbacks, underseas clathrates, water vapor, permafrost change, & hoping for no other mal-contributions, then models' scariest near 9 degrees F by 2100 *may be* less likely on recent understanding. (That would be less than 9 F from here, as there's been some warming). Those models assumed a high fertility, widespread global coal, and failure to strongly embrace renewables. Such models may be realistic, but their highest/worst-case predictions of an unlivable 9 degrees F warming so very soon, may be less likely. On the other hand, studies in 2021 showed eg, carbonate/limestone permafrost in Siberia, if thawed, may potentially yield enormous methane via fractures. Methane can be *even more climate forcing*, in the near-term.

If we regard highest end Representative Concentration Pathway (RCP) 8.5 unlikely, heaviest CO_2 emissions of that band improbable – then we should also regard lowest RCP 2.6 even more unrealistic. It assumes widespread embrace of renewables already far greater than is seen, and No use of coal (ha). Neither one, especially latter, was close to accurate early 2020s.

And lower-end of that wide and heavy-emissions RCP 8.5 band, seems scarily still feasible. It foresees, arguably, a catastrophic rise near 7 degrees F as possible, as soon as 2100s. Even 'lower-end' RCP 8.5 possibilities ought to concern nations & leaders, greatly. RCP 8.5 one basis for the prediction (above) of mass loss of the inhabitable niche of climate by 2100.

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

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

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

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

A Decarbonized Power Grid by 2040, Climate Neutral World by 2070

Let's imagine in just decades hence: Europe & US on low-cost solar PV from China and vast new energy storage and great efforts, have 1st reached 100% net carbon free power by 2035. Much of world later got there around 2050. Electric vehicles scaled faster than expected! Green H_2 came to industry, richer nations climate neutral by 2060. China on nuclear got there by 2070, meeting targets. Rest of world by 2075 although with much fudging like with 'sequestration' claims, and hopes that the Earth still has thriving 'natural sinks'.

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

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

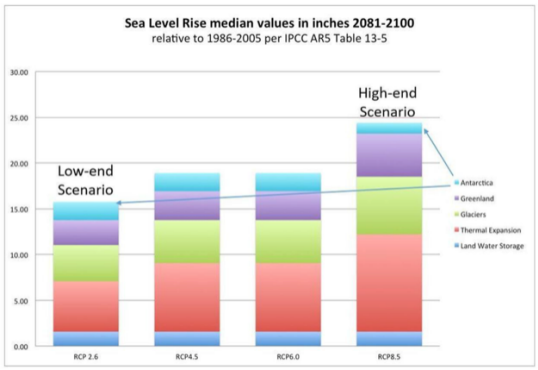
Imagine say, just 80 years hence. Note aspects of projections by an Intergovernmental Panel on Climate Change (IPCC) for sea level rise in 2100, may be a bit misleading. End of this century, rise may be unwinding at more rapidly accelerating rate, than what had seemed projected by IPCC. Getting that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

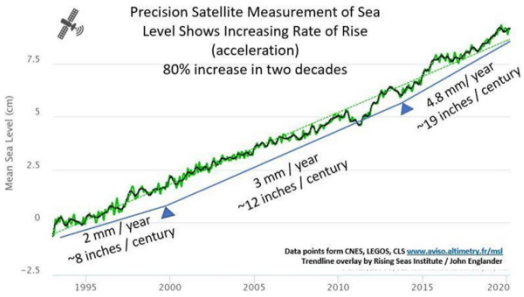
That actual sea levels seen in 2100, could be greater than IPCC projections is well laid out in 2020 piece, 'Twenty-first century sea-level rise could exceed IPCC projections for strong-warming futures' by M. Siegert et al., One Earth, 3 (Dec. 18, 2020). Their first paragraph nicely lays out cogently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

> Since around 1850, the concentration of atmospheric CO2 has risen from ~280 to over 415 parts per million (ppm), resulting in a global mean temperature rise of ~0.9 C – 1.2 C. Even if human-caused emissions are reduced to net zero by 2050, global temperatures may rise to more than 1.5 C above their pre-1850 levels. Global CO2 emissions are still on the rise, however albeit with a slight coronavirus disease (COVID-10) dip, and analyses of current policies suggest that greenhouse gas emissions will continue on an upward trajectory over the coming decades. This keeps strong warming futures, which exceed 4 C by the end of the century and continued warming thereafter, well within the realm of the possible.

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

Because uncertainty cloaks immense Antarctic dynamics, computer models have excluded some unclear mechanisms – so their potential rise is hazy. Shorn of important details, absence of certainty strongly suggests rise also might *max out over* 1.10 meters, roughly 3 ft. Difficulty in modeling ice sheet/glacier dynamics has, in a nutshell potentially left out possibly greater Antarctic contributions. It has removed complex & cascading rise potential, as a major factor. Especially in high heat scenarios where we seem to be trending in comparing most recent models to reality. Still the IPCC high-end curiously indicated the *least* rise would come from Antarctica, even in the RCP8.5 or highest heat scenario as seen in IPCC AR5:





Source for both charts: J. Englander. See also, J. Berandelli, 'Sea-level rise from climate change could exceed the high-end projections, scientists warn'. CBS News. December 23, 2020.

Centuries and millennia ahead need to be of concern. Scientists understand a crucial fraction of airborne carbon already emitted from industrial revolution, plus this century (and perhaps next) can persist for thousands of years. In short, CO_2 released from a relatively brief window extending from just 150 years ago, to a mere 1-2 centuries ahead, even if emissions are mainly halted in a few decades ahead(!), may have committed the world to great inertia in oceans. Impacts from rising seas, going on for maybe centuries, even perhaps many millennia.

Science suggests many tens of feet of rise or more are possible on CO_2. An accelerating rise, maybe locked-in, perhaps going for thousands of years. Past rise seems to have happened in non-linear ways, at times quickly. A meltwater pulse due to CO_2 from natural causes, at rates less than now, caused seas to rise between 50 ft and 80 ft in just 400 - 500 years.

That is 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 and greenhouse gases at rates not seen before. Global reshaping is what we're talking about. So put aside for a moment, noisy political debate. Ignore too impacts say of new diseases, heat, storms, famines, droughts, tornadoes, collapsing ecosystems. Follow-on impacts spreading out like ripples on a pond, like earthquakes following unburdening melting glaciers above land that affect distant tectonic plates. Just impacts of seas rising, is enough.

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

Politicians from Miami & State of Florida, like its people, no doubt want these places to exist beyond a mere few centuries ahead. Same in New York City, Boston, Washington D.C., London, Shanghai, Amsterdam, Mumbai and so on. Yet its leaders often discount all staggering losses these places *may* face ahead. That's due in part, to such a near 2100 horizon.

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

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

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

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

The data show how in recent past, a major rise in CO_2 and warming starting from 20 millennia crucially ago had brought Earth out of a last ice age. Air temperatures continued to rise over a period from that Ice Age to roughly a modern climate that began some 11 millennia ago. From that point, onward, both CO_2 levels and air temperatures sharply leveled off.

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

This mere sliver (in geologic time) of climate stability lasting past 10 or so millennia, dearly helped human societies and cultures to flourish. But a lesson ought to be that the seas are acutely sensitive to CO_2, and temperatures, and they can have inertia lagging the carbon cycle and climate systems. That means today's oceans *could* go on rising for very long periods after CO_2 might be steadied - even if humanity takes determined actions to slow rising CO_2 worldwide, and then decrease emissions. This thorny fact is not widely appreciated.

Combine that CO_2 persistence with inertia of seas, and it *could potentially* mean sea rise *might go on* for a millennium, millennia or more - the unimaginable. Despite our hubris, there's no off switch to halt rising seas. No matter how much the future may wish it to end.

