WilderShares, LLC

Q3 WilderHill® Quarterly Report: ECO, NEX, H2X, WNX Indexes, Sept. 30, 2022

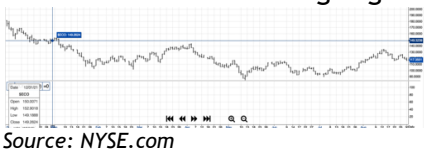
The Clean Energy Index® (ECO) started Q3 near 95, and late in volatile Q3 it was near 100. Or, these last few years ECO rose +58% for 2019. Remarkably it then rose by +203% for 2020, about the best performance of any Index, or Fund anywhere. Perhaps unsurprising after such gains 2019 & 2020, it fell by -30% for 2021 when a climate bill failed, pushing the theme down, plus inflation fears overcame recent decarbonizing trends that might favor renewables ahead. After falling again sharply Q1 2022 by 1/3rd to 100 - war brought a fast shift away from Russian gas and in war's first few weeks, ECO had jumped +40% on the better alternatives found here. It fell harder in Q2 to an 84 low on supply chaos; rose mildly on European green hopes; jumped in Q3 on passage of a slimmed-down climate law, then fell down fast on broad recession fears. Since start of 2017 when ECO at 38, by late Q3 2022 it was up some +210%.

ECO most certainly may fall hard; if viewed from a 280 peak Q1 2021 to under 90 in Q2 2022, this theme had plummeted ~2/3rds. History shows all 4 here, ECO, NEX, hydrogen H2X & wind WNX themes can & will at times 'drop like a rock'. So, jumps true, yet crashes happen too. Even if renewables bring an energy transition. Even if wind & solar become the best-priced electricity anytime, anywhere in history, there'll still be falls here along the way. Green equities may captivate; yet sink too. Perhaps not only in solar, also in wind & all renewables, hydrogen economy & fuel cells, electric vehicles, batteries & energy storage, thinking informed by decarbonization of everything and by ESG; it has always been thus.

Last 5 years the benchmark the ECO Index® live since 2004 and 1st for climate solutions, is up +160% to mid-Q3 2022. This over a period when any energy gains may stand out. For same 5 years despite huge recent gains oil & gas are only up +10%; they're *down* by -50% the last 10 years. By contrast, decarbonization as an organizing theme in ECO is up +155% last 10 years, showing very differing returns in sustainable energy. The first *global* clean energy Index is the WilderHill New Energy Global Innovation (NEX) live since 2006, with US and European trackers: NEX is up +85% last 5 years, it's up +200% last 10 years starkly beating fossil fuels.

After big falls 2021 to mid-2022, all 4 Indexes jumped in July 2022 on a slimmed-climate law. Here we offer mere observation: it's counter-intuitive perhaps, yet clean energy theme and so ECO Index spiked up during Bush II & Trump - though neither promoted green energy. Conversely ECO saw some big falls in 8 years of Obama & 2 of Biden who favored this sector. As for elections ahead, conservatives *may* take House and/or Senate, mixed leadership. Or conceivably, House stays + 2 new Senate seats go blue, for maybe $2 trillion to clean energy. Outcomes may well fall between those; but whatever happens, should prove fascinating.

In sum, 2 newest WilderHill themes for Hydrogen Economy (H2X) & Wind Energy (WNX) have joined the original 2 benchmarks ECO & NEX for 4 pure-play leaders. Meanwhile, energy that's long been mainly fossil fuels taken from deep underground & burned – increasingly is received in clean breezes & sunlight gifted freely and renewably, from up towards Heavens.



Source: NYSE.com

Amidst turmoil of late, some factors help explain why ECO & NEX, plus Hydrogen Economy H2X & Wind WNX themes after having dropped hard 2021 & 1st half 2022 – rose in July 2022. *Most acute was the 'surprise' Yes by 1 US Senator that led to an Inflation Reduction Act (IRA) of 2022, $369 Billion in a smallish yet notable step on climate crisis and CO_2. Meanwhile, *Wind & solar had easily the winning Bids 2022 reaffirming they're best-priced utility-scale electricity in a big UK auction; they obliterated an ability of legacy fossil fuels to compete, and European/Asian/US energy trends 2022 likewise saw renewables as smartest path ahead. *France's nuclear power was slammed by surprising corrosion in 2022 forcing ½ of its nuclear capacity offline to levels 3 decades ago; plus Summer brought dire cooling and drought issues. *With war, a lesser dependability of all fossil fuels (fossils) & nuclear, Europe over-reliant on Russia gas, energy insecurity spiked in bad ways in 2022. Fossils spewing CO_2 that science ties to weather extremes, fast lost lustre, -- vs. always intermittent, yes, but so many-ways better renewables growing increasingly robust, cheaper, more firm with new energy storage.

In an energy transition begun badly, gas weaponized, weather mimicking extremes once felt decades out, it seemed the 'center might not hold'. Some societies, especially those most depending on stable climates may one day be rent asunder. Climate crises, even collapses *may* rush forward. War brought shortages: of gas & electricity. Climates in change, have brought strange ironies of both drought & then floods, cold then record heat – casting green energy in favorable light. Meanwhile, many countries were forced back to burning coal.

Sharpest cause then of jump was the 'surprise' Yes in July, by 1 Senator who got what they'd demanded. Less $ spending, 1/5th of what President had initially wanted, 'just' $369 billion. Both fossils & nuclear gained incentives; a gas pipeline in state; promise to streamline Permits for all energy; cuts to prescription drug costs, Obamacare subsidies extended. Revenue-side, making sure all big US corporations pay >15% tax. Deficit Reduction. Much slightly Deflationary in bill; that Senator so named the Act. Senate majority leader got their desired Chips Bill the minority leader had held hostage. Smaller items too, like a top White House Aide apologized for heated words half a year prior. Thus, was much-slimmed-down IRA birthed at last in 2022 - after tough draining 18 months-long labor. Delivered hot weather in extremis.

Results across green stocks were immediate. Seen too in competing Indexes created after ECO Index® - like in a global 'cleanish' energy Index of just big-caps; one nicely solar-alone; or for EVs/Batteries – capturing narrower bits & pieces. ECO Index live since 2004 stands out instead as most comprehensive, the Clean Energy Index® - and it positively jumped. Day before the Senator's change of heart (a bit foreseen, as discussed ahead), ECO Index had closed at 100 (99.95). Just 8 trading days later, it hit 125 (127 intraday) up +25%. Then fell back.

That 2022 IRA carrots-only, was a small step, far short to avoid climate catastrophe. Not as CO_2 is rising fast. $360 billion had only felt big: it barely got a key vote; $100 *Trillion* may be needed globally. Still, that IRA *can* be a tailwind. Last decade, hydroelectric was the only big renewable making electricity: it met 10% of demand – but big dams can't grow. In the past few years, vastly both-scalable and better, wind+solar grew fast: wind had met 7%+ of demand and growing; solar had met 3%+ and growing. That 10% wind+solar, plus 10% hydro, met 20% of US demand late last decade. Another 20% met by nuclear - so 40% from zero-carbon sources. But, other side of ledger, dirty polluting gas & coal met rest of US electricity demand. Thus natural gas & coal, firm & dispatchable, had met ~60% of needs. With transport/heating still-being mainly-met by oil/diesel/gas, a switch to electrify all will take years. Long-ways to go. An IRA of no Sticks, may have felt like progress, but in truth, we're just very early innings. We'll discuss throughout this report, where clean new energy may be heading.

Look just a bit forward. At US electric generating capacity-built in the 1st six-months 2022, since that shows how US electricity will be made next 2 or so decades. My, that's changed! 2/3rds of newer US power capacity built in 1H 2022, was solar or wind. Wind is leading: near 6 gigawatts (5,722 megawatts) of newly-installed utility-sized wind (>1 megawatt). New solar was near 4 gigawatts (3,896 MW): these 2 became 67.01% of all power built 1H 2022. But, the bigger picture alarms, for they aren't 100%. Of 14 gigawatts (14,352 MW) US generating capacity built in 1H 2022, nearly 5 gigawatts (4,695 MW) or 1/3rd of that was still gas.

Geothermal can/should be a major, firm dispatchable renewable. In future eg, gyrotrons may dig ultra-deeply anywhere – to bring up steam at say old coal plants. But for now, it's too costly, so just 26 MW capacity was built. Biomass can be dirty, albeit renewable; just 2 MW of it was built. In a US hit by worsening drought, just 2 MW was hydro. Not surprisingly, no new current-generation costly & risky US nuclear plants built – nor were US coal plants (unlike some other nations 2022; even rich Europe was forced back into coal use due to war).

We'll be locked into new natural gas plants, so to coal/gas until they're retired. Flip side, is fast-coming US solar & wind pipeline. The Federal Energy Regulatory Commission estimated that ~200 GW new solar is in pipeline to be built next 3 years. 66 gigawatts 'high-probability' to be completed soon. Nor does solar have offsetting retirements – as seen in old coal, oil, gas, nuclear, all hit bad by fuel costs, breakdowns, maintenance, shorter lives. Just on solar higher-probability projects, they'll soon nearly-double 2022 US utility-scale solar capacity to 74 GW (74,530 MW). And if All solar pipeline from 1H 2022 gets completed, then it can raise solar near 4x. Plus, those figures were from just before the IRA was signed latter 2022; that law will no doubt stimulate yet more solar building ahead, somewhat faster.

New US wind capacity to be built by June 2025 may reach 70 GW (70,393 MW, miniscule 158 MW old wind retiring). In 3 years to June 2025, high-probability, new-installed US wind & solar capacity together may see over 2.3 GWs being built/month, not including smaller distributed solar, PV on homes, new geothermal etc. Again, pipeline from just before the (carrots-only) IRA was signed in August 2022. Hence even more US solar/wind could be expected first half of this decade; much offshore wind ahead. It's pretty good. Yet also not near enough.

Sadly, far from enough. New US clean energy capacity 1st half of 2022 had brought share of total wind/solar/hydro energy meeting US electricity demand, to only 26.74%. Better true, than 5 years prior 2017, when solar, wind, hydro then together had met just 19.7%. Or 10 years prior, those 3 had met only 14.76% of US electricity demand. That was mainly by hydro – only a small few percent was wind, a single digit 1 or 2 percent from solar. Hence global heating ahead, climate crisis. In future, blazing Summers may catalyze a new 'Cold Rush'.

As natural gas costs spiked up 2021-22, countries moved to burn coal. Devastatingly as we've already-burst through global carbon budgets. No chance to keep to 1.5 C degrees heating. The physics, chemistry are well known: global heating CO_2 facts understood by scientists for decades. Look ahead and on present trends, we're rushing past hotter, worse 3 degrees C heating. Then hotter, busting past unprecedented gigatons of CO_2 in 25, 30 years plus. Near-term may be gas-rationing despairs in Europe etc if freezing Winters, or blazing Hot Summers. We've written for years about Thwaites Glacier and melting ice sheets, so sea-level rise, eg https://blogs.scientificamerican.com/guest-blog/exposed-the-climate-fallacy-of-2100
Or, look way back: drilling 2 miles below Antarctic ice, scientists looked backwards in time. Peered into past climates, air bubbles trapped in ice past 1 million years reveals CO_2 had generally hovered within a rather narrow range over past 'just' 1 million years.

Here a bit of geological science helps, for it looks back over vast periods - more than a past few Quarters in Finance! CO_2 had dropped hard in Ice Ages to 160 ppm (parts per million). Such times of naturally bitter cold long before we humans, are explained by a fact Earth moves predictable ways around the sun, varied and not-perfectly-round, elliptical orbits. Over tens of thousands of years, plus, it also moves in changing ways too by 'precession' and 'axial tilt' like top spinning on a table. 3 predictable changes, all explained by Milankovitch cycles, varying amounts warming solar energy has been hitting the Earth over time.

Meanwhile the Earth's continents have drifted too, changing surface, impacting climates & ocean currents. Importantly, whether land's in Northern, or Southern hemispheres, effects how much heat they relatively absorb - or may reflect the sun's heat. For example, ice sheets on land near the poles reflect sunlight (cooling) – but dark oceans near poles/or facing sunlight will better absorb heat. Net result of all these variables, 26,000 years cycle in precession, 41,000 years cycle of axial-tilt, plus continents drifting, is when & how Earth cools and warms – it can/does change climate a few degrees C (and that's a Lot!). Over time naturally. Once renewed heating starts by a combination of factors, say, CO_2 released naturally by volcanism, or CO_2 instead from decomposing vegetation etc, that can 'kick-start' a more rapid-heating via water vapor that's naturally in the air too and a very potent greenhouse gas.

Earth's CO_2 levels varied little most of a recent 1 million years. From around 160 ppm in Ice Ages - to some 2x near 280 ppm by start of Industrial Revolution. Hadn't gone higher then - one must go back 4 million years for much hotter Earth, one over >420 ppm, like today. When CO_2 did rise hard & fast, it was generally over many thousands of years. Vast CO_2 that we now spewing in compressed 2-3 centuries, means a huge heating is baked in, and has just begun. Much, much, much more heating, & sea level rise to unfold over millennia+ ahead.

Hence our problem: we're massively burning fossil fuels, putting in atmosphere 'old' carbon that was safely locked away for millions of years. Going on decades now. Say. 20 years ago, we'd put eg 23 *billion tons* of CO_2 in the air, by burning fossils. Tons released don't correlate to the tons of fuel – instead it's on ratio of carbon intrinsic to each fuel. Natural gas as seen per carbon atom, has the most hydrogen atoms, a 4:1 ratio of CH_4. However, for marketing purposes, that industry likes to call itself 'clean natural gas' (it is Not!). Only because burning gas is just a bit less-horrid per ton for carbon and pollutants, than burning oil or coal.

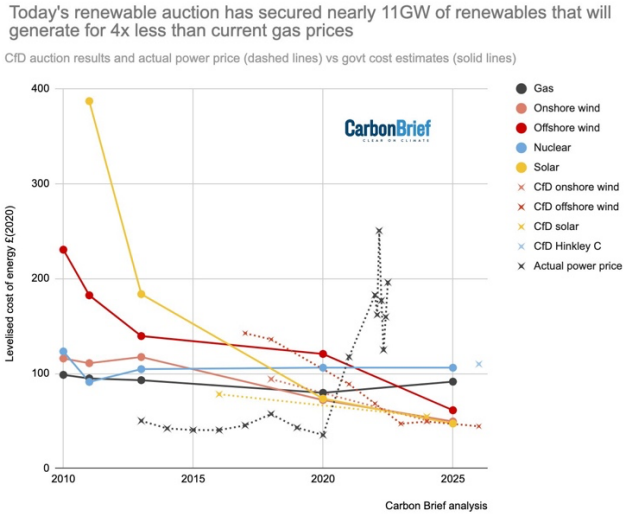
Take black coal, anthracite. Nearly all of it is carbon, so it's very carbon dense. Burning just 1 ton of it to make electricity, makes 4 tons of CO_2 - much more, per ton, than natural gas. Coal spews 67% more unwanted CO_2 plus toxic mercury, particulates, sulphur dioxide etc, awful way to make power. Young wet brown coal with impurities is being burned, though it incredibly is even worse than black coal. Net result is that say, some 20 years ago, coal was responsible for 41% of the CO_2 from fossils in our air (oil was bad at 39%, gas bad too, 20%).

20 years later, Russia's invasion in 2022 spiked gas prices. With shortages, so more coal use. June 2020, US natural gas had cost $1.48/million BTUs; but by August 2022 it was $10.00, so up +500% and was much more elsewhere! China had to ration electricity 2022. A Europe that 2 years prior nearly got off coal, had to restart burning. Global return to coal, was a death knell for stable climate. Short-term was warmth & power. But mid and longer term, there's a price to be paid for burning that carbon gathered over millions of years, released at once. Especially as electricity can & should be made far more sanely - than by fossils or in eg a Zaporizhzhia nuclear plant, shelling nearby in war(!). Tsk, all silly ways to boil water.

A big UK power generation auction in 2022 shows some paths to come. In UK, Europe, and US, gas-fired plants still make much electricity. Given gas infrastructure, not much changes fast. But, auction bid results 2022 showed far-cheaper wind, solar, & tidal will soon displace more UK gas-fired power ahead – a record 11 gigawatts (GW) of green electricity won in bidding – at just 1/4th cost of gas! Put another way, mid-2022 green power Bids came in 4 times cheaper than the then-current, gas-fired electricity! Consumer bills potentially can *drop* thanks to renewables, and by more if only the renewables (thanks, free fuel!) can grow fast enough.

11 GW = enough to power 12 million UK homes at once. In 2021/2022, prices for coal, oil & gas had jumped. Yet remarkably in 2022, 4th UK Contract for Difference (CfD) offshore wind bids were nearly 70% lower, than was seen in a 1st Round in 2015! Past 7 or so years offshore wind had gotten far, far cheaper. Electricity from fossils + nuclear had jumped in costs – while global new energy wind/solar in 7 or-so years to 2022 instead saw remarkable cost *decreases*. That's good for everyone (but fossils)! Those Bidding cleared prices in £GBP/MWh were very low: offshore wind 37.35; onshore wind 42.47; solar just 45.99. Frankly those 3 bids blew away all 'the once-cheap' fossils, so they certainly beat an always-pricey nuclear too.

All indicative of what was happening globally, and a factor in green stocks rising in July 2022. Of UK projects bid, the largest share, or 7 GW with 93 winners, was offshore wind. It can grow UK offshore wind capacity by about 1/3rd, helping reach 50 GW by 2030. With notably that low-price bid of GBP 37.35/MWh, offshore wind was nicely the cheapest electricity of all. Nearby European Ports like Danish City of Esbjerg were ready to ramp wind strongly, EU-side as well. Increasing offshore wind, towards a target 150 GW by 2050. In a world climate crisis discussed at length ahead, global emergency rife with scary news, here at least was spot of happy news. UK consumers could pay less ahead, get abundant & secure domestic electricity, new jobs too, all thanks to welcome growth soon in rather *deflationary* wind energy:



Source: CarbonBrief

Startling to see above how swiftly wind & solar costs plunged past 12 years. Gas' story went from relatively 'lowish' costs 2010 – like nuclear – to ghastly expensive 2022. It's a tale we'll tell in pages ahead. Not so much about volatility of fossil fuels, or very high-costs of nuclear – as it is about lovely cost-reductions in clean innovative renewables. Wind & solar fast became, simply put the most affordable electricity of all. Clean, secure, abundant.