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

So current rates of change are very concerning. It had taken a long period from 21 millennia ago to 12 millennia ago, for atmospheric CO_2 levels to jump by 80 parts per million - from about 190 to 270 ppm. Over that span, global temperatures rose an average 7 degrees F. We're on track to maybe repeat that increase degree - but over a far, far briefer period.

For where we're going given CO_2 already is over 410 ppm & rising fast, think first Pliocene. About 3-5 million years ago, a hot Earth with forested arctic. We might reach such climate rather soon. Of course, it'll take a lot longer for equilibrium, for flora & fauna to react, vast changes then along with mass-extinctions. But those temps existed a couple million years before humans later evolved (in more comfortable world nearer 230 ppm). We can get hotter still, next like Miocene, 400-600 ppm. Perhaps coasts submerged. Interestingly, at 'just' 400 ppm Pliocene, much of Greenland's ice sheet was gone; glaciers may be sensitive to 'modest' warming. Those millions of years ago, CO_2 changes occurring naturally took thousands of years to unwind, maybe over tens of thousands of years+ to slowly rise or fall. By contrast in a single human lifetime now we're exploding CO_2 by an astounding 100 ppm + (!!), so flora & fauna only beginning to react. Cascading exterminations, extinctions unavoidable. It's not just the Fact of this Change – but rather the Extreme Pace of Change, that's deadly.

Post-Pliocene 3 - 5 million years ago (or Miocene 5 - 23 million years ago), over long periods of time of millions of years of hot Earth before humans appeared, PPMs and temps fell. Down off earlier Miocene 400-600 ppm or at times 2,000 ppm perhaps on extreme volcanism, eventually giving way to hospitable carbon levels and temps wherein we evolved nearer 230 ppm. Key then, was our planet's ability to pull CO_2 out of atmosphere over very, very, very long periods of time by Earth's natural 'rock thermostat'. Specifically, CO_2 was absorbed for example as by rocks over millions of years. Taken up as by calcium carbonate and oceans.

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

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

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

Conceivably, innovations might arise. There's new Prizes for cleverer ways to pull CO_2 from air, incentivizing better/though bitter action ahead. Perhaps CO_2 may be made as carbonates, benign solids as building materials and stable for many thousands of years. Perhaps 2 pounds of carbonates for every pound of CO_2. That can be a lot, on 30 billion metric tons pumped into the air each year. Like abalone making shells on CO_2 in dissolved mineral ions in seawater. But this would have to be far faster, require very little energy, and be ecologically benign, no easy task! Or a single step non-thermal plasma conversion of CO_2 at room temps and say, 15 PSI pressure, rather than requiring 500 degrees F and over 150 PSI. This riddle may not soon be solved. And 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 in 2013 gave scenarios for rise this century, that was straightforward on expansion of warming oceans. They'd only allowed then for a small influence from new runoff as from marine ice-sheet instability, known as MISI, primarily on the assumption that Antarctic ice sheets were too stable and vast to irreversibly shrink during this century.

So that report presented an optimistic low-end CO_2 scenario. It assumed strong actions would be taken later in this century to reduce CO_2 emissions, and predicated on that estimated just 1 foot of rise (0.3 to 0.6 meters) by 2100. A high-end estimate, based on current trends continuing, little strong action this century to reduce CO_2, led to about 3.5 feet of rise by 2100, with rate increasing rapidly to between one third to over half of an inch (8 to 16 millimeters) per year in last two decades of this century. Yet such a rate just under a century hence, could be up to 10 times the 20th century average rise, and it might possibly start to approach what had occurred around end of the Ice Age, when seas rose rapidly.

In years since that major report, several newer papers on ice-sheet dynamics have shown our prior understanding was incomplete, and that MISI mechanisms may be much more extensive across the Antarctic. The enormous Pine Island Glacier in Antarctica, for example, looks to be currently thinning and retreating at quickening rate. Like a cork in a champagne bottle, it holds back much greater rise. Mechanisms in newer models show mass loss by unstable retreat may potentially become significant, sooner than expected. Some early collapse may be starting perhaps at Thwaites Glacier now. Unexpected collapse of the Antarctic marine ice sheet could cause previous upper estimates of sea level rise to be exceeded, not long after the end of this century. Although the timescales are profoundly uncertain, much more rapid collapse *could* occur possibly in a relatively short time period of say, two to nine centuries.

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

Consider: likely CO_2 can make a complete failure of pouring billions or trillions of dollars into armoring coastlines. One can imagine enormously long and expensive walls, say 10 feet high, being topped in just a century or two. One can't even imagine bigger seawalls able to handle what could become oceans going 50 feet higher and rising without pause.

The point here is that 2100 shouldn't be regarded as a terminal year. Nor 1-3 ft of sea rise. To do so, is folly; it's wrong-thinking. Life goes on, people do not end there, it's but a year on an artefact human calendar: the world's seas will not suddenly halt their rising then.

Scientists are natural skeptics, not prone to dramatize their findings. But cause for abundant hope is fading. That ought to stretch our thinking. Listening to the sea, and to science, ought to adjust our thinking about what's wise. Paleoclimate records indicate that in periods of meltwater, or termination of last 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 still rise by yet (much) faster rates ahead. Given aggressive CO_2 trends, it must be considered.

Keep in mind what big rates, big scales of change may mean. A difference of 7 degrees F has separated today's "ideal" climate - from extreme conditions of an ice age. In a refresher, the Ice Age had built up ice sheets over Canada, New England, North Midwest US, Northern Europe, Northern Asia. Great Lakes were born of sheets retreating. Meltwater retreat made Long Island NY, & Cape Cod MA. Huge impacts were wrought by a 7 degrees F 'delta'. Ice stood a mile tall over some of North America, shaping whole continents we know today.

Just imagine another 7 degrees F change – but instead global warming ahead. Certainly it will alter land, sea & ecology in scales and ways hard to fathom. Looking back to Earth's record, it's conceivable on a temperature rise "only" 2 to 5 degrees F warmer, seas could rise fast in non-linear ways, say going 15 to 65 feet up drowning much today like Florida. In a thought experiment, adding 5 degrees F warming is very imaginable on current trends of more CO_2. So it is reasonable to imagine seas 60 feet higher. No seawall could ever stop that. It renders shapes of many whole countries as we know them, today, a distant memory.

Mechanisms by which this happens are easy to fathom. Greenland's ice sheet stores 'only' 22 feet of potential sea level rise, possibly ongoing some 10 millennia. However, Antarctic ice sheets store much more: 150 feet of potential rise in that same time frame. Ironically, over a past dozen+ years, the East Antarctic ice sheet annually gained some 175 trillion pounds of thin new ice (precipitation). But West Antarctic annually has lost much more, some 275 trillion pounds of critical ice. Plus Greenland has averaged 600 trillion pounds of ice lost yearly, which is equivalent to 10 billion trucks a year carting ice away to melt in the sea.

With CO_2, plus inertia, we may be heading beyond conditions known in human history. Earth may begin to exhibit changes of states that only can be guessed at. A new study for instance, shows net melting is causing Earth to slightly change how it moves on its polar axis. Days are getting just very slightly longer, as ice melts at poles and redistributes mass as water towards a bulging equator. Very tiny changes in Earth's spin may not seem (at first) troubling, yet it helps to show magnitude of changes possible from CO_2. The Gulf Stream that helps make Northern Europe far warmer than 'it should be', may already be slowing significantly.

Just a century from now, perhaps even only decades hence, the science implies people may look back on our current era - with its record-breaking high temperatures year after year and storms, or bitter cold snaps, rapid disappearance of Arctic sea ice, gradually rising sea levels - as part of a much cooler far more desirable past. One that can never be recovered.

Tiny sea level change/s we're accustomed to now – a rise of only a bit over 1 inch per decade, considerably faster than 50 years ago - might jump to many inches per decade. That ramp could just be beginning. Early maybe, irreversible glacial collapse in Greenland and Antarctica indicates that *considerably more rapid rise might possibly* be in store. The issue is, that it's impossible to say exactly when, or even if, this might even occur. A delta could be huge.

Based on what we once were prepared to give, 2020s may feel like progress. Clean energy now seems to be 'fast' (not really) replacing fossils. But on the CO_2 budget, even 'ambitious' action puts us in a perhaps unbearably hot future. Fast rising seas or worse. Once, we'd dug most energy as fossils from beneath our feet, from underground. That it was filthy, wasn't viewed as a problem. Thankfully clean energy is now looked to, coning from above towards the Heavens. Renewably it shines on our faces, blows across our cheeks in ways sustainable, desirable, and economic. Arguably a better future, if only we can build it (in time) …

Conclusion:

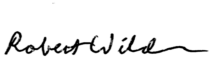
The Clean Energy Index® (ECO) started Q1 2022 near 150, ended Q1 near 136 down some -9%. Or over the last 3 years, ECO rose by +58% in 2019. Then remarkably it rose by +203% in 2020 for about the best performance of any Index or Fund, anywhere. After those 2 gains, not surprisingly it fell -30% in 2021. That drop partly was due to a big reconciliation bill's failure in 2021 that pushed this theme Down hard(!), rising inflation & interest rates (Down!) – which outweighed decarbonizing trends that may favor renewables ahead. After falling early in Q1 1/3rd to near 100 - war since brought speedier shift away from overrelying on (Russian) natural gas – and in the war's first few days ECO jumped +25%; and in first few weeks it rose +40% on the better alternatives found here. Or since 2017, when ECO was 38, it's up some +260%.

The first *global* clean energy Index is the WilderHill New Energy Global Innovation Index (NEX), live since 2006, with tracker in Europe; it's up over +100% last 5 years starkly beating fossils. NEX has oft outperformed too vs. a not so clean and less-pure, independent other global 'clean energy' Index in sizable periods of past 10 years, 12 years, since inception etc; the greater thematic purity in NEX & equal weights may help explain that divergence. In sum the WilderHill themes are green, purer-play benchmarks. And energy that's long been dug from deep down underground & burned - increasingly is captured sustainably in whole new ways – using clean fuels gifted to us freely & renewably from up towards the Heavens.

6 Additions to ECO for Q2 2022 were Energy Vault, Lilium, Navitas, SES, Solid Power, Tritium – and 6 Deletions to ECO for Q2 were Advent, Kandi, REGI, SPI, Sunworks, and Woodward. At the Global NEX for Q2 2022, the 11 Adds were Iljin Hysolus, L&F, LG Energy Solutions, Yadea, Elia, Archer, Cloudberry, Hexagon Composites, Tritium, Solid Power, Unison – and 11 NEX Deletes were Abalance, Meridian Energy, Eos, Cell Impact, Renewable Energy Group, American Superconductor, Soltech Energy, Pod Point, Xebec, 2G Energy, and Lilium.

As always, we welcome your thoughts and suggestions.

Sincerely,



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Appendix I: ECO Index (via independent tracker PBW) Descending Weights in latter-Q4 on 3/14/2022, or about ~2 weeks before the rebalance to start Q2 2022. 78 Stocks:

Name	Symbol	Weight
Sociedad Quimica y Minera de Chile SA ADR	SQM	2.38
Infrastructure and Energy Alternatives Inc	IEA	2.34
Sunlight Financial Holdings Inc	SUNL	2.00
Piedmont Lithium Inc	PLL	1.94
Woodward Inc	WWD	1.91
EVgo Inc	EVGO	1.88
SolarEdge Technologies Inc	SEDG	1.82
Azure Power Global Ltd	AZRE	1.81
Renewable Energy Group Inc	REGI	1.78
Ormat Technologies Inc	ORA	1.78
Quanta Services Inc	PWR	1.77
ReNew Energy Global PLC	RNW	1.72
Canadian Solar Inc	CSIQ	1.68
ReneSola Ltd ADR	SOL	1.64
JinkoSolar Holding Co Ltd ADR	JKS	1.64
SunPower Corp	SPWR	1.62
Bloom Energy Corp	BE	1.60
Daqo New Energy Corp ADR	DQ	1.58
Universal Display Corp	OLED	1.57
MP Materials Corp	MP	1.56
Advanced Energy Industries Inc	AEIS	1.53
Sunnova Energy International Inc	NOVA	1.50
FuelCell Energy Inc	FCEL	1.50
TPI Composites Inc	TPIC	1.47
First Solar Inc	FSLR	1.46
Ameresco Inc	AMRC	1.45
Livent Corp	LTHM	1.44
MYR Group Inc	MYRG	1.43
Enphase Energy Inc	ENPH	1.42
Sunrun Inc	RUN	1.42
Hyzon Motors Inc	HYZN	1.41
Gentherm Inc	THRM	1.41
Lithium Americas Corp	LAC	1.39
Maxeon Solar Technologies Ltd	MAXN	1.37
Wolfspeed Inc	WOLF	1.36
ESCO Technologies Inc	ESE	1.36
ChargePoint Holdings Inc	CHPT	1.35

Kandi Technologies Group Inc	KNDI	1.35
Ballard Power Systems Inc	BLDP	1.34
Lightning eMotors Inc	ZEV	1.33
Wallbox NV	WBX	1.33
Li-Cycle Holdings Corp	LICY	1.32
Albemarle Corp	ALB	1.31
Plug Power Inc	PLUG	1.31
Tesla Inc	TSLA	1.28
Blink Charging Co	BLNK	1.28
Lion Electric Co/The	LEV	1.28
FTC Solar Inc	FTCI	1.27
Itron Inc	ITRI	1.16
ElectraMeccanica Vehicles Corp	SOLO	1.16
Array Technologies Inc	ARRY	1.15
American Superconductor Corp	AMSC	1.14
Shoals Technologies Group Inc	SHLS	1.13
Arcimoto Inc	FUV	1.12
Joby Aviation Inc	JOBY	1.11
Canoo Inc	GOEV	1.08
Workhorse Group Inc	WKHS	1.03
Standard Lithium Ltd	SLI	1.03
Fisker Inc	FSR	1.01
QuantumScape Corp	QS	0.96
Gevo Inc	GEVO	0.94
Archer Aviation Inc	ACHR	0.90
Lordstown Motors Corp	RIDE	0.89
Enovix Corp	ENVX	0.82
NIO Inc ADR	NIO	0.81
XPeng Inc ADR	XPEV	0.75
REE Automotive Ltd	REE	0.73
Stem Inc	STEM	0.71
Advent Technologies Holdings Inc	ADN	0.63
Rivian Automotive Inc	RIVN	0.62
View Inc	VIEW	0.62
Sunworks Inc	SUNW	0.57
Eos Energy Enterprises Inc	EOSE	0.56
Fluence Energy Inc	FLNC	0.56
Romeo Power Inc	RMO	0.56
ESS Tech Inc	GWH	0.54
SPI Energy Co Ltd	SPI	0.48

Beam Global	BEEM	0.42

There's strong representation above from *Lithium & Materials for Batteries; *Solar Power, and *EVs.

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

INDEX (ECO) SECTOR & STOCK WEIGHTS FOR START OF Q2 2022. 78 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 - 16% weight (12 stocks @1.33% each)
Array Technologies, ARRY. Solar, tracker mounts follow sun through the day
Azure Power Global, AZRE. Solar, India; aims for very low-cost green energy.
Canadian Solar, CSIQ. Solar, vertically integrated solar manufacturer, China.
Daqo New Energy, DQ. Solar, polysilicon/wafer manufacturer; China-based.
First Solar, FSLR. Thin film solar, CdTe a low-cost alternate to polysilicon.
FTC Solar, FTCI. Solar panel trackers mounting systems, Utility-scale.
JinkoSolar, JKS. Solar, wafers through solar modules, China-based OEM.
Maxeon, MAXN. Solar, efficient PV panel manufacturer after spinoff.
Ormat, ORA. Geothermal, also in areas of recovering heat energy.
Renesola, SOL. Solar, project development, operations, China & globally.
Sunlight Financial, SUNL. Solar residential financing, credit provider.
TPI Composites, TPIC. Wind Blades; also light-weighting transportation.