But it's not been a straight line. Nor same, all places. Europe for instance, in 2022 enjoyed relatively better/lower costs to install solar power vs. in US. Why? For starters Europeans didn't pay tariffs on solar modules like US buyers had had to on clean energy kit from China. Didn't have America's state by state net metering costs. Didn't have same restrictions on regions of China. Plus, natural gas is a core competing fuel in Europe, and gas had become very expensive there 2022 at $40+ per Mcf. That gas was 3x+ more than in US – helping to make any pro-clean energy decisions much easier in Europe. In short it became (much) easier & cheaper to install new wind & new solar in Europe - than it was in the US in 2022.

Per IRENA data for 2021, Europe had already cut its average all-in installed utility-scale solar costs, a lot. Germany had pushed its solar install costs down to just $0.69/watt. Italy to $0.79, UK $0.85. Meanwhile, US was among the costly 2021 at $1.09/watt. Europe shaved $0.10/watt for PV relative to US. Surely in a world facing unended climate crises ahead, one might think decarbonizing faster should be a priority. But No. The US had been champion of less regulatory burdens once: but lately the US had higher soft costs to install solar - design, permitting installation – vs. burdens vs Europe. Compare like for like, 2 systems of similar size and put aside costs for PV hardware (lower as well in Europe), America was quite inefficient.

Step back, prior cost *trends* to install renewables, in 2020 to 2021, worldwide did then do what one hoped to see: Decline. More recent inflation in 2022, hadn't yet shown up in these data; we'll see that inflation ahead in data. But looking back just at 2020 to 2021, levelized costs of energy (LCOE) for new utility-scale solar PV electricity *fell* 13% in 2020-2021 to $0.048/kWh. Onshore wind fell 15% y/over/y to $0.033 per kWh. Offshore wind, fell by 13% year over year to $0.075/kWh. This is significant. Take say, Germany. It has *potential* to raise its offshore wind generating capacity to 81 GW. Pretty immense, is like say 81 mid-sized current-gen nuclear reactors. The wind is intermittent, yes – yet in Germany that faced electricity rationing 2022, it could be stupendous. 10x more power, than 7.8 GW its operating offshore wind had made 1H of 2022. To put that into perspective, 139 billion kWhs of clean energy made by all Germany's renewables just 1H 2022, met 49% or half its total electricity demand! Its onshore wind energy had made 59 billion kWhs; solar plants 33 B kWhs; its biomass 24 B kWhs; its hydro B 9 kWhs, and its offshore wind had made 12 B kWhs.

Yes 2022 renewables costs had risen some for new solar & wind. Still, was far worse at fossils, where prices jumped inordinately. Renewables by comparison, moderately up, handily beat in unprecedented ways fossils & nukes. Look at average fuel-only costs, for natural gas-generated electricity (no CO_2 Fees) in 2022, those rose to $0.23/kWh. That's 23 cents per kilowatt hour ***for just the fuel alone***. Built gas plants were pricier to run - than building new onshore/offshore wind, or solar on free fuel. Gas fuel costs mid-2022, 540% pricier than 2020. Add carbon Fees like in Europe, and 'once-cheap' so-called "clean" (Not clean) gas-fired electricity = >27 cents per kilowatt hour! 4 to 6-fold more than was new solar & onshore wind in 2022. No wonder, renewables competing on even-playing field were the obvious choice. And thermals coal, gas, nukes, struggled to stay cool, just to work all Summer 2022.

Over about the dozen years, 2010 to 2022, the LCOE figures by 2022 pretty much said it all. For electricity from natural gas, costs had hit 23 cents per kilowatt hour fuel-alone, or 27 cents with a carbon Fee in places like Europe. By comparison, onshore wind costs were down near just 3 cents(!) thanks to 68% cost declines since 2010! Solar PV costs down near 5 cents thanks to declines of 88%!). Offshore wind just 7 cents, on fall of 60%. As renewables enjoy free fuel, plus get generally cheaper over time to boot, it was becoming really No Contest.

As for (Russian) natural gas once a top EU choice for electricity, it was suddenly costly, a red letter of shame. Especially in going from cheap/plentiful for industrial Germany using much – to a huge security risk. Any Russian gas suddenly, was a liability. A dire weakness. Energy Security hawks thus wanted all the non-Russian natural gas they could get asap, even via LNG regasification vessels hence more fossil fuel infrastructure. On other hand, the Climate hawks wanted immediately to move off all that. Go directly to new zero-carbon infrastructure exclusively on clean energy. Keeping any gas at all, was therefore a mutual suicide pact.

Yet both concurred 2022: industrial Germany could no longer rely on *any* Russia gas. Emphasized a great need, agreed on by all for vastly more electricity *Storage* - seen ahead. (Electricity storage can be measured as power, in watts – or as energy, in watts over time like megawatt/hours. And 95% of electricity storage was pumped hydro moving water between 2 elevations, power on turbine size & elevation difference & globally 165 GW could be stored. As energy, how long/how much water in reservoirs, 2021 was 9,000 GW/hrs, or 9 TW/hrs). Anyway, all that pumped hydro storage capacity was capped, dams can't grow and best dam sites taken. Past electricity storage capacity once mainly pumped hydro - now nowhere near enough, given intermittency and diversity of renewables. Electricity as its made must be used immediately, or be stored, so new intermittent sun & wind demanded much new storage, maybe green hydrogen too. Storage is now the key to magnitudes of clean energy growth.

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

Meanwhile, some rely on hope. Hoping, say, energy crises ahead in 2020s will be not as bad as those of the 1970s. And yet, this decade may be worse. The 1970s were only about oil. In 2020s they're partly about oil – but notably too vital natural gas – even nuclear-fuel-cycle. All that demand pushing up the costs of coal too. Meanwhile CO_2 only grows worse

Or some deny the climate science & CO_2. But given consequences if they're wrong – science all but shouts that Wrong they are – that's a slender reed upon which to hang one's hopes. In 2022 one world leader stood-out, perhaps intending to stoke conflicts among Europe's elites. With an invasion to re-claim past territories, cause energy rivalries. To divide EU/and West. Tear down leadership elites, promote global populism. As a key energy supplier for Europe, they had wherewithal to withhold natural gas. Daily we were reminded of the horrors of war. Yet there were several other non-war issues, big things going on in the early 2020s too.

Those included negative surprises non-covered by media. Consider: methane concentrations in air 2022 were inexplicably far higher than expected, or projected. If due to anthropogenic causes, say leaky natural gas pipes, that's one thing. Or agricultural practices, it too may be addressed. But methane is a very-potent greenhouse gas. Much more so than more typically discussed CO_2. Should a record 17 ppb methane increase up to 1,900+ ppb be instead due to 'natural, positive feedbacks', to global heating effects we can't mitigate – then surprises could be truly frightening. That it's being today overlooked, is of little comfort.

Battles rage of opposing ideas, differing views of what's most desirable. For those aiming for climate goals, 2020/2021 in the US had been about passing a huge predecessor bill, one before an IRA. That omnibus draft Build Back Better (BBB) bill had carrots – but also sticks critically limiting fossil fuels. After it narrowly failed, both 2021 & 1H 2022, that was about a narrower path. After that too failed, only hopes were big Executive Action. In words of one US Senator, it was time for Executive 'beast mode' with say a Cost of Carbon Rule; Require Carbon Capture from All Major Emitters; Stricter Limits on co-Pollutants of Coal, Gas Plants; Stronger Emission Controls for Light/Heavy Vehicles; Put Emissions Front & Center in Procurement (like USPS); Locate Methane Leaks with Satellites & Enforce; Utilize DOJ for Climate Litigation, and more. Yet each one and all the suggestions above, were far easier said than done.

Each was sure to be harpooned IRL, or 'in real life' in 2022. With inflation then rampant – opponents surely would call any above, inflationary (though renewables *reduce* energy costs and so are deflationary). Plus, Europe badly wanted America's LNG due to Russia's cuts, many in America were calling for a big ramp up/export in fossils. A US Supreme Court had tamped down on the EPA's ability to address carbon. Plus, all above would be bogged down in Courts. No doubt too it could also be reversed on day one by a new President's stroke of a pen.

So, the July 2022 reversal by 1 Senator letting Reconciliation Bill's 51 votes pass into law, short of a filibuster-proof 60 votes – was in fact 'a big deal'. Broke logjam, made IRA happen. Yet not all can be reconciliation: some actions ruled by Parliamentarian as non-revenue, need bipartisan 60 votes. To eg streamline permits for oil, gas, grid – and the conservative party angry at that Senator – likely to balk at giving them a 'win' even if streamlining permits was desired. They may thus prefer the other W. Virginia Senator's Bill. But, getting that 1 Yes for a slimmed-down, compromised, carrots-a-rama, $369 Billion IRA was important. In July, brief up catalyst for clean themes in stocks, thus ECO, NEX, and H2X, WHX. Then they drifted back afterwards in a much broader tech selloff, on fears of higher inflation and so rates.

Yet even with IRA, issues abound vexing clean energy going forward. Untouched by IRA. Grids must eg be vastly expanded for renewables & storage, fast. Permits streamlined. Or for example in hardware: offshore wind turbines are eye-opening big. Sensibly so as wind power output doesn't just double if rotor diameter doubles – but can go up 4x; doubling wind speeds by going offshore can give turbines 8x more power – so all the maths point to enormously scaled-up offshore turbines. Note then extant ships capable of installing a not long-ago 'big' 1.5 megawatt-sized turbine in oceans, just cannot cope with now skyscraper-tall blades for the gigantic turbines that can put out 15 MW, some 10 times prior power.

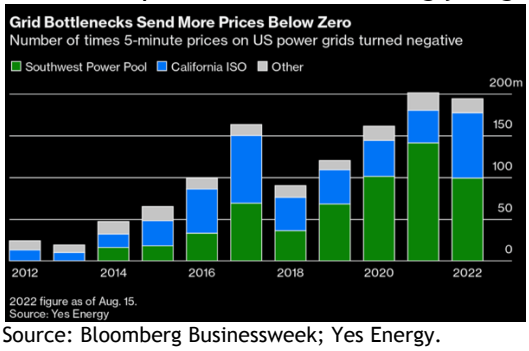
Nowadays these ships are purpose-built giant wind turbine-installation vessels (WTIVs). But in the US, this gets 'interesting' due to a longstanding Jones Act, which disallows foreign-owned, built, or crewed vessels, from operating between 2 US ports. Hence big European WTIV vessels already built can't be simply brought over. Yet the IRA contemplates a very rapid increase (huzzah) in offshore wind capacity off the US; 30 new GWs by 2030. Costs are eye-wateringly high to build WTIVs for these giants, the first Jones-Act ready vessels not come online until 2023 soonest. So, work-arounds for a few years are needed. Like base European-WTIVs off Canada at first, to help install huge turbines off New England. Or US flagged barges transport these turbines out to the waiting WTIVs sent over from Europe or Asia, etc. IRA of 2022 has created issues as well. Eg the EV tax credits are just for US built EVs (few), with key battery minerals sourced, processed and refined too in US or ally nation (fewer) so sparse EV credits available at first. But mainly, if climate crisis/CO_2 is our real foe, then a *carrots-only* IRA that continues all fossils burning (and no sticks) – was No Answer at all.

It may be easiest to think of the scale of what's needed to 2050 by using rough back-of-napkin figures. Focus Not on what 1 Senator may be prepared to give – but rather on CO2 reductions needed, given a global carbon budget, and according to available science. These figures are enormous – but that's the scale of this problem, growing more speedily undeniable. Very roughly, it's been estimated $100 Trillion total will be needed worldwide to decarbonize human activity in decades to 2050. Tremendous sums of course. But going to create immense new wealth too – very unlike the *costs,* say, of global heating, or of sea level rise destroying forever for instance the State of Florida much sooner than yet realized. According to the International Energy Agency, getting to net-zero (not even to true zero) emissions, will mean spending some $4 Trillion/year globally over the near three decades to 2050.

Back-of-napkin, let's say the US spends 25% of that, about $25 Trillion over 3 decades. China a similar 25% but on much differing nuclear-heavy path, emphasizing wind/PV manufacturing, strategic minerals, its own new electric vehicle base. Europe etc spends say a hefty 20% over 3 decades moving into renewables, green hydrogen+ for heating, a shift to EVs, etc.

On that metric, and big US needs – that $369 Billion in the 2022 IRA was clearly just a start. For example, one place where US needs are great is a new stronger power grid. Interestingly, an antiquated, full of bottlenecks US grid of 2021 had forced wholesale electricity prices to go negative 200 million times in 2021. That was 2x the figure from five years prior (measured in 5-minute intervals over 7 US grids and 41,000 nodes) – due to bottlenecks. Not so great a problem as to crash overall wholesale pricing. But so much distant wind & solar has gotten bunched-up distant places, prices going below zero, users are *paid* to take that electricity. More notably, it's now preventing a rapid-enough growth in new wind + solar power.

Insufficient transmission prevents wanted, green electrons reaching far-off users, seen for example in Southwest Power Pool (SWP). It's a vast windy area from New Mexico to Montana – yet only around 19 million people serviced. Not surprisingly wind energy is main electricity generation. And January-July 2022, wholesale prices there went negative a huge 17% of the time. Versus 7% in heavily-populated California or main Texas grids. 2nd Quarter of 2022, close to 25% of all SWP real-time wholesale prices were negative! Wind+solar see increasingly vexed bottlenecks, throttling back their potential for growth. One consequence in 1H 2022 was that wholesale prices went increasingly negative in certain grids, as was clearly seen here,



Source: Bloomberg Businessweek; Yes Energy.

A Princeton University study estimates around $2.5 Trillion will be needed by 2050 to meet new grid transmission needs. Of course, that's a lot of $$! But with current grid nearing-end of expected life in many places; built in a different era for 1-way power transmission from big thermal plants; with costs from blackouts now far-higher, in context of $25 Trillion total US spending, this one-tenth figure going to grid improvements seems even appropriate(!).

New, modern grid infrastructure means better ways to make, use, & share power – with far greater resilience. An improved capacity for more solar panels as infill on homes, rooftops. Far more places EVs can charge up – and for Vehicle to Grid (V2G) storage, or Vehicle to Home (V2H) like in acute emergencies. Even regularly arbitraging higher power costs during day, by letting car owners sell back into grid – and then changing up more cheaply at night.

Grand changes more akin to Constructing the US Interstate Highway system in the 1950s. It's been so far, patchy grid repairs, very few big upgrades, catch as catch can. Because of grid bottlenecks, wholesale electricity prices went negative in 2022 (YTD to August 15th) a big 6.8% of the time – vs. 4.6% in 2021. Wind/solar curtailed (shut) at times or would have been worse. While fossil/nuclear industries like to criticize the renewables for intermittency, as huge defect (when No wind or sun) – they prefer Not to discuss when sun or wind, the flip side, are especially abundant. Then, it forces 'firm' coal/nukes (not nimble and unable to start/stop) to operate with prices dropped near zero – even negative! On May 7, 2022 a big Texas coal plant saw prices briefly fall to -$8,977.46 per megawatt/hr; *paying* wholesale users to take their power! 'Firm' becomes a liability, when renewables can/do make power at times very, very cheaply. So, $2.5 Trillion useful for grid on a host of reasons. Some are good, some are bad; but an aged US grid dates back in some parts to nearer earlier half of last century.

Not to be overlooked are Big related needs for a More Resilient grid. Not just in US of course. To Sept 2022, 28 major grid outages affected 1+ million persons each globally, past 4 years – Puerto Rico was 28th. 10 outages affected at least 10 million people each! If uninterrupted power is mission-critical, outage over >8 hours is longer than lithium-ion batteries can bridge. So instead of just storage, one path points to fuel cells to carry on, unlimited – as long as supplied with fuel. For days, weeks, months. In 2022 fuel was likely polluting natural gas/CH_4 – but not far out, may be green hydrogen to fuel cell – no pollution. (Even traditional natural gas to a fuel cell, is typically less costly with more BTUs than usual alternate diesel genset; a diesel turbine spews 161 lbs of CO2 per MMBtu, a gas turbine bad too at 117 lbs – while a fuel cell works by electrochemical reaction – not combusting, so is more efficient & less polluting. Best is same fuel cell working soon on pollutant-free green hydrogen, H_2 – and no oxides of nitrogen from burning, thus H_2 fuel should be from wind or solar plus electrolyzers!).

Consider past severe power outages: 3 days long impacted 100 million people in India due to a coal shortage; 7 days for 1 million people in Canada due to a Derecho; 10 days for 1 million in UK due to lightning strike; 1 day for 120 million in Indonesia due to power line disruption. Clearly more and bigger power grid failures are at our collective doorsteps. Really scary is a blackout for weeks, months which means many fatalities. Followed by untried and risky black start attempt, all that can be done to fast bootstrap large grids back into operation.

Look at IRA of 2022 as being a small start, and there's many ways one reasonably may expect climate legislation gets built-on ahead. For example blackouts bring Shouts to modernize/fix the grid asap, '*today*'! Another, conservative-states like Iowa (60% of its power from wind), Kansas (near 50%), Oklahoma (close behind) long opposed to renewables – increasingly benefit from wind jobs: it's conceivable a few Senators tear away from past 100% partisan opposition. New weather extremes – or 2 Senate seats going blue – either one may bring forward a key element left out of IRA: 'sticks' forcing CO_2 heavy plants to shutter. Once-heretical ideas like a carbon-tax to be considered. Trillions in new spending. Next few years both on downsides of fossils like climate disasters, wars, shortages – and clean energy as better & cheaper option - one might expect a great deal more positive developments in policy and law.

A brief history of why that 1 Senator did change their vote to Yes, helps explain how IRA got defanged. Among the Senator's top concerns, was the bill mustn't be Inflationary; Americans were struggling. Note then Larry Summers who'd correctly forecasted Covid stimulus as very inflationary, had the bona fides in warning on big government spending. Summers confirmed for the Senator this narrower, smaller, draft IRA bill would be slightly disinflationary. So too did economists from the U. of Chicago, and the Wharton School at U. of Pennsylvania.

Bill Gates emphasized importance of this draft bill in funding US innovations: access to early capital is key & government could play a unique role. Bit like a national industrial policy, or picking winners. China after all had very successfully nurtured early-on its nascent battery industry and by 2022 it controlled sources of strategic battery, rare Earths & other minerals, plus processing/refining, battery production too. Gates favored particular ideas in advanced gen (generation) nuclear, liquid sodium Natrium - vs current/risky old gen II; sequestration; green cement and more. Overcoming a 'green premium', the Senator's 1 vote could help do that. When the Senator & spouse dined with Gates, they'd discussed how IRA could benefit West Virginia workers who'd lost jobs in coal mining/power plants. White House reps, and manufacturing interests too pointed to how even a defanged IRA can help the state long wedded to coal. Two Cabinet members had visited praising a proposed new battery plant. Steel firms raised solar manufacturing in the state. Pile on at crunch time. AFL-CIO, United Mine Workers noted how IRA at last fully funds black lung health benefits, prevailing wages, builds renewables nearby closed coal facilities. In the end, with all that + Deficit Reduction = the Senator gave that key, Yes – to a defanged, slimmed-down IRA with all carrots-only.

Changing topics to renewables & global *investing*, look at just before IRA had passed in 2022 – at first half/1H (Jan.-June) 2022. It saw more total investments into renewable energy, than any prior 6 months period. But not so much investment $ into public stock markets; that level of investing was off globally by 65% in 1H. Instead, private/public funds put together had reached USD $226 billion (EUR 220 billion) for an 11% gain over 1H prior year, thanks to newly massive amounts on private side. Solar saw USD $120 billion or 33% increase over 1H 2021; wind investments saw USD $84 billion or 16% gain. Despite wicked solar/wind inflation. And much of that new USD/RMB/CNY was China-based and was China-centric: it had put equal to USD $58 billion into new wind 1H 2022, and put USD $41 billion into big-solar projects.

China notably was aiming remarkably at a target 1,200 GW of wind/solar capacity by 2030. Worldwide, offshore wind was set to grow sizably in many nations. 1H 2022 investments rose year-over-year by 52%. From a total global offshore installed wind in 2021 of 53 GW, it was expected to grow 10x to 2035. Combine wind/solar + with storage, so firm, dispatchable, and available when needed. Or maybe made as green hydrogen, then as ammonia or methanol.

This also points to our two new WilderHill Indexes launched 2022 for Hydrogen Economy (H2X), and for Wind Energy (WNX). Both H2X/WNX Indexes are deep green, Europe SFDR Article 9; are liquid with average daily trading value floor past 90 days >$750k for existing and >$1m for new components. Like NEX they notably give each component voice by being very helpfully equal-weighted. And already have trackers available as well, in Europe. We'd first started indexing informally for Hydrogen & Fuel Cells back in late 1990s, and so have a deep bench of experience here. Their websites for Hydrogen Economy are at, https://h2xindex.com & Wind Energy, https://wnxindex.com For the antecedents from 1999-2007, our predecessor informal Hydrogen Fuel Cell Index is seen at, http://h2fuelcells.org

A consequential 2022 thus changed much from a year before. Not just in clean energy, or fossil fuels. Another energy option some had hoped might shine – build more nuclear power – was hard hit by a huge wall of problems. One might have thought current-generation nuclear would come 'riding to rescue' 2022 on invasion of Ukraine. That France, with its big fleet of nuclear plants and know-how, would grow its nukes full tilt. Export ample electrons to Europe, sit pretty, unvexed by spiking gas prices, or by any possible cessation of Russian gas.

Instead, France 2022 was badly handicapped, ½ its modern nuclear plants stuck offline. Not long ago they'd been *the* poster child for top-shelf nuclear. Proud of her sovereign technological nuclear abilities, highest-percentage nuclear in world, without mega-disasters of Chernobyl or Fukishima. But instead, France in 2022 was hard hit by massive, forced domestic power cuts. 12 of her 56 reactors offline, a 27% year over year output drop to lowest power levels of 30 years. Taxpayer subsidized high electricity costs that may go on to vex in seeming perpetuity. Big projected power cuts 2022, fell to under 300 terawatt/hours. All with consequences for Europe, struggling itself to find enough fossils-created power.

Not then well-known yet, was France's nuclear plants had been acutely hit by unexpectedly bad corrosion issues, needing maintenance that will take years to properly sort. Besides having to worry about rolling blackouts, France looked to nationalize her $30 Billion debt-laden private champion of nuclear – and then moved to do so 2022. And they weren't alone. Big problems in current-generation nuclear were rife at Hinkley Point C power station going up in Britain. Predictably far behind-schedule, far, far over-budget – yet biggest modern nuclear plant going up in the West. In the words of The Economist (June 25, 2022):

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

What then of spiffy new nuclear plants being built more speedily elsewhere? Aren't they going up faster, on budget, having learned from colossal mistakes like Hinkley? After all, nuclear-proponents talk of lessons learned. Yes, but not in the West. Take America's attempt to build nuclear cheaply, swiftly at modern Vogtle 3/4 in Georgia – latest 2nd gen nuclear in 3 decades. Begun 2009 with well-understood Westinghouse designs, their original certified costs were a big $14 Billion, to be done by 2017. But, instead, it drove Westinghouse bankrupt. By 2018 its costs were newly estimated $25 Billion. Then in 2021, costs were re-estimated at $28 Billion, with those 2 reactors still not completed by 2022! France's 'new' Flamanville plant had begun in 2007 then was a decade behind schedule, incomplete, hundreds of workers redoing welds 2022 costing added Billions of Euros. Likewise a modern Olkiluoto nuclear plant in Finland was due to open 2009; yet it had only begun its very earliest testing in 2022.

On the other hand, plans to retire *built* nuclear plants were put on hold in a 2022 crisis. True, China & Russia have shown an ability to build big nuclear plants on schedule, on budget. But, to contract with Russia, for a new nuclear plant, was now 'impossible'. That has left China, but future contracts with it too, were a question mark for the West. A major point was, is: There's No Easy Simple Energy Answers! And much had changed dramatically in 2022.

As discussed, 3 factors 2022 were *Inflation in solar, wind, batteries, rather than falling as usual - costs rose 30% year over year in *rises* not often seen here; *War, when energy prices spiked in turmoil; and *Supply Chains chaos. All the renewables grew more costly in 2022 - but then fossil fuels plus nuclear did too even more so. Inflation torments: green renewables and batteries accustomed to price *Declines*, to cost *drops* – instead, found no safe port as the green stocks were hammered 1H. Costs surged for everything: labor, capital, materials, shipping. Usually-declining prices for wind & solar – rose in 1H 2022. Tech equities fell Q3 2022. And global EV prices rose too so electric vehicles became less-affordable.

Secondly, turmoil was by no means confined. In April 2022 Russia's Rosneft put up 37 million barrels of flagship Urals crude for May delivery at 'fire-sale' (though high) prices, on fears Europe may halt buying: cheap spot prices if 100% pre-paid. Rosneft pivoted to China, India. One Western oil major sought to pull out of its Sakhalin-1 mega-project; a big trading firm abandoned a 10% stake in Vostok-1 mega-project. February 2022, Rosneft had signed in very prescient fashion, a huge $80 billion, 10-year supply deal with its big China counterpart CNPC. India's refiners signed on for heavy crude. Europe looked for alternate suppliers for its oil & critical diesel, natural gas, mindful of cold winters ahead, hot summers. Some coal, nuclear plants slated to close – kept going, even restarted. Despite the fact, and here's looking at you, coal & fossils, that the climate crisis will be much worse than people yet recognize.

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

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

Clarity was needed then on many green-energy fronts. Would the Congress extend US tax credits to 10 years for wind, solar, stand-alone storage? Once 1 US Senator (wanting a smaller bill, mountain valley pipeline, more US gas to Europe) got much in July, so IRA signed August. That answered some questions. (Opposing conservatives could possibly gain a bit in Fall 2022 elections, or not – so it had been 'then or never' for clean energy legislation). But now after, needed too were eg insights on European green incentives, and for efficiency, hydrogen. Plans first arose 2022 for 5-fold increase in UK solar capacity up fast from 14 GW - to 70 GW 2035. Germany began planning for blossoming of solar going from 22 GW – to 215 GW by 2030. Hence a big positive push in Europe and elsewhere for renewables. Sensibly: renewables plus storage are great foil against relying on (Russian) fossil gas. Meanwhile, all energy; the renewables – plus fossils including critical diesel, coal, oil, natural gas – and nuclear - saw prices spiking up – even gas & electricity rationing flared in 2022. So clean energy went from a recent growth/ margin expansion in 2020 – to margin compression across 2021/2022.

For Europe to wean itself off all Russian gas starting 2022 wouldn't be easy. Take German car manufacturing, so core in its economy. Germany was exiting diesel – starting towards new EVs that can become renewably-powered. But, what of her big factories? Could they too, go beyond natural gas in manufacturing? For high heat, say, in vehicle paint shops? How ready was it to shake an addiction to cheap Russian natural gas, for heat, from 2023/2024/2025…?

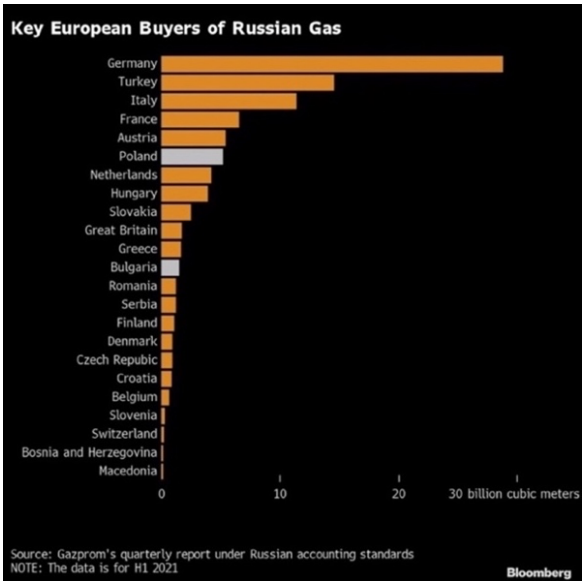
Shell-games like 'carbon offsets' or 'renewable energy certificates' once let firms pretend to be using less natural gas. (Claiming say, trees on slopes so steep couldn't be cut, 'reduced' fossils via carbon credits). Or, that non-transparent excess European hydropower certificates, could somehow incentivize renewables. But that's more virtue signaling. Once the Russia's gas supply was first cut – then off – it fast exposed how utterly dependent on non-renewable fossils gas & coal for heat, as well as for electricity – her auto industry actually was.

And it was, by a lot. 2021 well over >½ of the Germany auto factory power came from non-renewables. Put another way, only 13% of heating needs at her 3 big carmakers was met by renewables. At Volkswagen 80% of its heating was by non-renewables. It aimed to move to cogeneration, combined heat & power at Wolfsburg >6.5 million square meters plant. Go from coal - to gas, but war 2022 meant it stayed longer on awful yet abundant coal. At BMW, 60% of its energy came from fossils; mainly gas so typical across industry. A Potemkin-Village-like façade, a crowd-pleasing-response was site big renewables near a factory. But those only supplied overall some 1% of electricity/energy in 2021 at Volkswagen, less at Mercedes, BMW. An exception was a BMW I3 plant in Leipzig that got 20% of its *electricity* (but not heat) from 4 nearby big-wind turbines. Still, cheap-hydroelectric was hit by drought in 2022, due perhaps to climate crisis and those very same fossils; it stifled nearby industries like in Sichuan China - where 30% of China's hydro was sited, thus manufacturers, aluminum smelters etc.

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

For how much easier green *electricity* from renewables was, big auto parts maker ZF in 2022 signed power purchase agreements that bought 210 GWh wind power for its manufacturing in Germany. Statkraft Norway supplied ZF with 100 GWh from wind farms in Spain 2022. Then, 150 GWh more in 2023. 2024 & 2025 Enovos Energie Deutschland provides ZF green electricity from its wind farms in Scandinavia. So ZF gets green electricity that could power 72,000 German households. Modest start at least on the *green electricity power* supply front.

A hard fact remains: *electricity* (green or otherwise) is a very poor way to make *heat*. Homes can get good low-grade warmth by heat-pumps for sure. But for high industrial heat – to go from fossil gas to decarbonize via green hydrogen, ammonia, methanol, means in light of climate crisis, too much time. Time-scales of decades is a hothouse world very different from our habitable one of today. In short, green electricity & green *energy heat* are needed ***Now***. Given climate crisis – plus suddenly from 2022 an energy security crisis. 1st half of 2020s decade, 'solutions' were Not happening swiftly enough. Not one bit. And not much needed high industrial heat can come directly from sustainable wind energy - or solar.



Source: Gazprom's Quarterly Reports; Bloomberg.

As seen in a chart above, Germany, Italy, France etc were in a bad bind. A big worry early 2020s was thus natural gas rationing in Europe. Fast moves off Russian oil especially off gas was demanded. Thus, Spring 2022 Europe first looked at a 210 billion euros (USD $221 billion) REPowerEU plan upping renewables (some) from 40%, to 45% in 2030. EU renewable energy generation targets rose to 1,236 GW. To cut 6 years of red tape for wind permits, 4 years for solar, to new 'go to areas' that mean permits in 'just' 1 year. It aimed to grow EU solar capacity by near 2x to 320 GW by 2025; then to 600 GW solar by 2030. New 113 billion euros for renewables, energy efficiency, hydrogen infrastructure and heating for industry. But - that still wasn't enough. Plus there was much spending on adding fossils/gas infrastructure too. Rather like seen in the US. Replacing in 2 to 3 years Russian piped gas - with new LNG infrastructure bringing fossil gas in by ships – just not coming from Russia.

Despite all this new spending & attention to clean energy, it seems counter-intuitive – yet it did not, & does not equate to persistent equity gains in clean energy, so ECO, NEX, H2X, WNX. In month of April 2022, ECO dropped hard: -22%. In May, Year to Date (YTD) was down -40%. It swooned again June 2022 to go once more under <100 on fast-rising headline inflation. To be fair, ECO jumped in July. And famous tech-heavy NASDAQ was also down -13% in April, then -30% YTD to June. From its own peak, 'Naz' far off highs; S&P500, Dow too dropped hard YTD in bear markets in each one. Not as volatile as ECO, to be sure, but as 3 of the world's most-watched themes, those NASDAQ/Dow/S&P500 big drops were no small-potatoes. Then as noted ECO briefly jumped, +22% in July. Much more than major Indexes – then fell back.

Curiously, a well-known active fund manager did criticize passive Indexes & ETFs in Spring 2022, claiming 1) passive indexes underperform active-managed funds, & 2) Indexing prevents having high-growth stories like a notable Tesla, early on. Yet both claims demonstrably are wrong. The first shown repeatedly false for years: in fact passive Indexes *Outperform the active-managed Funds some 80% of the time!* No wonder passive indexes have been 'eating active Funds lunch', growing at latter's expense. We've seen how ECO has beat an active-managed Fund in this space over most periods. 2nd, ECO in fact had added a Tesla so notable to this theme, at its start/IPO. So, that Tesla, cited (for Not being added to Indexes early on) was in fact added here, and in the first Quarter possible, at the start Q3 2010, https://wildershares.com/pdf/2010%20Q3%20ECO%20Quarterly%20Report.pdf Prior to that too, we'd written about that important EV company – and they'd kindly noted us as well.

Let's take a brief look specifically at ARKK, as a well-known, big-performing (active) fund that rose especially well in 2020. If one wishes to find a Fund of similar performance to ECO, past 5 years to Q3 2022, then interestingly it presents a pretty comparable chart. Their ARK Innovation Fund (ARKK) is younger yet also innovation heavy; it began a decade *after* our ECO in a mildly differing, disruptive theme. Yet moves since were roughly similar, though ARKK began much later (ARKK began 2014 – vs 2004 for our ECO, 2005 for independent tracker; our 1st Global clean energy NEX was born 2006 / tracker launched 2007). Again, the themes center on innovation; for past 5 years here to mid-Q3 (Aug. 30) 2022, clearly **ECO** (darker blue) and **ARKK** (light blue) had both jumped up about same time, March of 2020 – then fell back.

But we can see ECO jumped higher & went farther up, than ARKK co-peaking Feb. 8, 2021. And while both painfully plummeted after as seen in chart, ECO ends much better in Q3 2022 at up about +155% - vs. ARKK at not so good same Aug. 30th here up 'just' +25%:

Past 5 years to mid-Q3 2022: **ECO** higher at +155% (dark blue) vs. ARKK (light blue) at +25%:

Source: finance.yahoo.com

For all of our warnings of ECO & acute risk, it had gone up more, went down less than ARKK. As always innovation/tech is volatile, with significant risks. Clean energy's wind, solar, EVs, hydrogen, etc are never havens of calm, nor safety! Early 2020s look to be a time maybe when all energy sees acute shortages, rationing, perhaps some calamitous blackouts.

Energy is unavoidably complex. Full of 'on the other hands.' Take renewables, in applied on the ground ways. Blackouts threatening worldwide 2022/2023/2024 on: decrepit aging grids, war, fuel scarcity, fuel switching from Russian gas, new weather extremes, wildfires, attacks more. 'On the other hand' a positive milestone 2022 was California on a windy day for a 1st time briefly got 100% of power from renewables. A sample, less-windy day, say, May 5, 2022 – it saw eg 23,000 MW of demand; with 17,000 MW or 70% met by 3 renewables: solar, wind, geothermal. Each may be ramped greatly, potentially ahead, displacing 17% from natural gas. On that day 70% of demand was met by solar, 23% met by wind, 4% by geothermal (which may co-produce lithium from hot brines like at its Salton Sea). Yet renewables arguably need to grow much faster, still. They're far behind where they need be on CO_2 & climate emergency. Supply chains in 2022 were at sixes & sevens – bottlenecks galore. All at a time when California was badly short by some 1,800 MW of much-needed electrical power – not enough to handle hotter coming Summers/cold Winters. Small wonder its lone nuclear plant making 6% of the State's power was extended 5 years in 2022, from 2025 to 2030 Retirement. As new shortages threaten, maybe horrific Blackouts, not just in this rich US state, but globally too!

Clearly, bearish troubles had overshadowed clean energy as 2022 opened. One worry was that *only* a bipartisan $1 Trillion Infrastructure bill had passed in 2021. Little in it was relevant to clean energy – none to climate crisis. Compared to a BBB reconciliation draft whose $1T+, then $550 billion would have focused on clean energy & on climate - but had stumbled/ failed in 2021, this was thin gruel indeed. For example, making an aged US electric grid net-zero may mean +60% capacity upgrades. Yet the Infrastructure law's text only gave DOE facilitation item small $ amounts. Grid resilience got $11 billion, but power failures discussed ahead are real now, can potentially already cripple states; the $3 billion matching grants in this law nowhere near up to task. Overall, that 'small' $65 billion for overall transmission would be quickly eaten up by spending on fossils, outside of pressing need for decarbonization.