Energy Storage - 26% sector weight (21 stocks @1.23 each)
Albermarle, ALB. Lithium, specialty materials in batteries for energy storage.
Chemical & Mining of Chile, SQM. Lithium, large producer in energy storage.
Enovix, ENVX. Silicon-anodes, 3D for improving new lithium-ion batteries.
Eos, EOSE. Zinc grid batteries, 100% depth discharge, longer-life not li-ion.
ESS Tech, GWH. Iron flow batteries, longer duration is non-lithium storage.
Fluence, FLNC. Battery storage, for renewables and digital applications.
Lion Electric, LEV. Urban electric trucks, buses, vans; vehicle to grid storage.
Lithium Americas, LAC. Lithium, deposits in State of Nevada U.S. & Argentina.
Livent, LTHM. Lithium, and compounds used in batteries for energy storage.
Lordstown Motors, RIDE. Electric commercial pickup trucks, American startup.
NIO Inc, NIO. EVs, China-based startup premium vehicles, battery as a service.
Piedmont Lithium, PLL. Lithium, US domestic source battery-grade lithium.
Quantumscape, QS. Battery, solid state lithium-metal energy dense fast charge.
Rivian, RIVN. Electric vehicles, trucks and commercial fleets, charging
Romeo, RMO. Battery packs, designs & builds energy systems, snap in uses.
SES AI Corp, SES. Li-metal anode battery, may be safer, faster-charging.
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.
Workhorse, WKHS. Electric Vehicles, large electric delivery trucks, early-stage.
Xpeng, XPEV. Electric vehicles, advanced mobility, swappable batteries, China.

Power Delivery & Conservation - 27% sector (21 stocks @1.28% each)
Ameresco, AMRC. Energy saving efficiencies, net zero CO_2, decarbonization.
American Superconductor, AMSC. Wind, grid conditioning; superconductors.

Archer Aviation, ACHR. Electrifying aircraft, vertical takeoff & landing.
Arcimoto, FUV. EVs, smaller very low-cost 3 wheeled electric vehicles.
Blink Charging, BLNK. EV Charging, among bigger EV charging networks.
Canoo, GOEV. Electric delivery vehicles, configurable and multipurpose.
Chargepoint, CHPT. EV Charging, global including for fleets and businesses.
Electrameccanica Vehicles, SOLO. EVs, 3 wheel, custom electric vehicles.
EVgo, EVGO. EV Charging, DC fast-charging Networks, renewable power.
Fisker, FSR. EV crossover SUV, is assembled by contract manufacturer.
Infrastructure and Energy, IEA. Renewables, power generation to delivery.
Itron, ITRI. Meters, utility energy monitoring, measurement & management.
Joby Aviation, JOBY. Electric aircraft, cleaner, more energy efficient.
Lilium, LILM. Electric jet aircraft, eVTOLs for vertical takeoff & landing.
MYR Group, MYRG. Grid transmission and distribution, for solar & wind farms.
Quanta Services, PWR. Infrastructure, modernizing grid & power transmission.
Ree Automotive, REE. EVs, modular propulsion and steering in wheel arch.
Shoals, SHLS. Solar, for electric balance of system, wiring, combiners.
Universal Display, OLED. Organic light emitting diodes, efficient displays.
View, VIEW. Smart glass, shades electronically, reduces solar heating.
Wallbox, WBX. EV Charging, allows bi-directional vehicle to grid, V2G.

Energy Conversion - 23% sector weight (17 stocks @1.35% each)
Advanced Energy, AEIS. Power conditioning: inverters, thin film deposition.
Ballard Power, BLDP. Mid-size fuel cells; PEM such as in transportation.
Bloom Energy, BE. Stationary fuel cells, not-yet cleanest/renewable fuels.
Energy Vault, NRGV. Gravity energy storage; can repurpose old wind blades.
Enphase, ENPH. Microinverters, also energy storage systems and software.
ESCO Technologies, ESE. Power management, shielding, controls, testing.
FuelCell Energy, FCEL. Stationary fuel cells, distributed power generation.
Gentherm, THRM. Thermoelectrics, heat energy, battery management.
Hyzon Motors, HYZN. H_2 fuel cell powered heavy trucks, buses, coaches.
Li-Cycle, LICY. Battery Recycling, closed-loop of lithium, other materials.
Lightning eMotors, ZEV. Electric powertrain conversions, heavy vehicles.
MP Materials, MP. Rare Earths, domestic U.S. source Neodymium, NdPr.
Navitas Semiconductor, NVTS. Gallium Nitride GaN fast charging EVs.
Plug Power, PLUG. Small fuel cells, for eg forklifts; drop in replacements.
SolarEdge Technologies, SEDG. Inverters, solar optimizers, inverters.
Tritium, DCFC. Ultra-fast DC, electric vehicle charging networks.
Wolfspeed, WOLF. Electrifying power, Silicon Carbide SiC, converters.

Greener Utilities – 7% sector weight (5 stocks @1.30% each + 1 *banded)
**Beam,* BEEM. EV Charging, rapidly deployable portable PV power platform.
ReNew Energy, RNW. India renewables, among largest there in solar & wind.
Stem, STEM. Microgrids, smart new energy storage via machine learning.
Sunnova, NOVA. Solar provider, operating fleet for residential, plus storage.
SunPower, SPWR. Solar system provider, storage and distributed generation.
Sunrun, RUN. Residential solar systems, PPA, lease or purchase rooftop PV.

Cleaner Fuels – 1% sector weight (1 stock @1.00% each)
Gevo, GEVO. Biofuels, lower carbon liquid fuels from renewable sources.

Appendix III: **WilderHill New Energy Global Innovation (NEX)** descending weights late-Q1 via independent tracker (PBD) 3/14/21, ~2 weeks before Rebalance to start Q2 2022. 125 stocks:

Name	Symbol	Weight
Azure Power Global Ltd	AZRE	1.37
Renewable Energy Group Inc	REGI	1.34
Sociedad Quimica y Minera de Chile	SQM	1.18
Piedmont Lithium Inc	PLL	1.11
Boralex Inc	BLX	1.10
Nordex SE	NDX1	1.06
Solaria Energia y Medio Ambiente SA	SLR	1.05
Encavis AG	ECV	1.04
SolarEdge Technologies Inc	SEDG	1.04
Meridian Energy Ltd	MEL	1.04
EVgo Inc	EVGO	1.03
Arcosa Inc	ACA	1.03
2G Energy AG	2GB	1.02
Innergex Renewable Energy Inc	INE	1.02
Energiekontor AG	EKT	1.00
Universal Display Corp	OLED	0.98
Alfen Beheer BV	ALFEN	0.96
Canadian Solar Inc	CSIQ	0.96
NEL ASA	NEL	0.95
Neoen SA	NEOEN FP	0.95
SFC Energy AG	F3C	0.95
EDP Renovaveis SA	EDPR	0.95
Terna - Rete Elettrica Nazionale	TRN	0.94
Ormat Technologies Inc	ORA	0.94
Bloom Energy Corp	BE	0.94
MP Materials Corp	MP	0.94
Cadeler A/S	CADLR	0.93
Grenergy Renovables SA	GRE	0.93
Signify NV	LIGHT	0.93
SMA Solar Technology AG	S92	0.93
Landis+Gyr Group AG	LAND SW	0.92
United Renewable Energy Co Ltd/Taiwan	3576 TT	0.92
Acciona SA	ANA	0.92
Orsted AS	ORSTED DC	0.91
Vestas Wind Systems A/S	VWS DC	0.91
Corp ACCIONA Energias Renovables SA	ANE	0.91
Enlight Renewable Energy Ltd	ENLT	0.91