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

Globally, 2022 was strange for both its big energy needs - & big equity declines. China, Europe, and US - all saw demand for solar, wind, batteries, EVs. Ahead maybe hydrogen too. Yet interestingly, as renewables grew worldwide – the risky high PE green stocks 1H 2022 had plummeted after an already hard-dropping 2021. Clean new energy may show promise ahead – and yet stocks in the theme and so ECO - were down very hard 2021 and 1H 2022.

Consider one of the world's biggest wind turbine suppliers start of 2022, Siemens Gamesa, a leader making turbines in the West, outside China. (In China too, a domestic wind gear manufacturer saw profits decline 5.3% in 2021; revenues grew just 3.3% as material costs and energy surged even as supply chains broke). For 'Siemens G.' its stock declined by -45% early 2022; its market cap had likewise plummeted near half. October-December 2021 saw revenues fall to 1.83 billion euros, year on year declined -20%. Plus, it expected revenues to fall even further early 2022. It blamed supply chains, worse than expected cost inflation. Pointed to volatility that "impacted some customers investment decisions", project delays. It was in dire straits, but was not alone: competitor Vestas noted "supply chain instability caused by pandemic" along with much "cost inflation within raw materials, in wind turbine components and energy costs." All those doubtless were at issue across wind.

And yet, zoom in closer for other factors. Take 2020 onshore & offshore turbine orders at a big 4: Denmark's Vestas, America's GE, Germany's Nordex, and Spanish/ German Siemens G. Together, they only saw a 3% decline in new wind business year over year. Orders at all 4 leaders had dipped yes, but only a bit – to 48.5 GW 2020 from 49.8 GW 2019. The 4 accounted for much wind manufacturing in West/and world. But in non-uniform ways. Of the 4, Siemens Gamesa's own offshore & onshore turbine orders had fallen the most, -17%. Meanwhile, Vestas had seen a +6% *increase* in 2019 as it reorganized. Orders at GE, Nordex had remained near steady in 2019, they'd dipped just by -1% & -3%. So, what might have been involved with Siemens Gamesa's much larger declines – harsher than seen at the other three?

Perhaps partly, on Siemens G.'s moving from higher volumes to more profitable projects, departing some markets. And it suffered in having been visibly an offshore wind leader: it was the one all others had gunned for. Vestas introduced its massive 15 MW offshore turbine hoping to take market share, so too did GE with Haliade-X turbine. Vestas & GE hoped too to 'eat Siemen's lunch' as Siemens G. went from 60%-70% offshore wind 2011, to 'down' near 50% in 2021. Siemens G. reported in early 2022 a EUR 377 loss, less revenues, negative margins given supply chain chaos. Only the Servicing of turbines saw its only growth.

If *onshore* wind ex-China was growing, even modestly – *offshore* wind, *could* grow by a nearly annual 23% rate. Still, take Vestas famous for wind turbines: early 2022 it too reported dismal results. Despite record top line revenues up +5.2%, poor net profit of EUR 176 million was off -77.2% vs. previous year. At fault: skyrocketing raw materials costs, tough logistics, Covid difficulties across wind manufacturers. Vestas too was hit by cyberattack data theft. Yes, revenues had been healthy 2022 near EUR 15 billion. But transport costs, logistics vexed Vestas' bottom line. Of note steel maybe 2/3rds cost of a wind turbine structure, 66%-79% total turbine mass – yet it *doubled(!)* in costs in pandemic – subsiding a bit later 2022.

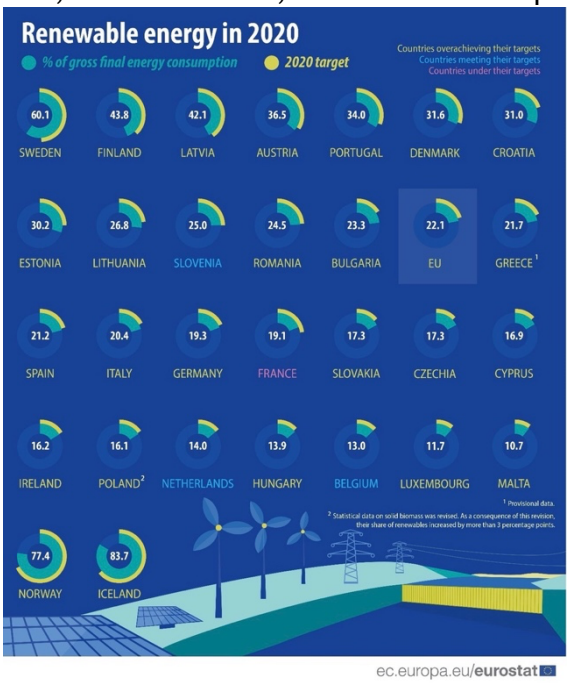
Siemens Gamesa had expanded like in England, thanks to the UK's wind vision. One rotation of its most huge blades could power a house there for a day; coming bigger blades, could power a house 2 full days/per rotation! Wind's growth had meant that by 2020, 25% of UK power lately came from wind over a full year. And UK wanted wind to account for more, for one-third+ of its power by 2030. In Europe wind power was generating on average near 16% of electric power in 2020 and growing. Pairing that wind resource with new energy storage, key wind/solar together could become firm dispatchable power. Green hydrogen, too, *might* be seen as more viable idea - but only if wind/solar first get very cheap.

And yet as noted, wind's growth hadn't translated into equity gains. Siemens Energy AG in 2022 stepped in to buy all of Siemens Gamesa, a last 33% of it on verge of hard times. Siemens G. was flailing, in a "deteriorating situation" to be "stopped as soon as possible". Ironically, wind power was a leading renewable early 2020s, many places. Onshore wind grew moderate rates given land and other constraints (China onshore wind grew by leaps & bounds despite high steel costs). Meanwhile, Offshore wind was really taking off from scratch, unconstrained, starting to rocket. Orsted for instance grew its operating profit by 94% in Q1 2022, confirmed EBIDTA guidance 2022. Meanwhile, Solar too has an enormous fantastic potential. Though still a tiny slice of overall power generation, far smaller than wind, look for that to change fast too this and next decade. In places, solar & wind together will become greatest 2 power sources, not just for clean renewables – but all electricity. Nicely too more affordable than all else, maybe hastening energy transition. With war as Europe moves from overreliance on (Russian) natural gas – that too hastening some renewables' growth early this decade.

Once, hydropower's big dams were the main/only Only renewable resource 1970s & 1980s. Some places huge dams generated 10%+ of energy mix – 100% of all renewables. But their potential mostly is capped, no new places for big dams to go, and ecologically harmful, so is with no regret that hugely scalable solar & wind are instead, now what's growing fastest. Meanwhile, run-of-river hydro and new geothermal have new potential too. They could go in many places and as desired firm power. Oil firms may begin to explore geothermal as it means drilling holes in the ground, which they're good at. Early 2020s, geothermal was costly, though conjoined with say, lithium co-production, it was beginning to show much promise.

A net result was wind & solar were the 2 big renewables start of decade, and rich Europe led. Europe's gross electricity consumption met by renewables was then 1/4th, or about 25% of its demand. 2020 figures below showed that very highest/best were Norway & Iceland, at 77% and 84% respectively. And among the 27 EU members, Nordics again led: Sweden 60%, Finland 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 then just 14%. Both had only barely met targets, unusual then vs. rest of a more ambitious Europe.

So nearly all EU-27 was *beating* targets. The bloc had set goals in 2009 and while included as 'renewable', a dubious municipal waste burning (Not classed as clean here at ECO), their main focus rightly was/remains wind & solar. Mostly they'd exceeded goals. Lovelies Sweden & Croatia did so by 11 percentage points. Poorer Bulgaria by 7 percentage points. Poland (16%) lagged hard in renewables, but altered definition let (dubious) biomass burning meet EU targets. And a 'less green' lane like biomass burning was an exception; most goals were beat on truer clean energy – primarily wind & solar. Russia's 2022 invasion gave fillip to dirty coal, oil and biomass, but that too shall pass. Here's how they EU had looked 2020:



Source: Eurostat.

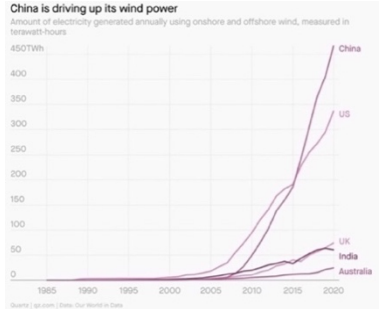
The UK famously left a 27-member European Union in 2020 so isn't seen above. But, the UK in 2020 had sourced 42% of its energy from renewables, thanks largely to a wind push. Expect offshore wind to fast rise in UK & Northern Europe. Yet curiously if renewables' costs in UK like elsewhere plummeted past few years – why did UK average home energy bills 2021 *jump* to GBP 1,200/USD $1,630? And go *higher* start of 2022, when UK wind power was offered at just 5p per kilowatt hour (kWh) – under ¼ what a homeowner pays?! That, was due to 4x increases in natural gas prices from 2021 - since energy markets are set by the *costliest*, most needed (still fossil!) fuel. In an awkward energy transition, it has made no intuitive sense to see UK energy bills spike – as renewables got cheaper! Ireland showed what could be; in Feb. 2022 its wind power supplied 53% of needed electricity. In less windy hours, wholesale electricity costs were EUR 229/MWh; windier hours it dropped to EUR 134/MWh. Hence the brilliance of combining Wind - with Storage! Still, skyrocketing natural gas as a big source for Ireland's electricity – meant that its power costs had jumped 3x year over year.

Meanwhile a US that 2020 got only 19.8% of its energy from renewables, lagged Europe's then 22.1%. On war 2022, Europe fast-upped its commitments to renewables – and the US lagged. Of US 20% from renewables in 2020, 13% or 2/3rds was solar/wind; 7% or 1/3rd was hydroelectric; as 2021 saw a record US $105 billion investments in renewables, batteries etc – for 37 GW of solar & wind. Yet gas was making Twice that, 2x that much power, so 40%. Even as Europe pulled ahead in its renewables, the Big picture was not Europe, nor US, made anywhere enough clean power. Each must grow over 2x faster given decarbonization's goals. Yes, war changed much 2022; Europe & acutely Germany resolved to grow renewables fast, EVs too. Europe's light duty EV vehicle sales were 19% late 2021 – double an 8% world average – nearly 1 of every 6 cars sold in Europe (and China) were EVs. That vastly beat a US then at 1 EV out of 20 cars. But a fact remained for Europe: 1/3rd of its oil, and more of its gas 2021 was still coming from Russia. Nightmarish then with the invasion of Ukraine.

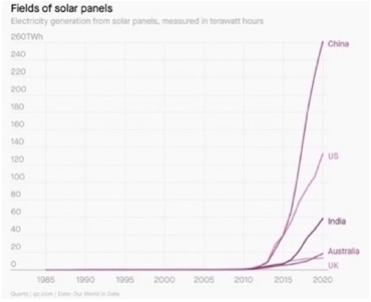
What of China? As one of - if not as The most important bloc for renewables? China in 2020 was The Clear World Leader in total green energy generating capacity. Yet its 342 gigawatts (GW) capacity then made (only) 14% of its power from renewables. Like Solar/Wind for the US. Still, figures can deceive. China's energy demand is enormous, so ramping renewables even faster can be bit of a damp squib. Yes, relative to Europe, or US, its GWs growth trajectory far outstripped all, everywhere. In 2021 it aimed 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 be envisioned. Yet a burning issue early 2020s, was China is so utterly still reliant on burning record-breaking-amounts of polluting coal.

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

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



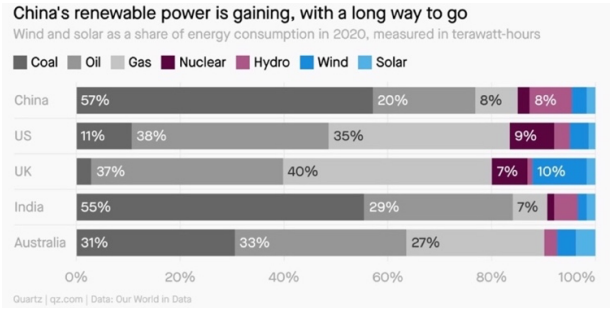
Source: Quartz / Our World in Data.



Source: Quartz / Our World in Data.

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

See below how 5 big economies had fared of late. In duller colours charcoal, brown & gray, it's clear 3 fossils still dominated at left, 2020. Meanwhile at right in brighter colours of blues & pinks, we see solar, wind, hydro (also nuclear) at just mild penetration near 20% in 2020 - although growing. And this was before regressive shifts 2022 from gas, back to dirty coal due to war. That all left us with (way too much) room to improve (as Rome burns):



Source: Quartz / Our World in Data

Coal-loving Australia for instance once relied on coal for 60% of its electric generation, 2021. Even though renewables are a better bet. A wind farm in eg Badgingarra, Western Australia hit a big capacity rate (how much time operating) of 64%, 2022. Competes well with coal that must shut for maintenance; and coal must pay for fuel. Like nukes must pay for wastes - unlike wind, solar. Even current-gen nuclear touted by proponents as firm faced dire straights in 2022. France was forced to nationalize its nuclear leader over unforeseen corrosion issues – and capped electricity retail prices. Like poor welding at Flamanville reactor in France (and reactor issues in Georgia, US). All as worsening heat, drought, threatens an ability to cool plants, vexed all of current-generation-nuclear power. Small modular nukes can aim to be far cheaper, better; whether they will in fact deliver is very highly questionable.

World fossils linchpin China, still burns so much coal, in absolute & relative ways, it ensures we humans release unprecedented CO_2. In 2021 China's coal production leapt to 4.07 billion tonnes/year for acute concerns on climate, +4.7% over prior year. Rising electricity demand there 2021 was met by a +9% *increase* in coal use. 2022 was worse, more coal. Meanwhile we're releasing potent greenhouse gases like methane to air as well, freely, like to a sewer, treated as meaningless. A trend gone on for decades despite flowery words by rich nations, like a US to contrary. It's allowed – no, more truly it's been *making* – today's climate crisis an exceptional, foreseeable, even maybe an existential threat right under our noses.

Even supposed climate leaders flailed 2022. Take California - which did in 2022 ban gasoline cars sales after 2035. Yet a quasi-governmental Commission overseeing utilities, seemed to favor centralized power generation, mostly from big thermal fossil fuel gas, when it had proposed to consternation of many that this green-leader State – should *reverse* incentives for home rooftop solar. That 'NEM 3.0' could move back solar payback from 7-9 years that made solar a sound economic choice – to over 20 years. Thus, making solar unaffordable, or purely non-sensical, to just about everyone. This, in 2022 in verdant green California!

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

Discriminatory, anti-solar, fixed charges paid only by the homes with solar PV, were rare: seen only at 2 of 172 investor-owned utilities nationwide, <3%. While 27 times in past various utilities had *proposed* adding charges for solar homes only, nearly all were later withdrawn, or were rejected outright. And none were imposed retroactively, like was asked here.

Utilities saw they could take a 'holier than thou' view, showing concerns over home solar 'shifting costs' onto non-solar customers. Yet, providing electricity has long been "riven by cost shifts". There's cost shifts eg, between lower users vs heavy users, between rural and urban users, apartments vs. single family homes, those who invest in efficiency vs those who don't. Cost shifts going on for decades, have been well-accepted. Utilities may lay out 'No cost shifts' as their primary anti-home roof PV rationale, but it's a bit dubious as real top cause, given their major concerns over fast-growth of decentralized home-owned solar.

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

In 2022 a (rich) customer say in one of California's 3 big investor-owned utilities, could save about 50% by upgrading – by going from buying utility-supplied electricity & driving gas burning car – to instead solar power on their home rooftop & driving an EV. This PD sought to quash that option, even progressive California, even in 2022. Pushback was swift & vocal. Notably what California did – pushing off to perhaps another time - only piled uncertainty atop 2022. And it had pushed down a solar sector (already hit by anti-circumvention) even more.

Not just California, either: sunny Florida had factions trying to halt rising home roof solar PV there in 2022. A bill introduced in Florida's State legislature, backed by its huge electric utility, could have decimated 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 they may simply hold similar views on what's good for the State, that close nexus is notable.

A bit like California, it centered on net metering, how much $ a solar customer gets back and usually reimbursed at retail rate. Florida had come later to the home solar party, but it was rising fast. By 2022 it had 90,000 solar roofs (1%) - vs about 1.3 million in California. Florida utilities could see writing on the wall, but Florida's Governor in 2022 wisely Vetoed the bill. Another state, Nevada, had once before made such big change; years back in that case its nascent solar industry fast plummeted. It was later repealed, but impacts lingered. In sum, utilities may accept big central PV if they alone sell power from their own huge solar farms – but individual home rooftops, making decentralized home PV power, not so much. That said there is a regressive aspect to net metering in California – favoring often wealthier populations. Thus, more directly assisting or subsidizing lower-income applicants to go solar – doing so very transparently from the State's budget, could make good sense.

Or more optimistically, note a draft Plan from California Operator (CAISO) in charge of 80% of the State's grid. Drafted in 2022, it laid out State power supply for 2040. It would add new 120 GW (or 120,000 megawatts /MW) to meet California's fast-rising demand. Largest source was 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 of energy storage, 4 GW more.

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

To target turning away from natural gas power generation, is no small thing. Makes a gaping firm-power hole ahead. Hence, this Plan seeks utility-scale solar to triple. Energy storage short-term (<4 hours via batteries) jumps 15x from 2.6 GW it was in 2021. Longer-duration >4 hours energy storage like pumped water, rises to 4 GW. Of course, were just plans in 2022. How near-term, to actually replace GWs of firm natural gas – plus a lone big last nuclear plant soon, mid-decade – with anything near as energy-rich? In 2022 the answer wasn't 100% certain, with threats soon of rolling blackouts soon, ahem, very real. In an energy transition so far highlighting greater demand for yet *more* natural gas, and keeping nukes – not far less.

That 2022 Plan anticipates 12 GW of renewables brought in from out of state. New 5.2 GW of wind/sun on a SunZia line from New Mexico/AZ; 4.7 GW transmission of Wyoming wind by a TransWest line. The GWs can't happen soon enough. CAISO's draft Plan projected going from 7.8 GW California wind power, to 24 GW new wind including across West 2040. In past a long 8-10 years was needed for permits; far too long, green electrons are needed, fast. Helpfully, regulatory bureaucracy is being cut of late. $30 Billion for transmission upgrades was do-able. Like $11 Billion to improve substations & powerlines; $8 Billion to allow local off-takers to use offshore wind, $11 Billion to bring wind power in from out of state. Of course, $ Billions – and $2.5 Trillion over a decade: huge sums. (As Senator Dirksen joked, 'A billion here and a billion there, and pretty soon you're talking real money'). But in context of vaster sums for oil & gas, these $$ for renewables is relatable. Particularly when it means better resilience for California's $3 Trillion economy. Were the state, a nation, it'd be 5th largest in the world. Ahead of India and the UK. And Blackouts due to heat/freezes/attacks, must be avoided.

A biting issue early 2020s is poor US grid resilience – power lost frequently. In 2021, 180 major power disruptions; 20 years earlier, there'd been fewer than 2 dozen. Not just unprecedented weather extremes are at fault. The US grid has aged badly. 70% of transmission & distribution far into 2nd half of 50-year lifespans, with 600,000 miles of key transmission lines, 5.5 million miles of local distribution. Back in 2010, big 3 thermal coal, natural gas & nukes had made most US power; later natural gas became king as shale fracking made it cheap (beating coal/ nukes). Renewables afterwards began to compete, at times beat gas. But given intermittency of renewables & little storage, problems rife with all fossils, and nukes, razor-thin power reserves – plus old grid, power supplies became non-resilient. And it will stay this way, until vast new storage comes online. There's no easy answer. But certainly, with abundant, cheap & clean renewables, new storage & better grid has simply got to grow very swiftly.

Storage & grid will take time to be built. So, what of 2 big pieces of the puzzle: natural gas, & current gen II nuclear near-term? Right now, California needs all its 25 GW of renewables – plus 50+ GW more green generation. A new 17 GW utility scale solar to be added 'yesterday' - even utilities support that. More offshore wind, fast. Were new gen IV/V nukes safe, affordable, with no wastes, that would be wonderful! But in 2022 the sole gen II nuclear plant (life extended from 2025 – to 2030) is none of those things. California's grid in 2032 can be 70% renewables & 85% greenhouse-gases free. But next few years 2020s are scary.

A huge $5T climate & clean energy reconciliation BBB draft once drove up green hopes, almost passable 2021 on new President & 50/50 Senate. But it died. Political capital, trillions of dollars – went instead first/fastest to needed Covid emergency spending. Conservatives arguably had a point that trillions in Covid relief spending early 2021 could prove inflationary. Progressives, arguably had a point that higher gasoline prices at pump weren't due to US energy policy, nor to green energy (that's anyway not inflationary) – for oil prices are not set by a President, but by markets worldwide. Unsurprisingly the oil industry refrained from swiftly ramping back supply to meet demand (it had suffered huge losses in last bust) – so on that and the exigencies of war, gas a weapon – prices of oil, gas, & coal, jumped.

For clean energy, inflation plus war spiked input costs like for nickel. EV batteries may soon favor chemistries instead needing little or no nickel – like iron/phosphate. Benefits include less fire risk then too, as cells needn't be surrounded by liquids. And whole battery pack architecture can on new designs, contain far more battery materials. Going from say 40% as battery, to double that. While packs grow cheaper, last longer and go much farther.

Big picture invasion of Ukraine had put Europe on war-time footing to end dependency on Nord Stream I cheap piped gas. Even a verdant Green party in Germany grew more willing to accept short-term prolonging of its current-gen nuclear, even shipped non-Russian LNG gas – to get quicker to deep 100% renewables. Arguably an understandable though quite agonizing choice – and one that Conservatives worldwide applauded Germany's Greens as 'mature'.

Something a bit like that might happen in US as well. While a big US >$4 Trillion, Build Back Better Bill had died 2021 – the IRA was passed in 2022. And further Bills in 2020s sare certain – but they may have more fossils and nukes. Acknowledging facts on the ground, new elections may end a razor thin Senate majority – maybe a small House advantage. Or not! But in US, like elsewhere, there's going to be energy tumult, new expectations ahead.

Conservatives for their part, see writing on the wall; clean energy's not going away. Instead, it's becoming often economically a best-option; even some red-states at first reluctant, now embrace it. Wind, solar, perhaps green hydrogen in future - stored say under salt domes. Geothermal at times led by fossil firms. More wind in US Midwest – soon offshore too.

There's wide consensus that coal should be eliminated based on its costs, its health burdens – and the fact it can readily be replaced. Natural gas though, not so much. The world called for much more LNG in 2022, to replace Europe's piped gas. Progressives understandably find wretched any natural gas or current-gen nuclear. But in compromise, conservatives to win $$ for high-carbon sources & nukes – may be willing to accept more clean energy they've heartily opposed. It's a question of how swiftly renewables, especially storage, can be brought online and how cheaply. Right now, this year and next - *Before* the middle of present decade.

So, to win some goals, progressives may be swallow hard, All the above 'energy independence' with fossils and nukes. America won't then really be energy-independent – each barrel of oil in global supply isn't an identifiable barrel a, b etc. But, if that gets support for renewables, some more compromises after the IRA of 2022 may happen. Oil firms want eg more subsidies for so-called 'carbon sequestration' - that isn't really reducing GHGs. On the other hand, the tremendous key downside to this all (world of politics, which we prefer to avoid) is that 'IRL' - ongoing use of fossils Dooms Us All from the more objective climate-perspective.

It's easy thinking above just of politics, to forget how CO_2/climate actually has final say. Politics ignores this fact, although science indicates such may revisit us many-fold. Yet work is happening in future-gazing science, like getting more right the models that help better see what may be ahead. Clouds especially, long bedevil forecasts. Just how clouds/key water vapor interacts ahead, contributing to heating – or not – with other greenhouse gases (GHGs) is vital. Potentially, clouds *may* mean Earth gets much hotter still. Or, reflective clouds may mean it's a bit less of a blazing cauldron, than what models to this point have predicted.

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

Past brute models have been somewhat right - even if at times *understating* heating. A look at 17 basic models used 1970 to 2007, showed pretty good overlap with what was later seen. Still, modeling clouds due to complexity, vexes. Older models had expected if CO_2 levels were to double from start of industrial era – from that earlier roughly 270 ppm, to 550 ppm where we're fast now headed with CO2 already over 420+ ppm, then we all may be baking in say early next century by between 2.7 degrees F - and 8 degrees F (1.5 C - 4.5 degrees C).

CESM2 implies that an unbearable 9.5 degrees F (5.3 degrees C) baking may be possible! A result of doubling+ CO_2 partly due to water vapor/clouds. Near 1/3rd higher temperatures, than prior models implied, so getting accurate modeling was no small interest 2022. Such 9 degrees F would feel in places like a furnace. On accuracy of climate models, then, much depends. And it's an entirely different way to forecast what may be, than looking back in geologic time to when CO_2 levels were roughly similar and estimating what temperatures may be like ahead. (Maybe it's back to the Pliocene, then the Miocene for us)! Either way the 'mere' transitory heat we may feel in a first century or two at 550 ppm, can pale to a far hotter equilibrium unfolding over several millennia. With rising seas discussed ahead.

That's why, when a review of 39 climate models found 13 showed higher heat ahead, partly water vapor/clouds, it was potentially very troubling. A 'wolf pack' of outlier results hadn't matched actual temperatures – so models were reworked. And UN climate assessments stayed away from high heat predictions, given uncertainty. But, what if those models are even partly right? To say nothing of an unstoppable permafrost melting on land, undersea methane, clathrates or hydrates like 125,000 years ago Eemian era when seas were 20 ft higher.

Let's shift gears from climate - to finance & equities for some helpful developments here. One is much better breadth of late across potential, candidate clean energy stocks. Far more public companies are working in clean new energy, and in climate solutions. Markets & policy are better in advancing global new energy innovation. Firms here are by their market capitalization in 2020s now often (much) larger than at turn of millennium 2 decades ago, or even a decade ago. And in applied side-note related to Indexing here, market consultation in 2022 resulted in a few changes to the NEX Guidelines in early 2022. The NEX average daily traded value (ADTV) floor grew to USD $1 million per day Past 90 days for adds, USD $750k for existing components; with screens too on UN Global Compact Principles. These are noted on the NEX site at, https://cleanenergyindex.com/about_nex.php

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We turn to stocks more broadly, to perhaps reasons 2022 opened rough for equities. One was, many investment banks were already in late 2021 predicting sparse profits for all 2022. Earnings targets for big S&P500 firms were for 'lower-highs & lower-lows'. Take a newish S&P500 name, Tesla: it had a huge market cap, among the S&P's biggest when it entered the 500 (funny enough maybe late on hesitancy over reputational risk) yet set a tone as its brilliant head aptly expressed concerns over supply chains risks for the whole coming 2022 year.

One higher-end estimate for S&P in 2022, foresaw only a gain of +9.1%. Other forecasts were flat, or negative, like S&P ending 2022 down -7.7%. Average predictions at 9 institutions, saw a puny +2.8% return for all 2022. Causes for that dismal pessimism importantly weren't transitory either; instead, they saw headwinds that could be sticky all the next year.

Partly, because valuations had begun 2022 so high. The late 2021 S&P500 price/earnings (PE) ratio of 27.2 maybe meant more likelihood of falls, a plummet – than gains. Such high 27 PE, hadn't been seen since the tech bubble, and we know how that one had ended. To expect future earnings were sure to justify such very rich PE of 27, was maybe a fool's errand.

Back in 2019 there'd been better reasons for optimism ahead on earnings & growth. S&P500 profits then had just hit a record. Government stimulus was about to flow due to Covid. Profits just jumped +25% to new records. But, operating margins then hit a plateau. Late 2021, there wasn't great room for big new rates of growth like was seen a couple of years earlier.

Pessimism about 2022 was backed by metrics, like a cyclically-adjusted price earnings (CAPE) of 40. CAPE since 1877 had only hit 40 once-before – in a dot.com frenzy, and again we recall how that ended. When S&P dropped a total -40% over a long 3-years, in a dot.com decline, it would then take another 13 years until that S&P again reached its prior levels.

Another broad headwind at start of 2022, was rising interest rates that can kill equity themes. Not long-ago, investors had gotten nearly Zero % in bonds. Thus, demand grew for higher-risk themes, better-returns (at times) in volatile themes like here. But, if lower-risk alternatives could soon boast respectable rates - then Treasuries, corporate/government bonds may see a flood of capital looking for a smart place to call home. Real rates 2014-2018 meant inflation-adjusted 10-year Treasuries yielded expected just +1.0%. And they fell in Covid emergency to an eyebrow-raising *negative -1%*. As PEs shot up from more common 21 – to a very high 27. CAPE went from normal 20s – to (wow) 40. On rate hikes, a return to mean can be bearish for stocks especially in quantitative tightening. All fundamental points in 2022.

If a threat in 2022 was not of 'Unprecedented' inflation (given was was awful in 1981) – then maybe it was of very high inflation taking root, growing hard to kill. Inflation is partly a state of mind, part psychological. If expectations take root, gets persistent, hard to knock down. Combining rising rates with stagnant, or sluggish economy (stagflation, slugflation) and Fed's Rates tools get wickedly un-useful in recession. No central bank wishes to hike rates going into a recession, economy cooling. The equity-risk premium of holding onto stocks (vs safer bonds) - makes equities a decidedly less happy place. As interest rates rise, money is no longer free. High rates are something a younger generation doesn't 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'd all been above 5%! Broadly then, rising rates 2021/1H 2022 was maybe not so great a time for the risky, volatile, high PE growth themes here in green/technology.

The Impossible, is to successfully time markets: to know a bottom, ahead of time. To see it in anticipation entry points. Like came May 2022 as ECO had hit an intraday 84 low, amidst broad markets turmoil! Compelling forces had pushed much Down hard in early 2022 – far beyond energy as *Inflation was much worse than a Fed had initially recognized; so *Rising Interest Rates in 2022 hammered themes reliant on future income; *Capital Shifted to Value, hence *Re-Pricing Risk, given too issues of *war in Europe, tensions in China/Taiwan. In sum an *End of Liquidity and easy money had sent clean ECO plummeting. For a theme as volatile, as dependent on future earnings, it was a poisonous setting that saw the May 2022, 1H low.

Made worse 1H 2022 by factors specific to clean energy. As noted, 1 key US Senator had *Declared late 2021 that a huge BBB bill with billions for clean energy & climate, Dead; again, in early July 2022 – then changed their mind late in July allowing for the IRA of 2022! That legislation however, isn't the end of it. More lenient, accommodating EV credits, bigger help for instance may perhaps be resurrected post-2023, re-introduced – or perhaps *Not*.

Next, changing topics, lightening mood, coincidences may be seen *looking back in time, only*. For example ECO had hit a big prior high Dec. 26th of 2007 at 297 (297.05 close) – just coincidentally, a next big peak Feb. 10, 2021 had proved near-ish that: 287 (286.89 close). Or, passive ECO going up/down last 2 years twice plummeted by a strangely non-imprecise ½ to nadir low both in 2020 & 2021. Thus calendar 2020, it fell by a nearly neat -50% from a 94 intraday high (92.53 closing) – down to 47 low (47.37 closing). Afterwards, it rose 6-fold from 2020 nadir to Feb. 2021 top. It again fell unambiguously by -50% from that peak 287 high (286.89 intraday) Feb. 2021 – down ½ to a 142 low closing (142.39 intraday) for 2021. Again, -50% just by chance, looking *back* at rich data. Oddly 2 non-imprecise consecutive declines, both near a 'perfect' -50%. Or for instance, Q1 2022 hit about a same bottom 4 times near 103, on 28 January; 24 February; 28 April, and 2 May. But then May/Q2, it fell much Lower.

Just spotting coincidences in data rich past, is meaningless looking forward. Does though point to how volatile ECO is, like falling -50%, even in big gains years! Or take a non-calendar 12 months from say, end of Q1 in 2021 – to the end Q1 in 2022. That period was oft in a 150-200 band, from a peak April 1, 2021 at 211 (211.09 intraday) – but followed by 2 lows on Jan. 27th & Feb 23rd both at a 107 close (102 intraday). (Come to think of it, funny how those 2 similar lows were both again not far off neat -50% dropping 211 to 107)! War sparked a brief +40% rally on better clean solutions Q1 2022, before falling back mid-Q2 to near 84. But to cherry-pick data so is NOT predictive. Only bit of fun, looking back; coincidences in ample past data. As Mark Twain humorously, aptly put it, "Lies, Damn Lies, and Statistics". Playing with ample data is really more a parlor trick, no real help when looking forward.

One mustn't read much into it other than to confirm a great volatility, often down! Like Jan. 2022 alone, passive ECO fell by near neat -30% in a blow-out selling month; never predictive, it's ephemeral. May lend just bit of attention to 'enter on dips' – 'sell on rips'! Just for giggles, let's for conjecture say *if* year 2022's early high was a 154 peak (154.41 intraday) seen early 1st week, Jan. 4, 2022 - then a hypothetical 3rd calendar year low ½ down - could then (still playing) be a nadir 77 in 2022. Any realistic nadir is possible of course – and all the maths indicate it's very, very unlikely to be that figure! It was a level seen Summer 2020 – and may go lower still – say on global events like larger war, soaring inflation, recession. May be interesting to see where a 2022 nadir, in fact is. Highly unlikely it's to be that 77! Simply No Telling, looking ahead. (Interestingly, however, May 12, 2022 ECO did hit intraday low of 84.34 – and that 84 not very far off a 2022 nadir, on a 50% drop of 77)!!

Q3 2022

ECO certainly had risen in weeks just before/after Senator's 'surprise' Yes, for IRA of 2022. Not only up absolute ways. When clean energy's theme so ECO rises, it may outperform many competing, all-younger (as ECO/NEX were first) green Indexes. At first that happened here, then all fell back on broader inflation fears (and smaller-caps in ECO pushed it down harder!). Big stock gains are oft associated with surprise; what surprise 1H 2022? For this look at what set the stage. Of course there'd been long-ailing, then-failing draft $4 billion+ BBB bill: its repeated failure owed to staccato NO from 1 Senator – had pushed clean energy equities Down Hard across all 2021, Again 1H 2022. That helped compress the spring, knock down equity prices to early Q3. Left only a narrow lane, for that 1 Senator to assent. We'd written on it previously, and on lane left open, so that wasn't a total 'surprise' Yes in July, really.

Same for Russia's 2022 war, impacting world. Energy exports used as a weapon, made fossil prices spike (and indirectly showed too, how better & cheaper renewables are). War in Europe like nothing seen in a generation; once beyond Crimea/Donbass, 'all hell broke loose'. First few weeks of war, ECO did jump +40% from intraday Q1 low of 101.64 on the Feb. 24th cusp of Invasion – to a 141.82 on March 30th. That was maybe on re-assessments done 'round the world – of a need for speedier transition to the clean alternatives that are found here. And for energy security: 13 European nations had depended on Russia for >1/3rd their oil. Yet ECO fell back, more, to slip under 90 then in May: dropping as clean was stymied by a supply chain chaos worldwide. Yet arguably, that invasion too should not have been such total surprise, if one had been watching closely. There were small hints of what was to come.

For global intelligence assets watching in a run-up to war, there'd been warning signs. To wit, 1-2 months prior to its invasion Russia had moved 3 large LNG ships to a geopolitically vital, yet stranded Kalingrad Oblast on Baltic Sea. Natural gas piped from its ally Belarus first had to go via Lithuania, to reach Kalingrad territory – preventing Russia *potentially* from shutting off gas to Lithuania. So, by re-positioning these 3 ships unusually to docks in Kalingrad, it gave Russia a new option to *possibly* sever gas to Lithuania, if it so wished. This could provide its vital Kalingrad with an added 4 or 5 weeks plus of much needed gas supply.