SolTech Energy Sweden AB	SOLT SS	0.91
Gurit Holding AG	GUR SW	0.91
CS Wind Corp	112610 KS	0.90
ReneSola Ltd ADR	SOL	0.90
FuelCell Energy Inc	FCEL	0.88
Ameresco Inc	AMRC	0.88
JinkoSolar Holding Co Ltd ADR	JKS	0.88
Nexans SA	NEX FP	0.87
VERBIO Vereinigte BioEnergie AG	VBK	0.87
SunPower Corp	SPWR	0.87
Mercury NZ Ltd	MCY	0.87
Scatec ASA	SCATC	0.86
Wallbox NV	WBX	0.86
ITM Power PLC	ITM LN	0.86
McPhy Energy SA	MCPHY FP	0.86
Daqo New Energy Corp ADR	DQ	0.85
Prysmian SpA	PRY	0.85
Livent Corp	LTHM	0.85
CropEnergies AG	CE2	0.84
Verbund AG	VER AV	0.84
GS Yuasa Corp	6674 JP	0.83
Lithium Americas Corp	LAC	0.83
PowerCell Sweden AB	PCELL SS	0.83
Hannon Armstrong Sustainable Infra.	HASI	0.83
Wolfspeed Inc	WOLF	0.83
NKT A/S	NKT DC	0.82
Xinyi Energy Holdings Ltd	3868 HK	0.82
Xinyi Solar Holdings Ltd	968 HK	0.82
Enphase Energy Inc	ENPH	0.81
Sunrun Inc	RUN	0.81
Cell Impact AB	CIB SS	0.80
Flat Glass Group Co Ltd	6865 HK	0.80
Siemens Gamesa Renewable Energy SA	SGRE	0.79
Motech Industries Inc	6244 TT	0.79
TPI Composites Inc	TPIC	0.79
Kingspan Group PLC	KSP	0.78
Sunnova Energy International Inc	NOVA	0.78
First Solar Inc	FSLR	0.78
Ballard Power Systems Inc	BLDP	0.77
ChargePoint Holdings Inc	CHPT	0.77

China Datang Corp Renewable Power	1798 HK	0.75
Maxeon Solar Technologies Ltd	MAXN	0.75
Lion Electric Co/The	LEV	0.75
FREYR Battery SA	FREY	0.75
Li-Cycle Holdings Corp	LICY	0.74
Plug Power Inc	PLUG	0.74
Pod Point Group Holdings PLC	PODP LN	0.73
Proterra Inc	PTRA	0.73
Doosan Fuel Cell Co Ltd	336260 KS	0.72
Gevo Inc	GEVO	0.71
Abalance Corp	3856 JP	0.71
Joby Aviation Inc	JOBY	0.71
Eolus Vind AB	EOLUB SS	0.70
Itron Inc	ITRI	0.70
Novozymes A/S	NZYMB DC	0.70
Ceres Power Holdings PLC	CWR LN	0.69
AFC Energy PLC	AFC LN	0.69
American Superconductor Corp	AMSC	0.68
West Holdings Corp	1407 JP	0.68
FTC Solar Inc	FTCI	0.68
Sino-American Silicon Products Inc	5483 TT	0.67
Nibe Industrier AB	NIBEB SS	0.66
Shoals Technologies Group Inc	SHLS	0.66
Gencell Ltd	GNCL	0.65
Samsung SDI Co Ltd	006400 KS	0.64
Electreon Wireless Ltd	ELWS	0.64
Iljin Materials Co Ltd	020150 KS	0.63
Xebec Adsorption Inc	XBC	0.63
Canoo Inc	GOEV	0.62
Ganfeng Lithium Co Ltd	1772 HK	0.62
Fastned BV	FAST	0.62
Array Technologies Inc	ARRY	0.61
Fisker Inc	FSR	0.60
QuantumScape Corp	QS	0.59
Ecopro BM Co Ltd	247540 KS	0.58
BYD Co Ltd	1211 HK	0.57
Xinjiang Goldwind Science & Tech.	2208 HK	0.56
SK IE Technology Co Ltd	361610 KS	0.55
Lucid Group Inc	LCID	0.52
Lordstown Motors Corp	RIDE	0.51

Aker Offshore Wind AS	AOW	0.49
XPeng Inc ADR	XPEV	0.48
NIO Inc ADR	NIO	0.47
Stem Inc	STEM	0.41
Lilium NV	LILM	0.36
Eos Energy Enterprises Inc	EOSE	0.35
Rivian Automotive Inc	RIVN	0.32
RENOVA Inc	9519 JP	0.28

There's strong representation above from *Lithium & Battery Materials, *Wind Power, and *Solar.

Appendix IV:

WilderHill New Energy Global Innovation (NEX) - for start of Q2 2022. 125 Stocks.

Also NEX Index Composition is at, https://www.solactive.com/indices/?se=1&index=US96811Y1029

Name	Description	Sector	Currency	Activity
Acciona SA	Sustainable infrastructure, separate renewables.	RWD	EUR	SPAIN
AFC Energy	Fuel cells, alkaline has greater H2 fuels tolerance.	ECV	GBP	UK
Aker Offshore Wind	Offshore wind, new floating deepwater technolgies.	RWD	NOK	NORWAY
Alfen NV	Electric Vehicle charging, smart grid, energy storage.	EEF	EUR	NETHERLANDS
Ameresco	Energy savings, performance contracts, renewables.	EEF	USD	US
Archer Aviation	Electric aircraft, eVTOL vertical takeoff and landing.	EEF	USD	US
Arcosa	Wind tower structures, grid power and infrastructure.	RWD	USD	US
Array Technologies	Solar, ground-mounted axis sun trackers.	RSR	USD	US
Azure Power Global	Solar, India, aims to offer lowest-cost electricity.	RSR	USD	INDIA
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
Boralex	Renewables generation, operates wind, hydro, solar.	RWD	CAD	CANADA
BYD Co.	Electric vehicles, batteries, rail, and more.	ENS	HKD	CHINA
Cadeler A/S	Offshore windfarm installation vessels, specialized.	RWD	NOK	DENMARK
Canadian Solar	Solar, vertically integrated solar manufacturer, China.	RSR	USD	CANADA
Canoo	Electric delivery vehicles, configurable, multipurpose.	EEF	USD	US
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
Cloudberry Clean Energy	Renewables, operates wind and hydro in the Nordics.	ROH	NOK	NORWAY
Corp. Acciona Energias	Renewables, one of world's biggest: wind, solar etc.	RWD	EUR	SPAIN
CropEnergies AG	Bioethanol, from cereals and sugarbeet, Germany.	RBB	EUR	GERMANY
CS Wind	Wind power, both onshore, and also offshore.	RWD	KRW	S. KOREA