Militarily-vital Kalingrad Oblast lets Russia alter NATO's power even in its own backyard. So, was notable when Gazprom had sent 2 LNG carriers, Energy Integrity & Velikiy Novgorod – & big 3rd vessel there to convert LNG to gas. The latter Marshal Vasilevskiy built 2019 was named for an Officer who'd led the Soviet recapture of Kalingrad in WWII; it moved there Jan. 2022. Before that, it was blandly carrying LNG from Russia's Far North - to Asia. To re-position the Integrity, the ship weirdly traveled a long distance – going from Cameroon to Kalingrad. Until then it was sending Cameroonian gas to China (only 2 of 58 shipments were to Europe region, both those to Turkey) - so it was all quite unusual. Having moved 3 LNG ships to Kalingrad, before a potential invasion, meant if conflict began and went beyond Ukraine, intentionally or not, then Russia using energy/gas as weapon could keep its strategic Kalingrad outpost 4x the size of Manhattan, militarily significant, energized for extra weeks.

But that narrative soon was flipped on its head, post-invasion. Lithuania instead halted buying piped Russian gas! Vilnius turned instead to floating regas vessels to import LNG from Qatar, Norway, US, Algeria. Replacing the 1/4th of gas that was Russian. Italy, Netherlands, Estonia, could do same via LNG. Germany though, had bigger problems needing 90 billion cubic meters (bcm)/year – far more than Lithuania. But floating LNG re-gasifiers were suddenly the rage. A chess game that meant Russia no longer held all the power. Lithuania could even ban trains from carrying any sanctioned goods across it's tracks going from Russia to Kalingrad!

Soon after Russia relocated to Kalingrad, 3 of its advanced MiG-31E warplanes with Kinzhal (Dagger) hypersonic missiles. Smack within NATO between Lithuania & Poland (1 Kinzhal early in war obliterated big Ivano-Frankivsk Ukraine weapons depot). For a pathbreaking bigger, broader change, Germany at last began to cut its overreliance on Russian gas. Once, Russia & Germany had promised Nord II was a commercial project only – never political leverage. Yet on war, gas cuts to it and Nord I put paid to that idea, proving opposite! Germany drafted to bring forward 15 years its 100% renewables to 2035. Started planning solar capacity of 20 GW/year in latter decade. Onshore wind to 10 GW/year. Offshore wind capacity from scratch to hit 30 GW 2030, 70 GW by 2045. Germany's Greens 2022 had a voice in government, yet could see LNG terminals - if meant hitting sooner the key aim of 100% renewables. Plans had been to shut all its nuclear, zero-out coal; but no piped Russian gas, something fast was sought to fill cold winter's gap as renewables got built. Fast-filled gas storage <40% to >80% was one; LNG terminals (afterwards to be for green H2) 'til renewables fully take over, another. Still: gas storage can get over Winters. But then, what happens come Spring, near-zero in reserve, Summer's heat again approaching!? All as ECO fell in May 2022 to under <90.

That was a stage from which clean energy jumped up, in July, Q3 2022. In Real-Life, 'IRL', on the ground, oil & gas prices jumped like nothing in recent memory. Oh my, what reversal from what we'd seen over at those losing fossil fuels last decade! But now, especially a new IRA, and from ECO <90, clean energy also jumped – before it fell back hard in latter Q3:

Source: finance.yahoo.com

How could clean energy prices have stayed cheap-ish – as broad energy prices overall spiked??! Overall, energy prices tend to reflect the 1 fuel most crucial – the most key to grid stability. Rather like how income tax rate reflects highest marginal rate paid on highest dollar earned. Natural gas was still key and so as its price spiked – energy costs did too. Even US electricity from coal, rose +22% in sympathy 2021. Such energy cost spikes will no doubt recur ahead. Even if renewables (a minority of power supplied) rise in cost a bit - hold steady, or decline - as we'll see ahead. In sum, fossil prices *rose* hard 2021 and 2022 – but only after very long, very deep lows there. Rather predictably, given their longstanding boom/bust cycles.

Past is Prologue: spikes up were only *after* fossils had plunged in 2020. Only *after* US coal production had hit 50-year lows, 151 mines closed or idled. Only *after* oil had hit historic lows in 2020 on Demand Collapse. Oil industry needs oil at least $60s, so oil down at 'just' $50 2020 had punished shale producers, $40 oil was misery for producers. Equities are inherently forward-looking, so oil in 2020 hadn't been attractive for investment. Only after big supply cuts, shuts downs + then renewed demand discussed ahead - did oil rise to $110/barrel on supply curtailments. At any rate after that bust, oil & gas prices spiked 2021/2022 etc. That too may again make renewable alternatives relatively more attractive ahead.

A key point to be repeated, is that *Costs for wind & solar 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 had no floor. What had changed dramatically 2021 after demand destruction – was demand rebirth. It's aptly said 'the *cure for cheap oil, is cheap oil'* - lo and behold, fossil prices jumped 2021 & 2022.

Said another way were a prior 100m+ barrels/day of oil still supplied early in 2020, that could have prolonged collapse. For coal, it's no longer tracked by an ETF, no new coal power plants built in US. Yet demand for coal/so prices too jumped by +25% in 2021 partly on overseas demand and on a gas crunch price spike. US domestic coal economics are dismal, so miners look where it's being burned, and Asia (even Europe) had a huge appetite 2022. So today, the fact that America's own domestic coal supply had once been the 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 can render H_2 (hydrogen) from fossil gas about as awful as burning directly - and Russia's 2022 war bodes ill for 'blue H2' in Europe. Yet, scarily, electricity made from gas will still be huge in US & China in 2030. Given the climate crisis, that's a huge worry as is burning more coal. Rich Europe *may* 2030 have reduced its gas-use sizably – coal more so, with big stumbles like acute gas shortages discussed ahead. But late 2021, China had hit a coal record mining 385 million tonnes of coal, walloping previous monthly record. A new record up +4.07%, as global coal grew +9%. More coal was used in 2022, as natural gas costs rocketed. Even in rich EU, coal made more electricity - than a year before. As a result Western Europe/Germany, *may* get (gasp) near 50% of its electricity from renewables in 2030. Yet scarily, that 2 or 3 of world's 3 big blocs could still be relying on much non-renewables (and perhaps coal too!) at end of this decade, looms large.

Another issue discussed ahead was a possibility of forced labor in China. Horrid to contemplate, it led 2021 to a Withhold Release Order (WRO) by US Customs. Products using forced-labor, are obviously wholly wrong. Thus PV panel makers & others must more speedily, carefully, address all supply chains. Tracing complex supply-chains taking time & effort. By late 2022 many Gigawatts of solar PV from China were being withheld from entering the US, due to this WRO issue. It has started to be addressed, and we watch carefully.

Broader change is afoot. Some is helpful. Maybe spiff electric aircraft to help electrify all, challenging fast past hegemony of fossil fuels for more efficient short range air transport. Cleaner power for ships. Batteries made for less-cost, on lower-carbon lithium, or graphite. 'Greening' rare Earths in wind, EVs, etc. Likely recycled batteries, better anodes/cathodes, new circular economies. For sure IRA of 2022 attempts to ramp domestic US production of lithium for EVs, and rare earths. But given CO_2 levels already in 2022 were over 420+ ppm and are growing fast, there's no realistic possibility of holding global heating to <2.0 C aims. Let alone to <1.5 degrees C. Hence climate emergencies, crises, seem looming soon ahead.

Advances are welcomed & necessary - yet have been nowhere near fast enough. With some irony, Russia's attack on Ukraine, gas cut offs, Europe rationing fears may accelerate action. Might mean 'Marshall Plan'-like levels of action for clean energy. Faster wind, solar, maybe green hydrogen, though shorter term (!?!) all is still prolonging LNG & fossil gas in a vexed compromise even Germany's Greens grimly accepted. Due to that ongoing use of natural gas, of oil, of even coal, most acutely this has been simply a climate opportunity, lost.

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

Those data since have made clear too, there never was any Covid hoped-for 'green recovery'. Clearly, no pandemic moves *away* from fossils; as CO_2 emissions first dipped, then exceeded pre-pandemic by over 5%. Worse 2021, then worse still in 2022. On climate we're losing badly. The facts so far, are no cause for optimism. Not for this decade, nor even this century.

2021 did flesh out much debate over big proposed US climate legislation. Outlines of this Gordian knot were well-known: 2 legislative bills were in play. One was a classic 'small' Infrastructure Bill supported by some conservatives, Bipartisan. However, it would do *nothing* for climate solutions. Less-costly of these 2, yet still $1.2 Trillion(!) it had clear 'pay-for' revenue sources - relative to 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 or $550 Billion was climate/clean energy and needed No votes from conservative party: it could pass but ONLY if voted-unanimously by the liberal party. At first a $3.5 Trillion wish-list of liberal aims, it was climate-heavy. Early text 2021 had Grants (carrots) for utilities to green - 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 10x that by utilities *not* cleaning up, could be hit by fees. Nuclear might benefit too as would solar, wind, hydro: each might win as 'zero-carbon' under this initial proposed legislation.

As for politics, the key 1 oft described moderate Senator from fossils-state couldn't support BBB reconciliation bill as conceived. Both on substance, saying a transition from fossils to clean was 'already happening' so why spend taxpayer dollars to speed 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 risk. But, that Senator plus many House moderates did want new 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 that their CO_2 somehow might be cheaply avoided.

Progressives weren't as concerned on pay-fors. Nor, $3.5 Trillion reconciliation size. For them new taxes on wealthy worked fine, or a 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 this smaller bill, so there was tension late Q3 to agree on a 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 that any BBB figure would be well under $3.5 Trillion, so there was choc-a-bloc uncertainty. All got pushed to Q4 - when a deal *might* happen near Christmas - or it might then all fall apart. If BBB died, there'd perhaps be only a narrow lane to resurrect parts say as pro-clean energy tax credits in more piecemeal fashion later in 2022.

Were just $1T bipartisan fossils-heavy bill all that could pass, that was worse than nothing to many progressives; so several wouldn't support it. Progressives' leverage was linking both; 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 BBB done. One progressive leader felt $6 Trillion BBB was right, given scale of problem, taxes and/or deficits could pay for it, $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 had no-doubt enjoyed the moderate's call to pause on 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 infrastructure in that moderate Senator's state was very poor, their willingness to wait, or move goal posts meant BBB's window would soon close. Finding a sweet spot soon on $$ size was key. All agreed Infrastructure = jobs. That Senator as Committee Chair had helped sculpt the bipartisan bill, so desired it. Goodies could make much possible (recall Bob Byrd?) bringing moderates off fence. But, could a $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. Yet infra-party dissension could kill both. All came to a juncture just before a G-20 meeting, then a global COP26 Climate Conference in Scotland.

It boiled down to: could reconciliation with some teeth, some climate action, but 'just' $2T – and then at 'just' $1.5 Trillion – win unanimous support needed? Progressives felt it must be all, or nothing. They saw a $1T Bipartisan bill wedded-to fossil thinking, 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 – with more compromises on $1.5T BBB (yet maybe that falling apart) was nub of it.

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

Many things changed late 2021 as talks moved zig-zag fashion. The President had hoped to bring a legislative win to G-20, then to COP26 Scotland. Yet COP26 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 to be 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 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, Bipartisan Problem Solvers Caucus that had worked for months on bill, could instead supply the dozen or so 'Aye' votes needed from the 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. Having now the votes, before even taking up BBB for vote too, so de-linking the two.

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

On BBB, 1-2 Senators at odds with their liberal Party had 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 in key ways. Biggest change was deleting any/all sticks from a reconciliation BBB that would draw-down fossils. Originally, BBB had been envisioned as having both essential carrots, and big, 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 plans to clean up US emissions were shorn off, a blow. Efforts to keep in 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 still 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 far bigger legislation. It implied if liberal Party gains 2 Senate seats in future that could be disproportionately impactful ahead. But it's Not so likely; traditionally President's Party loses seats in midterms. Still, it's extremely likely climate emergencies aren't going away. And public sentiment favors action here. 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, of climate *inaction* – get ever-more bitingly clear.

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

For instance, that 1 Senator had watered down a proposed rule based on science that would have tamped down more 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 it might have prevented 168 million metric tons equivalent carbon dioxide. 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), and oxygen is 16 AMU, so mass ratio one CO_2 molecule to one carbon atom is roughly 3.67). The point here is just 1 person had killed a major draft methane rule in 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, new 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 avoided 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?); it though might be unconstitutional given a 16th Amendment's requirement though of realized income. Instead, 15% floor idea steered clear of increasing traditional taxes, cap gains, or taxes on unrealized income. In draft form it was joined with a proposed new surtax on very highest earners, helping to pay down the Debt.

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

Fury over how badly reconciliation BBB had been eviscerated in 2021 was immediate. Hyperbolic-sounding criticisms fast sprung up such as 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, singularly different. Worryingly, such critique *ought to have had* zero chance of being right. Terrifyingly there was maybe, perhaps, a non-negligible non-zero risk that it might turn out true.

Most of the time in politics, debate is on human-scale timeframes. There's a moderate place or a stance to stake out – a middle twixt 2 fiercely opposing sides. Common sense compromise between sharply opposing views. Singularly, for climate, this middle ground we instinctively seek isn't there. Punting to the 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, taking initial steps away from coal - China was hit latter 2021 by severe energy crunch. It grew less certain they could keep peak pre-2030 aims. Plus given rich nations had failed in their own $100 billion commitments to transfer funds & know-how to 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 that 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 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 industry, more of the same. Like state-owned fossil firms offering vague promises, glossy blue hydrogen ads, talk of distant 'carbon neutral' in a distant 2050 – all conflicting with more pressing CO_2 reality. This COP26 was only days after G-20, and all had failed regardless of any mere in-draft, 2021 fast-dying US BBB legislation.

For 3 reasons 2021's COP goals were maybe tougher than in the more-vague Paris Agreement. One, rich nations' big 'commitments' of $100 Billion/year for developing nations were easy to just mouth at Paris – far tougher to actually start mobilizing at Glasgow. Two, making global carbon market rules proved tougher than talk, like the US Congress flailing on a disintegrating BBB. Third, most blatant, cuts big enough to keep to 'just' 2 degrees C heating – 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 that 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 increased ambitions that it offered COP26, its new 'tougher' goals remained so lax, they'd still be in line with 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 allowable human CO_2 emissions are some 400 billion – 450 billion tons. Yet on current trends, we'll pass that max carbon release ceiling 'speed limit' within 10 years, by 2030. It's laughable to think we'll go 10 more years – then switch off all last CO_2 emissions at once. Over a century ago, Svante Arrhenius & Arvid Hogbom determined How, Why, then-forecasted 3 degrees C rise in global temperatures might result from each 3/2 rise in CO_2. The ratio since refined, but principle is roughly same – and producing heating at poles than equator. Linear increases for first CO_2, meant by power law for the second; rising 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 total failure. Senate Parliamentarian needed to agree all items spending-related, a 'Byrd Bath'. But scoring/spending had to be looked at by that 1 'moderate' Senator – whose vote was necessary. Things didn't look good at all. To cut big spending estimates, some Programs were in draft re-written as pared back from 10 years – to 3-year sunset (or even 1 year) hoping a 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, even a defanged BBB with small sticks would 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 perhaps for 2022. Even eviscerated a $550 Billion draft BBB would have gone farther than ever before on climate. Partly (though arguably not fully) paid for, it had revenue raisers that needn't have relied on raising regular taxes, nor capital gains as feared by moderate conservatives. Arguably that BBB was a missed chance late 2021. A loss, given what the bill might have been. And it might have finally started to take on overlooked GHGs, like methane, more seriously.

The 'smaller' IRA that was at last passed, and signed in August 2022, was thus a 'big deal'. And coming soon, attention to say, *tax advantaged Master Limited Partnerships here (MLPs once just for fossils, could be in clean energy too). Low-CO_2 hydrogen tax credits depending on carbon avoided, so not just much better green H_2. Electrolyzer-makers inventing new, more-efficient catalysts, getting hydrogen tax credit boosts. Thanks to the fact that the IRA of 2022 was negotiated quietly between Majority Leader and that 1 Senator, that narrow lane probably all that then existed. Yes, the IRA was defanged of all stocks penalizing fossil fuels – it was all/only carrots that also aided fossils & nukes. But it was the 'best' then possible. In all, the earlier BBB language though it died, helped show which way the wind was blowing.

For example, a draft BBB text had implied 10% more ITC if is 40% US-manufactured content. More if US steel used in US solar trackers. Residential PV could see a 30% ITC, renewed for long periods like 10 years; inverters aided too. In draft ITC can grow if projects near former coal mine sites, or coal power sites. Maybe a 45Q tax credit for 'carbon capture & utilization', or for direct air capture. And $$ for nukes. There were proposed Federal methane fees (any fees on methane are important, that did make it into law with signing IRA of 2022).

End 2021, that 1 US Senator had earlier declared a $1 Trillion+ BBB 'Dead'. No great surprise, as that Senator long criticized its size, scope, direction; especially social spending not energy/ climate from start. That Senator arguably did want a new 15% minimum corporate tax, lower prescription drug costs, subsidies to keep Obamacare. Not omnibus, but much smaller, more targeted. And so, like in the 'Princess Bride' movie, hopes lingered that it wasn't 'all dead' – just 'mostly dead'. A more slimmed bill *could* get to 'Yes'. In the movie, Inigo Montoya hoped to return to life, Buttercup's True Love. Miracle Max explained 'mostly dead' is slightly alive – and here maybe a slimmed down bill was better than 'all dead'. As in Washington DC, the joking was the 1 Senator might allow passing something – but that helps all fossil fuels too: no longer BBB – but rather 'Build Back Manchin.' Then, late July 2022, the Senator 'surprised' all by giving a big 'Yes' at last. Clean energy, as seen in ECO, immediately jumped up.

Very soon after, Inflation Reduction Act of 2022 was born. With many non-surprises like restricting $7,500 EV tax credits. Added income limits to it (the Senator felt giving tax credits to wealthy would be 'ludicrous'). New assistance for fossils and nukes; more oil & gas leasing acreage since that Senator wanted an All-Energy approach. Incentives to grow US domestic batteries, and mine/refine in the US critical minerals (China had captured strategic minerals supplies and something needed to be done). Though China had an enormous lead.

Think of carbon linchpin, China. So wedded to coal, it didn't speak at COP26 of coal 'phase-out' – but rather only of a 'phase-down.' Yet possibilities there for solar power are immense. China, more than anyone, can make vast solar growth happen. Reminiscent of a US mobilizing 1941 for war. By 2021 China already had 250 GW of solar power capacity, nicely 2x what had been called-for in its earlier Plans. It could boast, of 1/3rd of all global solar capacity being commissioned on its domestic China demand, with reverberating benefits planet-wide.

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

China's solar PV costs had averaged just 4.93 cents/kWh in 2020. The costs projected to drop to 1.3 cents/kWh by 2030. Then, as solar gets even cheaper – down to 0.3 cents/kWh by 2060! If a price is put on coal pollution, say a carbon tax, cost difference gets immense. And so, coal cannot compete ahead; all sides know it. But coal means jobs, is firm, dispatchable, an uninterruptible vast domestic power that nation had needed. Solar, hobbled by intermittency, dearly needs energy storage to be firm. Put together, storage + solar can be 100% dispatchable and by 2030 its projected 5.2 petawatt-hours of solar-with-storage might be available in China. All of that will be cheaper than dirty coal, too – near its total 7.5 PW total demand.

2060, solar + storage could be making 7.2 petawatt-hours, then near 1/2 China's electricity demand - met by sun. Complimented by huge wind onshore/offshore, and geothermal etc too. it could thus meet all needs. Still, there's great challenges to such a ramp. Especially in raw materials that pinch. Yes, battery designs once needing say, cobalt might hoover up 36% of world known cobalt reserves (on older battery designs). Thus, on new better batteries that don't need cobalt, discussed ahead, it all gets much easier. Even huge lithium needs, might then be 'only' 8% of global reserves. Hence green new alternative technologies, can be crucial – and myriad ideas beginning to blossom, that can require fewer costly raw materials.

Material availability, tech maturity, cost & efficiency considerations all impact choices. Looking back a few years, it may have been propitious to have 'gone into Photons' – that is to have invested in a solar "P" theme that rose after. Later in 2020-2022 surging inflation meant that commodities like oil & gas instead did relatively well, rising in value. Looking ahead, yet another P, here 'Protons' so risky energy storage & energy conversion (H2, fuel cells etc) *may* turn out possibly a bit propitious one day ahead too. But it's unknowable, especially now, given their huge volatility. What's certain, is that 'protons' theme early 2020s *is still hugely risky*; likely much more so than were photons/solar a few years ago.

For solar back then was already steeply cutting costs. On modern manufacture, it got ever-cheaper, like making computer chips. But energy conversion is quite different. Dogged by uncertainties, in 2022 many breakthroughs were still needed for protons (energy conversion) - unlike photons as extant PV sharply reduced costs. And unlike batteries that saw persistent recent annual cost reductions of 7% or 8% a year, very good and helpful. Instead, 'protons' in early 2020s, like green hydrogen, ammonia, methanol, was far more a wild card.

Another "P' maybe relevant, but insusceptible to analysis, is 'Politics'. Maybe a factor in ECO hovering 150–200 in Q2-Q4 2021 on whether BBB might pass. It didn't, so on BBB's 'death', inflation, rising interest rates – things fell <100 hard in Q1 2022 with sparse floor (just hope) to keep Index from falling – going to low 80s in Q2 no great surprise. There'd been an expiry date on hopes for a 'huge BBB' to pass. California/Florida early 2021 had looked at cutting support for solar, and a floor that perhaps once better held things up, faded fast. That turned around in July 2022 with a new surprise $360 billion IRA. And thus ECO jumped Q3 2022

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

If the US wants to grow its solar from meeting meager 2-3% of demand in 2021 - to grand 50% next 30 years by 2050, hurdles to expansion loom large. Think then of materials used in solar. Polysilicon's discussed ahead. But there are other, key materials in manufacturing solar.

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

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

Take large 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 dearer $350,000. So only 1,000 buses, pilot projects on grants were electric in national fleet 480,000 school buses. Think then of the passed 'small' bipartisan infrastructure bill: $5 Billion for half electric, half low-emission (like CNG) buses. That could mean, schools maybe buying perhaps thousands of electric buses ahead. Driving costs down sharply too, for future new EV buses to boot.

One big school bus manufacturer is Blue Bird. Half its 11,000/year buses back in 2021 had been dirty diesel. Other half burned alternatives, eg propane or compressed gas, still polluting & awful for kids and climate. It only sold a tiny number of clean electric buses: 775 in 3 years to 2021. Understandable, given high upfront purchase costs. Yet low-maintenance electric school buses *may* be afoot. Moreover, with greater battery storage, fleets of EV buses could be excellent backup to grid. Made cheaper 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 in a way and passed in 2021 in the Infrastructure Bill, means they'll improve faster as well.

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

Wind, yes is highly intermittent. So much so, a lack of wind over months ('wind drought') can be rough. That was so at times early 2020s, especially since there's not yet nearly enough clean energy storage, but this is changing fast. In 2016 the world had passed a storage marker: its first puny 1 gigawatt of energy storage capacity. Just 5 years later, in 2021 the world had 12 GW of new storage capacity – as much built new in a month, as was installed all 2016 year. New storage capacity upsizing quickening rapidly. So much that 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 what had been seen in early 2020's. Much of that now is batteries, but new technologies could bring far more. A large 400 MW battery installed in early 2022, while then world's biggest, should soon be regarded as just 'meh'.

For why natural gas storage is crucial, consider say a bitter cold Europe Winter. An issue began mid-2021 when Russia suddenly began exporting 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 2021, dropped to 20 mcm/day. Gas levels were already very low in Europe – in UK & globally. Why? Covid-driven supply shortages + weather volatility dropped gas supply worldwide. US hurricanes compounded it. Net/net on sharp loss of gas supply & less storage - natural gas prices jumped. Europe lacks big domestic gas supplies, so had long (over) relied on importing cheap Russian piped gas for electric power. As natural gas, so electricity prices skyrocketed latter 2021, Asia grew hungry for scarcer gas too; in no time all gave way to bedeviling gas shortages. And to eye-watering high electricity costs - especially late 2021 in a prostate Europe. Bitter cold - or heat, or another event (maybe War!) could create crisis.

It's been suggested perhaps gas exports tightened 2021 by Russia to spot markets, was to help it win needed OK for Russia's Nord Stream 2 pipeline to Germany. Or to prepare for coming gas stifling to Europe, in 2022. Europeans for their part needed much uncontracted, cheap spot Russian gas. Alternatives were few; more gas from Nordics – or import lots more liquified 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 late 2021 – and to build stored gas. Especially if a colder than usual winter, say 2023 or 2024. If sparse breezes make less wind power, nukes are down for maintenance, emissions tighten coal – and Germany aggressively targets 80%+ renewables by 2030 – it can get very tight.

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

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

In past, simmering European fears about over-relying on Russian gas were waved away by how bloody cheap it was; 40% of Europe's gas, more so to Germany. Until that blew up in peoples' faces. Literally. Approving Nord Stream 2, or softening up targets was maybe behind Russia's cuts; build support for pipeline II; or prepare for war. But paradigms shifted fast on fears Russia could invade Ukraine – faster when it did 2022. Just before China, Japan, S. Korea buying LNG had pushed prices >$15/per million BTUs. US gas rose too as all is interconnected, from $2 mm/BTUs - to over >$5 – unheard of in this US shale-frack era. Europe Market Winter gas demand competes vs JKM (Japan-Korea Market) – as geopolitical urgency meant Europe needed to fill gas storage fast. That and mild early 2022 helped. But all became scary on war. Maybe Hot Summers this decade. And maybe cold winters in 2023, 2024, 2025 etc.

Clearly 2022 had thrust Europe's debilitating over-reliance on Russian gas in a sobering light. It underscored an immediate need for More Renewables fast. GWs *more* solar/wind quicker - plus long-term battery storage needed for firm power. Lack of extant LNG gas infrastructure, of LNG storage vexed too – because clean hadn't yet grown to be big enough. In particular as Europe was trying to wean itself off coal, reduce ahead current-gen nukes (though they may persist longer to let renewables grow faster) - wind & solar all 2020s are at awkward stage. Growing yes, but not yet near-big-enough to be Hero. 2020 renewables met only some 20% of European electricity demand, not near enough in 2020s, to overcome gas' failures… yet.

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

For US solar, a deployment target had been to hit 45% electricity met by solar by 2045. From a scientific standpoint that growth wasn't only possible, it was *required* given climate crisis. Yet such a ramp would also be unprecedented. The US in 2014 had gotten well under <1% of its power from solar. By 2021 was 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. For 30 GW more installed in US each year 2022 to 2025. Rising 4-fold/year over that 2020. On to fresh 60 GW of newly installed solar in each and every year, from 2025 through 2030.

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

2022 needed only 30 GW more US renewable solar. For comparison each 1 GW can power 750,000 US homes, and is roughly like mid-sized albeit firm, current-gen nuclear reactor. With proper support, solar & wind can grow fast – along with battery/storage for firm power. Or, all may stumble & fall. Especially if future, bigger bills like a-once-huge BBB in $ trillions fail. Partly too why there's such huge volatility seen here. And why across the Atlantic, modular reactors are being looked at in UK as zero-carbon - where 7 big nuclear plants are cut back, though had made 17% of UK power 2021. 'Small' new gen IV nuke reactors may come in a standardized design (like China/France). But, can they also be made 100% safe? Less costly, and much less risky? Early 2020s on nuke state of art, that answer's murky, dubious at best. Hence questions have swirled around current-generation nukes 2022. Even so, China/Asia, Germany, UK, US and others are searching for much-needed baseload power answers. Let's next consider solar/wind/H2 themes, hence ECO & global NEX as oldest; + H2X/WNX best benchmarks. We'll begin with volatility here that's ever-dominating green themes.

After big ECO/NEX gains in 2019 & 2020, it was perhaps 'unsurprising' to see big falls in 2021 & 1H 2022. From a peak Feb. 2021, was then unknown of course if clean energy theme and so ECO might fall in harsh backslash shaped "\" down all 2021 – maybe into 2022 etc too? Or perhaps an "L", down then sideways; or on January rise an inverted "V" with ^ right leg down much further than short increase on left. For many reasons 2022 *might* go on suffering headwinds: *No Passage of a big $550B BBB and it may die; *China's 5-year plan and unforeseen exigencies in energy demand could push coal burning up past 2025, and *Europe seeing loss of Russian gas, or China pause might refrain from hoped-for very aggressive moves away from all gas, oil and coal in 2020s. All despite its strong global words on climate.

2 later worries became *Green stocks had hit very high P/E multiples early 2021, plus *Inflation + Quantitative Tightening Risk. Perhaps that Feb. 2021 peak was thus a soft ceiling? BBB was succor, if one felt bill could pass; its early $3 trillion *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 and "E" Earnings. Plus, maybe cumulative years of rising rates after Fed had let things run hot – meant years of tightening. Thus tech stocks had shifted fast to lower valuations/poorer expectations through falling 2021, discounting future values. Capital, unsurprisingly, went reflexively in 1H 2022 from growth - to instead value (so not to a future-oriented clean energy!). Markets may get re-accustomed possibly ahead to high yet historically more typical, non-zero Fed rates rates like of past. But was not so early 2022.

Valuations above 25x EBITDA (Earnings Before Interest, Taxes etc) might be seen again, but in risky green themes, few dividends, little positive "E" earnings – all swung bearish hard. In Global NEX, like in ECO, components fell then as one might well expect on the macro-picture. A classic sell-off that followed a Feb. 2021 peak was maybe overdue: The NEX/ECO had already spiked up 4-fold/& by 6-fold Q1 2020 to Q1 2021 – after big gains too 2019.

Recall how within Q1 2020, ECO had crashed by -50%. A plummet again by a same, neat -50% in 2021 wasn't so surprising. ECO went from 287 high close (286.89 intraday) Feb. 2021, down almost exactly ½ to a 142.39 low for 2021. Given 2020's gains, that took it to levels seen not long ago: ECO was 140s as recent as Nov. 2020; and would fall back to an 84 ahead May 2022. Or, say, if NEX goes down say by half; it had been at 315 recently as Sept. 2020. Much bigger drops in both themes can well be envisioned. After all, ECO in 2020 had a -50% fall from 90 to 45; down -50%, then rebounded. Just a coincidence to see a similar-sized, -50% fall once again in 2021. *Coincidentally*, was curiously a neat -50% decline to 2021 nadir. And near that seen again to an 84 in early 2022. Much further falls, can be envisioned for 2023 or after.

In sum 2021 was partly an interregnum; a rough patch rife with uncertainty. It had opened near a peak as this theme had spiked on hopes following Presidential results, a surprise 2 seat gain by his Party. Fueled by hopes of BBB passing. Thus when it didn't rest of year was weighed down by high P/Es, steepening inflation fears, uncertainty over if anything could pass in 2021 – then saw it had failed that year. An air pocket 2021 Q2-Q4 'twixt election outcome/hopes – then tougher clarity. Frankly some skepticism is always helpful, like how truly likely is more spending here after the 2022 IRA (whether blue party can hold the House and 2 more Senate seats switch blue as an important determinant). Without a doubt, passive ECO/NEX/H2X/WNX may fall more ahead; hence the plummet of ECO into the 80s in Q2 2022 was understandable. If P/Es are a useful metric - & in Q1 2021 they were very steep, the odds of wind/hydrogen/ solar themes again justifying such steep P/Es say 2023 or 2024, can be pretty daunting.

Much had happened early 2020s in clean energy & climate. Some was hopeful; a US President aimed to cut US CO_2 emissions by near 50% by 2030 (even in theory that's doable). Some not-hopeful: renewables growth since that pledge was nowhere near fast enough to reach that 50% cut in CO_2 by 2030. Yes, solar & wind themselves are inherently, *potentially* readily capable of it - but on recent trends we'll NOT hit 50% CO_2 emissions cuts 'til years later. Broadly this has been due to 2 factors: 1) Renewables not yet being grown fast enough to displace coal, oil & gas. And conversely 2) huge global inertia behind still-growing fossils is not even letting up, let alone are they being shuttered near quickly enough post-2021.

Solar & wind clearly are capable of it; *these 2 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 vast opportunity, the world 2019 only captured 0.7 PWh solar power, and 1.4 PWh of wind. Even though these free winds & sunlight could meet *all our power needs*. Forever.

So, no surprise they're at least expanding! Globally, solar growth was +39%/year last decade: it roughly doubled capacity every 2 years. Wind growth was 17%/year onshore; and an offshore newer wind boom might raise wind's rate of growth much higher ahead latter 2020s.

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

US offshore wind GWs, starting from 'zero', will likely see big gains this latter decade. But for 50% cuts in CO_2 to avoid crisis – all fall far short. That ought Not dissuade. New energy *can* deliver abundant, affordable, change. Electric cars *may* go from poor 2% of US car sales in 2021, to 50%+ in this decade; even as China & Europe are doing far better. In Norway new pure-battery EVs had hit 74% of sales(!) in 2021, for 11,274 units; EVs/ plug ins there totaled 95% of all new car sales! If Norway presages, then auto makers banking on 50% gasser lineups still 2030 are gambling with BK (bankruptcy). China, seeing this, was at 15% electrics in 2021 – and rising fast to become EV dominant soon ahead. Global EV sales in 2021 far overshadowed puny US figures. China sold 1.1 million EVs early 2021, Europe sold 1 million – both were far doing better than the US. And Europe leads in both its clean power generation wind/solar - & in EVs; meanwhile China is rising very, very fast from near nil. All that as the US lags.

Western Europe wind & solar were growing, with coal cut back – until war in 2022 revived all its dirty fossils! So natural gas can be reduced there - but not quite yet! Instead, gas shortages had made all of Europe's power prices jump. Yet things change. Especially as gas portrayed as a 'transition fuel' may be last pariah fossil; as socially unacceptable one day as coal or cigarettes. Europe's Climate Law may mean border tax on imported CO_2-laden products. Clean energy should win out, EVs on a cusp, but keen need to *heat* buildings had no fast green fix early 2020s. Replacing gas boilers with heat pumps, is costly. Renewable natural gas (RNG) blended with green hydrogen (H_2) still years away. As is running ships & aircraft on green H_2, or ammonia (toxic, so carefully) or methanol - greener fuels ahead. Yet all that is clean is vital – but is only one-side of climate coin. Other side has got to be moves especially by China to cut coal/CO_2/methane/greenhouse gases. Clean gains will be 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 declines in 2020 in Western Europe/US – was regrettably, a brief outlier. Elsewhere like 2021 and worse in 2022, in China, India, Japan, even Europe, coal saw terrifying growth. China is growing its renewable power + EVs: great! – yet also expanding too thermal and 'met' coal use at least in the 5 years to 2025. Notably China first half 2020 had added 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 up 90% of that. Plus, 2022 saw more of the world speeding up coal-use, like in India, given a war that had spiked costs for natural gas and all.

Not only China at issue: 33 of world's 60 largest Banks had grown fossil fuels funding in 2020. Any & all hopes to decarbonize the world 2020s are blown apart by coal alone. In 2021 world carbon emissions had spiked 1.5 billion tons, mostly on coal. 2022 worse. Instead of a big coal 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 early 2020s.

There's happier words. A 'US commitment' to cut emissions by 50% from 2005 levels by 2030. COP 26 in Scotland heard glowing blah blah blah. But look closer. Each Paris Accord nation sets Nationally Determined Contributions (NDCs). Some are quite lax: China, Russia, Japan, Australia, Brazil. And games are played; a UN baseline was 1990 – not 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 being played too, like counting *not*-cutting down trees. Or seeing oceans as 'carbon sinks', or in 'reducing emissions' by 'offsets' as a mockery of reductions. Some words inspire, but others do mislead. Air traffic & shipping are kept out of emissions tallies(!), and methane is too, so the facts are worse. Aircraft, ships, methane; each big greenhouse impacts, ought not to be so pretended away because they're just 'too hard to reduce'.

There's Huge Gap between *promised* cuts to 2030, 'blah, blah, blah' - vs. reality of science. The data show fast-*growing* CO_2 & GHG emissions worldwide in 2022/2023/2024 etc are led by coal. With no real actions to cut. 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. That's to say nothing (as we do) of uncounted methane threat starting to force big heating too.

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

We can squint for bits of hope. In 2020 the 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 wind & solar. Wind 58 gigawatts (GW) 2019 doubled 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% clean power generation total in 2019 – to 36.6% in 2020. *Yet that was far from 100%, let alone 50%*. The numbers and the science show we're nearing a precipice of perhaps irreversible changes. And it got (much) worse over 2022.