Daqo New Energy	Solar, high-purity polysilicon for solar wafers, China.	RSR	USD	CHINA
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 largest producers in world, Iberia.	RWD	EUR	SPAIN
Electreon Wireless	Wireless road charging, for EVs while driving.	EEF	ILS	ISRAEL
Elia Group SA	Smarter grid, high voltage transmission Europe.	EEF	EUR	EUROPE
Encavis AG	Solar, large solar park operator, also wind, Germany.	RSR	EUR	GERMANY
Energiekontor AG	Wind farms, also solar parks in Germany.	RWD	EUR	GERMANY
Enlight Renewable	Solar & wind power, clean energy storage infrastructure.	RSR	ILS	ISRAEL
Enphase	Inverters, micro-products for solar panels, storage.	RSR	USD	US
Eolus Vind	Wind power, also consulting services for wind.	RWD	SEK	SWEDEN
Evgo	EV charging, an early leader in fast charging.	EEF	USD	US
Fastned BV	EV charging, uses wind and solar power, Europe.	EEF	EUR	NETHERLANDS
First Solar	Thin film solar, CdTe low-cost alternate to polysilicon.	RSR	USD	US
Fisker	Electric cars, electric SUVs, with contract manufacturer.	ENS	USD	US
Flat Glass Group	PV panel glass, solar plants engineering & construction	RSR	HKD	CHINA
Freyr Battery SA	Batteries, decarbonization includes cell manufacturing.	ENS	USD	NORWAY
FTC Solar	Solar, ground mounted trackers; also PV software.	RSR	USD	US
FuelCell Energy	Fuel cells, high temperature and hydrogen.	ECV	USD	US
Ganfeng Lithium	Lithium, production of compounds, metals, for batteries.	ENS	HKD	CHINA
GenCell Ltd.	Fuel cells, hydrogen from ammonia, remote power.	ECV	ILS	ISRAEL
Gevo	Biofuels, lower carbon liquid fuels, renewable sources.	RBB	USD	US
Grenergy Renovables SA	Solar projects, and wind, batteries, Spain, Lat. Amer.	RSR	EUR	SPAIN
GS Yuasa	Battery technologies, also lithium for EVs, Japan.	ENS	JPY	JAPAN
Gurit Holding AG	Composite Materials in wind, lightens cars, planes.	RWD	CHF	SWITZERLAND
Hannon Armstrong	Energy efficiency, capital & finance for infrastructure.	EEF	USD	US
Hexagon Composites	Compressed hydrogen gas storage for vehicles, etc.	ENS	NOK	NORWAY
Iljin Hysolus	Hydrogen tanks, for fuel cell cars, trucks, ships, planes.	ENS	KRW	S. KOREA
Iljin Materials	Rechargeable battery materials, elecfoils for batteries..	ENS	KRW	S. KOREA
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
Joby Aviation	Electric Aircraft, more efficient transportation.	EEF	USD	US
Kingspan Group plc	Efficient Buildings, insulation for conservation, Ireland.	EEF	EUR	IRELAND
Landis+Gyr Group AG	Advanced meters, modernizing grid, Switzerland.	EEF	CHF	SWITZERLAND
L&F Co.	Cathode active materials, closing battery loops.	ENS	KRW	S. KOREA
LG Energy Solutions	Li-ion battery leader, in grid, EVs, transport etc.	ENS	KRW	S. KOREA
Li-Cycle	Recycling lithium-ion batteries, recover raw material.	ENS	USD	US
Lion Electric	Electric Vehicles, urban trucks, buses, V2G.	ENS	USD	CANADA

Lithium Americas	Lithium, projects in Nevada USA, and in Argentina.	ENS	USD	US
Livent	Lithium, production of compounds, batteries.	ENS	USD	US
Lordstown Motors	Electric Vehicles, pickup trucks, telematics.	ENS	USD	US
Lucid	Electric Vehicles, premium, higher-voltage, range.	EEF	USD	US
Maxeon Solar	Solar panel manufacturer, a spinoff from Sunpower.	RSR	USD	US
McPhy Energy	Hydrogen, electrolyzers using water, H2 storage.	ECV	EUR	FRANCE
Mercury NZ	Clean power, 100% renewable hydro, geothermal.	ROH	NZD	NEW ZEALAND
Motech	Solar, cells and modules manufacturing.	RSR	TWD	TAIWAN
MP Materials	Rare Earths, US sourced strategic Neodymium, NdPr.	ECV	USD	US
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
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
Novozymes A/S	Biofuels, enzymes used in partnerships, Denmark.	RBB	DKK	DENMARK
Ormat	Geothermal, works too in recovered heat energy.	ROH	USD	US
Orsted A/S	Sustainable wind, also biomass, thermal, Denmark.	RWD	DKK	DENMARK
Piedmont Lithium	Lithium, US-based source for battery-grade lithium.	ENS	USD	US
Plug Power	Small fuel cells, e.g. in forklifts; drop in replacements.	ECV	USD	US
Powercell Sweden	Fuel cells, transportation, marine, stationary uses.	ECV	SEK	SWEDEN
Proterra	Electric transit buses, EV charging solutions.	EEF	USD	US
Prysmian SpA	Cables, renewable power transmission, global.	EEF	EUR	ITALY
Quantumscape	Lithium metal batteries, solid state, quicker charge.	ENS	USD	US
ReneSola	Solar, project developer and operator, worldwide.	RSR	USD	CHINA
Renova	Wind, Solar, Biomass, power generation in Asia.	RWD	JPY	JAPAN
Rivian	Electric trucks and vehicles, fast charging network.	ENS	USD	US
Samsung SDI	Batteries, innovative energy storage, EVs, South Korea.	ENS	KRW	S. KOREA
Scatec ASA	Solar power, develops, owns and operates worldwide.	RSR	NOK	NORWAY
SFC Energy AG	Fuel cells, direct methanol (DMFC) technology.	ECV	EUR	GERMANY
Shoals Technologies	Solar, electric balance of system, wiring, combiners.	RSR	USD	US
Siemens Gamesa	Wind, onshore & offshore, turbines, gearboxes, Spain	RWD	EUR	SPAIN
Signify NV	Lighting, systems increasing efficiency, Netherlands.	EEF	EUR	NETHERLANDS
Sino-American Silicon	Solar, semi-conductor silicon wafer materials, Taiwan.	RSR	TWD	TAIWAN
SK IE Technology	Battery materials, separators and ceramic coated.	ENS	KRW	S. KOREA
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
Solid Power	Towards solid state batteries, sulfude eectrolyte.	ENS	USD	US
SolarEdge	Inverters, panel-level solar optimizers, micro-inverters.	RSR	USD	US

Solaria Energia	Solar, renewable power generation, Iberia.	RSR	EUR	SPAIN
Stem	Smart battery storage, AI energy management.	ENS	USD	US
Sunnova	Residential solar and energy storage installation.	RSR	USD	US
SunPower	Solar, efficient PV panels with rear-contact cells.	RSR	USD	US
Sunrun	Residential solar, leasing, PPA or purchase rooftop PV.	RSR	USD	US
Terna SpA	Transmission of electricity, increasingly is renewables.	EEF	EUR	ITALY
TPI Composites	Wind Blades; also light-weighting for transportation.	RWD	USD	US
Tritium Dcfc	Ultra fast charging, direct current for electric vehicles.	ECV	USD	AUSTRALIA
Unison	Wind power, maker of turbines, generators, towers.	RWD	KRW	S. KOREA
United Renewable Energy	Solar, also energy storage, hydrogen and fuel cells.	RSR	TWD	TAIWAN
Universal Display	Organic light emitting diodes, efficient displays.	EEF	USD	US
Verbio Vereinigte BioEn.	Biofuels, manufacturer supplier to Germany, Europe.	RBB	EUR	GERMANY
Verbund AG	Electricity supplier, hydro, a large provider for Austria.	ROH	EUR	AUSTRIA
Vestas Wind Systems A/S	Wind, wind turbine manufacturing & services, Denmark.	RWD	DKK	DENMARK
Wallbox NV	EV charging, can be bidirectional for vehicle to home.	EEF	USD	SPAIN
West Holdings	Solar, Japan-focused residential and commercial PV.	RSR	JPY	JAPAN
Wolfspeed	Electrifying high power systems, SiC, GaN.	EEF	USD	US
Xinjiang Goldwind	Wind, large turbine manufacturer, China.	RWD	HKD	CHINA
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

125 stocks/100 = Individual Weights for Q2 2022 **WEIGHT EACH COMPONENT = 0.800000**

125 Stocks for Start of Q2 2022.		#	% Approx. Weight
Energy Conversion	**ECV**	**15**	**12%**
Energy Efficiency	**EEF**	**26**	**21%**
Energy Storage	**ENS**	**26**	**21%**
Renewables - Biofuels & Biomass	**RBB**	**4**	**3%**
Renewables - Other	**ROH**	**5**	**4%**
Renewable - Solar	**RSR**	**29**	**23%**
Renewable - Wind	**RWD**	**20**	**16%**
		125	**100%**

11 NEX Adds for Q2: 271940.KS, 066970.KQ, 373220.KS, 1585.HK, ELI.BR, ACHR.N, CLOUD.OL, HEX.OL, DCFC.OQ, SLDP, OQ, 018000.KQ

11 NEX Deletes for Q2 2022: 3856.T, MEL.NZ, EOSE.OQ, Cib.ST, REGI.OQ, AMSC.OQ, SOLT.ST, PODP.L, XBC.TO, 2GBG.DE, LILM.OQ

Appendix VI: Historical Weightings: WilderHill New Energy Global Innovation Index (NEX).

NEX Historical Sector Weight Information

	ECV	EEF	ENS	RBB	ROH	RSR	RWD
Sector Weights	**Energy Conversion**	**Energy Efficiency**	**Energy Storage**	**Renewables - Biofuels**	**Renewables - Other**	**Renewable - Solar**	**Renewable - Wind**
Q4 2020	11.00%	20.00%	9.00%	7.00%	6.00%	24.00%	24.00%
Q3 2020	5.70%	24.10%	6.90%	8.00%	6.90%	24.10%	24.10%
Q2 2020	5.70%	23.00%	6.90%	8.00%	6.90%	26.40%	23.00%
Q1 2020	5.50%	23.10%	6.60%	8.80%	6.60%	27.50%	22.00%
Q4 2019	4.00%	23.00%	8.00%	10.00%	6.00%	26.00%	23.00%
Q3 2019	3.77%	22.64%	9.43%	9.43%	5.66%	26.41%	22.64%
Q2 2019	1.40%	29.72%	9.11%	6.13%	4.41%	21.75%	27.49%
Q1 2019	1.42%	30.07%	9.36%	8.48%	4.49%	20.72%	25.46%
Q4 2018	1.05%	30.25%	9.00%	7.94%	3.63%	21.78%	26.34%
Q3 2018	0.79%	29.62%	8.48%	6.60%	3.71%	23.67%	27.12%
Q2 2018	0.80%	30.50%	8.80%	7.90%	3.90%	22.50%	25.50%
Q1 2018	1.00%	30.67%	7.64%	7.74%	3.92%	23.37%	25.66%
Q4 2017	1.14%	29.36%	6.75%	8.21%	4.68%	20.58%	29.28%
Q3 2017	0.76%	30.88%	5.91%	9.11%	4.55%	18.80%	29.98%
Q2 2017	0.67%	33.68%	6.50%	8.75%	4.92%	18.73%	26.75%
Q1 2017	1.00%	31.83%	5.64%	9.03%	5.43%	17.92%	29.14%
Q4 2016	0.71%	32.00%	3.58%	8.48%	5.20%	18.84%	31.19%
Q3 2016	1.12%	31.00%	4.54%	7.76%	5.87%	21.09%	28.61%
Q2 2016	1.02%	32.18%	3.69%	7.15%	5.18%	21.60%	29.18%
Q1 2016	1.01%	34.83%	3.61%	9.38%	4.26%	20.14%	26.77%
Q4 2015	0.95%	33.54%	3.09%	9.19%	5.19%	20.40%	27.65%
Q3 2015	0.95%	32.97%	3.18%	8.05%	4.52%	24.65%	25.67%
Q2 2015	1.22%	33.68%	2.26%	9.55%	6.90%	24.88%	21.50%
Q1 2015	1.68%	33.88%	2.14%	11.54%	6.84%	24.86%	19.06%
Q4 2014	1.42%	33.67%	2.26%	12.31%	8.45%	24.67%	17.22%
Q3 2014	1.42%	33.42%	2.30%	12.44%	9.09%	23.78%	17.56%
Q2 2014	1.11%	34.20%	2.00%	12.16%	9.86%	23.16%	17.52%
Q1 2014	1.17%	33.13%	2.34%	12.17%	10.33%	23.95%	16.91%
Q4 2013	1.28%	35.26%	2.28%	14.02%	12.47%	19.58%	15.10%
Q3 2013	1.25%	35.04%	2.35%	14.61%	13.06%	19.10%	14.58%
Q2 2013	1.31%	33.43%	2.63%	15.42%	14.05%	17.54%	15.62%
Q1 2013	1.31%	33.43%	2.63%	15.42%	14.05%	15.90%	14.14%
Q4 2012	1.50%	33.93%	2.97%	14.50%	14.50%	19.59%	13.04%
Q3 2012	2.32%	28.30%	6.70%	14.22%	8.35%	21.17%	19.00%
Q2 2012	1.34%	28.14%	4.16%	14.61%	13.98%	22.00%	15.96%
Q1 2012	1.60%	28.01%	4.01%	13.85%	14.70%	20.83%	17.00%
Q4 2011	1.14%	25.06%	4.12%	12.13%	11.63%	26.48%	19.45%
Q3 2011	1.28%	22.72%	6.24%	10.17%	10.49%	24.60%	24.32%
Q2 2011	1.50%	23.34%	8.06%	10.69%	9.53%	25.76%	21.04%
Q1 2011	1.50%	26.95%	6.99%	10.50%	9.46%	24.59%	20.00%

Q4 2010	1.79%	24.32%	8.80%	11.21%	6.02%	24.16%	23.71%
Q3 2010	1.97%	20.31%	8.86%	11.70%	6.59%	24.42%	26.16%
Q2 2010	1.90%	17.29%	8.53%	12.36%	6.58%	24.29%	29.05%
Q1 2010	2.04%	16.93%	8.65%	12.25%	6.73%	25.03%	28.36%
Q4 2009	2.25%	15.20%	7.10%[1]	11.26%	7.10%	27.51%	29.58%
Q3 2009	2.59%	13.77%	5.38%	10.76%	6.81%	29.24%	31.45%
Q2 2009	2.42%	12.89%	4.79%	12.21%	6.49%	30.57%	30.63%
Q1 2009	2.77%	15.14%	5.29%	14.19%	8.25%	25.70%	28.68%
Q4 2008	2.25% [2]	23.93%	3.57%	12.09%	6.48%	26.63%	25.05%
Q3 2008	3.31%	20.03%	3.33%	13.14%	6.54%	27.27%	26.39%
Q2 2008	3.81%	17.85%	2.81%	14.32%	6.47%	27.03%	27.71%
Q1 2008	3.93%	13.56%	2.94%	14.26%	6.99%	30.00%	28.34%

*To Q2 2019, NEX components were divided into large or small in a survey of companies deemed active in new energy, adjusting for factors including exposure to new energy and exchange restrictions. Starting Q3 2019, all NEX components are equal weighted, the sector weightings are according to the number in each sector.

Appendix VII, Cool Climate™ Clean Solutions Index (OCEAN) for latter Q1 2022, 108 components:

WilderHill OCEAN Index components	Theme	Activity
Aalberts NV	Flow control, integrated piping, efficiency.	Netherlands
Acciona SA	Water treatment; greener transportation.	Spain
Acciona Energia	Renewables energy generation, exclusively.	Spain
Advanced Drainage	Water management, drainage products.	USA
AFC Energy	Fuel Cells, alkaline, may use ammonia.	UK
Aker Offshore Wind	Offshore wind, deep water, floating, Norway.	Norway
Alfa Laval AB	Fluid Handling, controls, on vessels.	Sweden
Alfen NV	Smart power grids, energy storage.	Netherlands
American States Water	Water and Wastewater Services.	USA
American Water Works	Water and Wastewater Systems.	USA
Azure Power	Solar power, India focus.	India
Badger Meter	Water Metering.	USA
Ballard Power	Fuel cells, future power in Ports and Shipping.	Canada
Beyond Meat	Plant-based meats, less impactful proteins.	USA
Bloom Energy	H2 fuel cells, power ahead ports, shipping.	USA
Bollore SA	Better Sustainability in Ports & Terminals.	France
BYD	Batteries, zero emission vehicles.	China
California Water Service	Water and Wastewater Utility Services.	USA
Canadian Solar Inc	Solar, panel manufacturer.	Canada
Canoo	Electric vehicles, multi-purpose.	USA
Cargotec OYJ	Better Sustainability in Ports & Terminals.	Finland
Ceres Power	H2 fuel cells, power ahead ports, shipping.	Britain
Chargepoint	EV residential and commercial charging.	USA

Corbion NV	Algae, sustainable alternative in aquaculture.	Netherlands
CS Wind	Wind, tower structures.	S. Korea
Danimer Scientific	Bioplastics, biodegradable materials.	USA
Doosan Fuel Cells	Fuel cells, future power in Ports and Shipping.	S. Korea
EDP Renovaveis SA	Renewables, among world's largest in wind.	Spain
Encavis AG	Renewable Energy, solar & wind in Europe.	Germany
Energiekontor AG	Wind, Solar, from planning to operations.	Germany
Enlight Renewable	Solar, construction and operations, also wind.	Israel
Eolus Vind AB	Wind power projects in Sweden, US, Estonia.	Sweden
Eos Energy	Zinc battery chemistry, alternative to Li-ion.	USA
ESS Tech	Batteries, long-duration flow liquid electrolyte.	USA
Essential Utilities	Water and Wastewater Services.	USA
Evoqua	Water, wastewater treatment.	USA
Fisker	EV designs, with 3rd party manufacturing.	USA
First Solar	Solar, thin film panels.	USA
Flat Glass Group	Glass, specialized solar panels.	China
Franklin Electric	Water, pumping, systems.	USA
FREYR Battery	Batteries, made from green renewable energy.	Norway
FuelCell Energy	H2 fuel cells, power ahead ports, shipping.	USA
Geberit AG	Waste treatment, supply, piping.	Switzerland
Georg Fischer AG	Water transport, piping systems.	Switzerland
Grenergy Renovables SA	Solar power parks, wind power.	Spain
Grieg Seafood ASA	Seafood, aquaculture with high ESG scores.	Norway
Halma plc	Water analysis, monitoring, treatment.	Britain
Idex	Water, pumps, flow meters, fluid systems.	USA
Innergex Renewable	Run-of-river Hydro power, Wind, Solar.	Canada
Intertek Group plc	Cargo and Trade services, quality assurance.	Britain
ITM Power PLC	Electrolysis for green hydrogen, zero CO2.	Britain
Itron	Smart Grid Power and Water Management.	USA
Kingspan Group PLC	Building Insulation.	Ireland
Kuehne und Nagel	Shipping Logistics, clean cargo group.	Switzerland
Kurita Water	Water Treatment, wastewater systems.	Japan
Leroy Seafood Group	Seafood, with high FAIRR Report score.	Norway
Maxeon Solar	Solar, higher-efficiency premium PV panels.	USA
McPhy Energy SAS	Hydrogen, for decarbonization.	France
Mercury NZ	100% Renewables by hydro, geothermal, wind.	New Zealand
Metabolic Explorer	Biologic alternatives to petrochemistry, green.	France
Metawater	Water purification, sewage treatment plants.	Japan
Middlesex Water	Water supply, and infrastructure.	USA
Mowi ASA	Seafood, with high FAIRR Report score.	Norway

MP Materials	Rare Earths, used in EVs, wind turbines etc.	USA
Mueller Water	Water Metering, and infrastructure.	USA
Nel ASA	Hydrogen, made from renewable resources.	Norway
Neoen S.A.	Renewables, using wind, solar, biomass.	France
Nibe Industrier AB	HVAC, other areas in sustainability.	Sweden
Nio	Battery electric vehicles, China based.	China
Organo Corp.	Water treatment engineering, Japan.	Japan
Origin Materials	Carbon negative materials, processes.	USA
Orsted A/S	Wind, offshore and onshore; also solar power.	Denmark
P/F Bakkafrost	Seafood, with high FAIRR Report score.	Norway
Pentair PLC	Water Efficiency and Treatment.	Britain
Plug Power	H2 fuel cells, power ahead ports, shipping.	USA
PowerCell Sweden	H2 fuel cells, power ahead ports, shipping.	Sweden
Primo Water	Water, less waste large refillable exchanges.	Canada
Proterra	Electric buses, trucks, vans, EV systems.	USA
Quantumscape	Solid state lithium-metal batteries.	USA
SalMar ASA	Seafood, aquaculture with high ESG scores	Norway
Samsung SDI	Li Ion Batteries.	S. Korea
Scatec Solar ASA	Solar, developer across emerging nations.	Norway
SFC Energy AG	Fuel Cells, direct methanol.	Germany
Shoals Technologies	Solar, electric Balance of System for PV.	USA
Siemens Gamesa Renewable	Wind turbines, and focus on renewables.	Spain
Signify NV	LEDs, was Philips Lighting.	Netherlands
Sino-American Silicon	Solar feedstock, wafers.	Taiwan
SolarEdge	Solar MicroInverters	USA
Solaria Energia y Medio	Solar, Wind, power from renewables plants.	Spain
Stantec	Consulting, Water, Buildings, Energy.	Canada
Sunnova Energy	Residential Solar and Energy Storage.	USA
SunPower Corp	Solar, services plus storage.	USA
Sunrun Inc	Solar, residential Installer.	USA
Terna SpA	Grid Efficiency for more Renewables.	Italy
Tomra Systems ASA	Recycling wastes, materials recovery.	Norway
Trimble	Precision Agriculture, greater efficiency.	USA
Veolia Environnement	Water and Wastewater Treatment.	France
Verbund AG	Renewable Energy, hydropower.	Austria
Vestas Wind Systems A/S	Wind power, in both products and services.	Denmark
Wartsila OYJ	Ports, Terminals, energy with sustainability.	Finland
Watts Water Technologies	Water quality, rainwater harvests, flow control.	USA
Wolfspeed	Electrifying power, Si-C.	USA
Xebec Adsorption	Hydrogen, generation and purification.	Canada

Xinjiang Goldwind Science	Wind, turbine manufacturer, also in services.	China
Xinyi Solar Holdings Ltd	Solar glass, has spun off solar farms.	China
Xpeng	Electric vehicles, connectivity.	China
Xylem	Water Technologies.	USA
Zurn Water Solutions	Water efficiency, products design.	USA

Equal Weight = 108/100 = 0.925925% each. 0.9259259

SECTOR	#	Approx %
GREENER TRANSPORT (GT) =	13	12%
CLEAN ENERGY (CE) =	34	31%
WATER (WT) =	27	25%
SUSTAINABLE FOODS (SF) =	8	7%
POLLUTION PREVENTION (PP) =	26	24%
TOTAL CONSTITUENTS =	108	

For Rebalance in latter Q1 2022 of OCEAN Index

5 Deletes: AMSC.OQ, Clb.ST, GUR.S, LILM.OQ, MEL.NZ

5 Additions: AALB.AS, FIN.S, METEX.PA, 6368.T, ZWS.N

**In 2021 this Index was re-named the Cool Climate™ Clean Solutions Index (OCEAN) to better reflect the theme being captured. (Previously, it had been titled Clean Ocean Index). Same stock symbol.
***In 2021, Clean Energy Low CO2 Sector (CE) was re-titled Clean Energy (CE); Greener Shipping (GS) re-titled Greener Transport (GT); Sustainable Fisheries re-titled Sustainable Foods (SF), and Water Treatment (WT) re-titled Water (WT).

Disclosure: from the 1990s the co-founder and manager of the ECO Index began to sell personal holdings pertinent to any of the 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.

For more on the WilderHill Indexes, see: https://wildershares.com
For a 1990s antecedent, the original WilderHill Hydrogen Fuel Cell Index: see http://h2fuelcells.org
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