Overall, the world electricity production pie is growing; yet a thing of it is coal's growing too. Coal vexes from mining to waste disposal, yet more is being built on new financing. Thus, even as renewables' share of electricity grows overall, total greenhouse gas emissions have continued 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 in other high heat industrial processes like making steel, aluminum, cement. Nor expansion due to war in 2022. Nor the massive embedded CO_2 in products exported from China etc to 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, on disingenuously trees, forests, oceans as a natural uptake. Coupled with distant targets like 2050, words can be meaningless. 'Carbon neutral' is proclaimed – yet is not same as 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 now, 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 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' (but only later-on). It follows: no nations merit praise. 'Twixt words & action, 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, 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 2022, gas was used as a cudgel in 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.

Stepping out, let's look at ECO/NEX back in 2020. Given these 2 Indexes/ETFs stood out as very top performers that year worldwide, ECO in particular was up +203%: why did these 2 do so very well? 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 as known to mainstream analysts; fewer analysts in cutting-edge innovations like in electric cars, Li-ion, green hydrogen, fuel cells, solar etc – may add sizable pricing inefficiencies. Fewer analysts 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 is impactful. 4th is so many 'ESG' baskets are still steeped in greenwash; for example, they still have natural gas! Our more truly clean focus is instead very unique & is consistent for 18+ years; that it's come into favor maybe is good fortune.

We'd seen similar for ECO back in 2004–2007 when green energy, long unknown, first grabbed a spotlight – 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 electric cars could *never* be as fast as 'real cars'; nor see a 200 miles range; nor ever be as pretty, nor as fun to drive. Views too often were that solar & wind 'weren't real' - vs. 'always cheap/er' coal. Future earnings estimates on such short-term valuations resisted penciling anew. Importantly, valuations were based *on only their future promise in 2007. Clean energy back then, was itself still much too costly.* And all crashed on overcapacity, high relative costs - and clean being still just 'promise only' back then 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 <under penny a kilowatt/hour, perhaps green hydrogen – all causing new look at valuations. Yet past inefficiencies in equity pricing, looked at again. 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, closer gaps from 'state A' – to 'state B' propels. At quantum-level on up to our own macro and visible, from a state A - to a state B can propel. On up to macro, 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 then, March 3, 2020 - to March 3, 2021:

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

10 components in any Index theme with Gains of +1,000% from 52-week lows, and a +2,600% is perhaps a bit remarkable. It helps explain ECO rising then 6-fold+. So, notable, was the *Speed by which clean energy could shine as Best option, *and by which policy moved towards zero-carbon, & maybe the biggest item, early notice of *Climate Risk. This last factor: how much CO_2/GHG can we afford, that's new to our species. Maybe a vital limit. Like *C* in Physics: all 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 a change, or 'delta': the Good, Bad, and the Ugly. Good, were the ***Huge Reductions then in costs** of clean energy. Solar becoming **least-cost electricity* in much of the world; wind power too. Solar should soon become *cheapest electricity in history!* So unimaginable to many, but a decade ago. Many models had long foreseen dirty coal or gas instead, as definitively lowest-cost power across 2020s!

Good driver too, ***unprecedented commitments*** by 3 economic blocs China, Europe, and 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 a seminal 14th new 5 Year Plan publicly was released to much anticipation. Possibly China could be a 'solar superpower'.

Did it mean all greenhouse gases? Methane/CH_4, HFCs too for climate neutral - or just in CO_2? How much disagreeably might dismal state of 'carbon capture & storage' (CCS) play a role? CO_2 just temporarily stored? A monoculture reforesting? Could 'carbon intensity' allow fast-increasing natural gas use – and be regarded as an improvement?! Might CO_2 be seen sadly as 'per unit of GDP growth'? That could/would distort true numbers around 'carbon-neutral'.

So, it was a big disappointment when its 5 year Plan of 2021 didn't take steps to end coal. And 2022 got worse. The world had needed coal to peak *before* 2025; biggest user China to commit to peak-coal first half of decade. It did not! Instead, it saw CO_2 peak post-2025, steeper CO_2 cuts later. In a fudge oceans & land were 'nature-based solutions', or 'CO_2 sinks'. Spurred by greater coal production in an energy crunch in 2022. Yet that push of peak coal to post-2025, fould/should have been avoided. CO_2 sinks may fast become sources, even a great Amazon Forest. *Instead, China's renewables were always its best answer*. Glinda the Good Witch, had known Dorothy's ruby-red slippers could always take her home back to Kansas. But first, Dorothy had followed a gold/yellow-brick road only to gain confidence. China's own ruby/gold slippers, its solar/wind plus vast storage potential *could* have started to replace coal already. Could have started being its 1st and best choice, already, before 2025.

Models by Tsinghua University have shown how China could reach its net-zero CO_2 by 2050, all greenhouse gases 2060. It requires big fast declines for 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 have started Decarbonizing already: a pathway that would have been so preferable to so many worldwide. China instead may ramp up nuclear first, rising from 'just' the 46 plants that had made 50 GW in 2021 - and no doubt some nukes worldwide will yet see devastating accidents ahead. Regardless of its exact path, China's new energy costs may well top $15 trillion! Far greater spends than contemplated by Europe, US: re-allocating 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 more solar manufacturing capacity. Tremendously 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: in electric vehicles & energy storage. Apart from a Tesla in US, China had clearly most seized opportunities. Like Japan, South Korea, Taiwan. About 1 million EVs were sold in China in 2019:=, or 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 2020 moves in ECO/NEX! Such demand had helped push battery costs down 80% in 8 years. Maybe already it was below <$100/kWh 2022 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 all the world battery making capacity in 2020, so change is happening! Ford, GM announced big goals, more reasons for valuation deltas. All vehicles electric, maybe >10,000 GWh new battery manufacturing/ year. 2x+ that for storage to replace fossils. In EVs, changes like maybe lithium metal anode rather than graphite, a 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. Cooling EV charging cords; GaN, SiC fast charging. Vanadium/iron flow batteries, maybe grid storage that get cheaper, better resisting degrading over time, etc etc.

China's early battery focus proved fruitful for it. By 2020 it had 80% 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 pulled it ahead of a US. One century ago, Des Moines Iowa had been a world capitol for electric cars. 30,000 EVs were then registered in US in 1912. And the US is once again letting a world-lead slip away. Something China, and lately Europe too seem very intent not to let happen to them.

All could = green jobs. China recognizing this, has had its foot on the accelerator. Yet its coal burning persists; China's big 53% share of global coal in 2020 was even more than 44% in 2015. Other side of ledger, China has led in clean energy growth. In 2019, China added 30 GW new solar capacity, 26 GW wind – for then total of 204 GW & 210 GW respectively. Next in 2020, China added 48 GW more solar, 72 GW wind. 60-70 GW solar 2021. Hopes for >100 GW/year for 2021 were dashed on an NEA draft @60 GW, yet think of what's needed now on CO_2 levels over >400 ppm, and it's why some **Climate** models call for 10x-100x more. Thousands of GWs of solar/wind power. Far faster necessary, on purely climatic, carbon-based concerns.

Or look to Western Europe; the European Climate Law enormous. It had laid out 'carbon neutral' by (distant) 2050, but could yet get 55%+ there *in this decade* by 2030. Little-discussed in US - yet seminal – that was given more teeth following war in 2022. Being fleshed out is a first legally-binding net zero Plan of these 3 blocs. Perhaps a 2030 target of 60 GW offshore wind, 5-fold increase from 2020; 300 GW by 2050. Greater since the Ukraine invasion. Plus, unlike China, Europe has started now – not later. (China's green growth to be fastest in world in areas to which it does commit, so note now where it's focused ahead).

Europe's Decarbonizing post-2022 is voluminous. Not just energy: industry, infrastructure, agriculture, water, buildings etc etc. All subject to consideration and change. Broadly accelerating EU may seek carbon tariffs and/or carbon taxes. Trillions of Euros in spending, carbon border adjustment mechanisms like on embedded carbon, affecting trading nations. Details being fleshed out may start the path of a (just somewhat) decarbonizing world.

There's ample coverage of what US might have done in 2022. Legislation could, say, have created green jobs in areas hit hard by coal, oil & gas job losses. But that had needed a couple more US Senate seats to pass. Lacking that, much less was possible. There was no chance for say a carbon tax, nor for a National Renewables Standard, nor reducing methane. Nor, say for US to start out-competing in solar/wind installations. Removed solar tariffs in 2021 could in theory have helped solar installers - lower-cost solar could have helped electrify the US. Better yet, solar panels (even from Asia) possibly built with little or no embedded coal. Instead, anti-circumvention strangled US solar installs 2021, fixed temporarily in 2022.

The Bad

Perhaps 'bad' factors too were behind 2020 gains. Bad, in a sense that to some, they didn't yet warrant exuberance; Hydrogen (H_2) & fuel cells come to mind. Not that they can't possibly and sooner than expected - be vital. More, they didn't yet justify hype, not 'til breakthroughs occur. But then this is a passive Index – not active managed – so not actively trying to predict rises or falls. And H2 & fuel cells in ECO/NEX had outperformed in 2020 (and are specifically in new H2X Index). Yes, H_2 then burdened by sparse CO_2 avoided, low efficiencies. But brown H_2 may yet be increasingly green/relevant. If still made from 'rock gas' (drilled natural gas) inextricably tied to fossils, then not worthy solution. 'Blue' H_2 on fossils & sequestration could only pass a very low bar; it is polluting. True, big Oil embraces a chimera of blue H_2 – but such may compete with green H_2 in this decade only, before green hydrogen may scale up big. For neither (ugh) blue H_2 with 'sequestration', nor uglier brown/grey H_2 made from traditional rock coal or gas - are made clean, green, in truly renewable and scalable ways.

Far better is green hydrogen renewably/cleanly made. By solar, wind, 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 capturing potent greenhouse gas (GHG) methane (CH_4) spilling from landfills, dairies, etc: maybe a 'renewable natural gas' (though may promote rock gas). Or a step further, drop-in replacement low-carbon bio/fuels. Not immensely scalable but if it's made renewably – by *capturing spilling* CH_4 and by using it – that may be partly a 'meh' transition bridge.

Green H_2 by contrast *can be* hugely scalable, and is 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 if made on site eg by offshore wind. (Blue ammonia, undesirably, is using rock gas). Visuals of wind/ solar making green H_2 – or 'green-ish ammonia NH_3' - in place of oil might be painted.

Cost is the rub. Affinity of H_2 to react & combine, means much solar/wind is required for electrolysis to split water. And green H_2 in 2021 was too costly vs brown H_2 steam reformed gas – with brown too costly in its own right. An inflection could be if: 1) solar/wind costs fall far; and 2) green H_2 goes <$2/kg by 2030 or to <$1/kg sooner. Profoundly then H2 is no longer 20 years in future. On a carbon tax of $50-60/tCO2, clean H_2 *could* make steel, cement, power ships, ports, planes and more. Manufacturers had reduced H_2 costs by 80% in 3 years. Going to well <$2/kg is targeted; even far cheaper <$1 may arrive in innovative new ways.

But all that was a dream in 2021. Green H_2 cost x-times too much, everywhere, seldom was seen anywhere. 42 hydrogen stations in California in 2020 – vs. 22,000 electric outlets to charge. Worse, inefficiency. Compared to batteries, H_2 loses half in going from water – to H_2/O, then loses more from H_2 – to electricity at fuel cell. A case may arise *if* cheap green H_2 'time shifts' intermittent renewable power, holy grail of abundant firm power & heat. Nearer term, green H_2 may displace rock gas at <15% content to not embrittle steel. Renewable natural gas may be drop in fuel. Uncapped methane captured, upgraded to H2 in renewable natural gas, and *truly* sequester C in stable form. Still, renewable natural gas is just on defense vs. climate risk. Not great, but of tiny help near term. In sum hope for H_2 fuel cells partly why clean jumped 2020 as equities are forward-looking. But the case for green H_2 was far hazier in 2022 - than it once was for solar, wind, electric cars. That said, green H_2 before barely conceivable, *may be* plausible ahead - *if* renewables bring us cheap power.

The Ugly

Ugly factors even if tangential, highlight how better are green solutions. Take a dismal state of the art now for CO_2 Direct Air Capture (DAC). Energy intensive, that non-starter needs gobs of power so burns more fossils & so on. But if DAC can get sensible, much lower-energy, then *that* could be huge. Even less worthy yet touted by fossil industries, is Carbon Capture & Sequestration (CCS). CCS might extend fossils by decades; it may inject captured CO_2 back underground to briefly help produce more oil. But then the question to be asked is: Why??!! When, Not burning coal, oil, gas is where we ought now to be headed in the first place? CCS is a non-starter; completely unsuitable if is done say for ugh, enhanced oil recovery.

There's matters too they won't raise. Like what if that CO_2 leaks in centuries?? At Lake Nyos, Africa, a CO_2 'burp' killed over a thousand people. Far better, would be stable, true CO_2 storage or mineralization mechanisms that are inert, safe, permanent. Solar's cheaper than coal anyway, so coal with CCS is no answer; costs to capture CO_2+pump it underground renders coal 4x too costly!! It's why we saw 'clean coal' (ha ha) in ads only - never for real.

A compelling DAC must instead *Remove CO_2 from the air & seas *Permanently, in *Practical, *Economic Ways, be *Scalable to Gigatons, *Benign, Stable, *Carbon Negative – not just carbon neutral. Telling absence of such so far early 2020s decade, boosts the green alternatives.

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

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

Closing gaps to go beyond past 'wrongs' – helps propel clean equities here up. A few years ago, conventional wisdom held EVs, like solar & wind power were costly toys at best, always seated only at the kids' table. Regarded unseriously. Thus rather than 'listening to the sea', or thinking holistically – electric cars were dismissed as always slow, silly golf carts forever vexed by hills. Their range too forever thought under <100 miles so always a sad joke.

How wrong! In proving old beliefs wrong, sleek electric cars have been/and are getting vastly better. They were fated to do so! Foreseeing such favors the bold. Closing gaps between state "A" (old beliefs) – and "B" (the truth) – can be disruptive, innovative, and useful. Clearly, it can make 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 also non-linear. Think tremendous falls back in 2008 as green themes crashed, again in 2021 and they certainly can/will do so ahead. A dozen years ago profit margins went non-existent, stayed down for years. There's a non-Euclidian, curved, non-flat geometry. Like disjointedly compressed margins, not straight lines. Solar margins in time did becalm a bit; we're learning to make solar about *least-cost electricity in history!* Learned cost-reductions led to virtuous circles. Electric cars got better in most every way. Think by contrast of heat engines; unfathomably still all around us, their spark plugs exploding to push pistons for power in cars, trucks. Coal makes electricity by heat difference. Nuclear too = as world's costliest boiling water. Delta is in hot - vs. cool. It's difference of state, temperatures in "A" vs "B". But that difference found in heat engines, is brutally inefficient unlike nature herself.

Mr. Babbage once captured delta by a difference-engine. Mr. Turing led us to computers; gap between '0's vs. '1's did the work. We don't know *when* razor-thin solar margins will again crash; when solar equities will again plummet as they'll do, in booms and busts. Or, when the top issue is made clear to our species: Earth's physical CO_2 and greenhouse gas limits.

This last issue is so significant, stands out as maybe *sui generis* in global crises. Potentially, heat and climate risk may devastate societies, humanity. Possibly an existential threat. Not yet understood. Tipping points, feedbacks: Permafrost melts, methane bursts, clathrates, that can't be unwound. No matter how hard we humans beg, bargain with, or badger nature. On most topics, scientists will counsel calm. Soothingly they'll remind us that things really aren't nearly half as bad, nor as extreme, as non-scientific laypersons paint them.

Not so on climate. Singularly researchers are now shouting. Maybe it's conservative to heed – foolish to reject that, which one day may hit us not in a spirit of bravely looking at solutions. Nor boldly advancing our better natures. Instead, maybe hastily saving what may be saved: remember Summers lasting only 3 months? Winters? Cool nights? A century out, who recalls living Coral Reefs? Sandy beaches? Healthy seas? How to prevent that as a future we bequeath. Especially when sustainable, no regrets paths will make us healthier, happier, richer, safer, more secure. Instead of costing spiraling blood & treasure. Recurring disease, pandemics, despair. Listening to the sea, is embracing the wisdom of *Prevention Rather than Cure*.

NEX/ECO/H2X/WNX all look to capture & track sustainable paths. Decarbonizing, electrifying everything, low and better-yet, zero-carbon fuels, energy efficiency including in heating & cooling, circular industry. Ideas yet to emerge of particular ecological advantage in Indexing themes. Consider for instance 14 of the most volatile, upside constituents in NEX early 2021; the themes most up over a past 52-weeks to early 2021, hence 14 biggest gainers then.

NEX back in January 2021 was near highs, so we'd avoided looking at a peak time. Instead, here's figures from March 2021 as NEX components in green & innovation equities globally had instead begun steep falls. These % figures moderated a bit by a look on March 3rd amidst then -25% YTD plummet. Nonetheless like ECO's story, where we'd also noted big gains up +1,000% from lows 52 weeks to March 2021 – here NEX worldwide, is what was most up. In these instances of rich gains globally, the 14 NEX components/themes with biggest deltas to March 2021 then showing gains of at least +600% from their 52-week lows were:

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

So 2019 & 2020 saw big gains in EVs, fuel cells, wind, solar - followed no surprise afterwards, by big falls here 2021 & 2022. Falling 2022, as ECO went down to low 80s; it could drop much farther yet! Should future climate bills bigger than 2022 IRA again die – stocks crash, rates rise, pandemic, war, massive power blackouts etc etc - these themes could plummet farther and swiftly so. Outliers may happen too like US Debt default, terrorism, war, pandemics, stock markets crash, CMEs, etc; once-high-fliers can be more seriously hit.

What was special in 2020 about those gainers? For sure, they were remarkably diverse. Some energy innovations scalable to go 'on offense' against climate crisis, like solar & wind. Names upstream in solar then included poly & ingots, wafers and panel manufacturing. Downstream we saw inverters, PV sales, and installation. There was advanced batteries and materials. Plus, highly speculative themes like hydrogen & fuel cells. Biofuels were diverse and present too, given new energy innovation reflects a range of what are today just possibilities.

There's 'defense' too on climate. Smaller steps, extant infrastructure. Capturing methane – otherwise indifferently released to air like to a sewer. 'Renewable natural gas' far from ideal, may turn methane to CO_2 – combusted to less potent greenhouse gas (keeps rock gas going). Or just lower CO_2 - or near-negative-CO_2 renewable aviation fuel, gasoline, diesel.

Past equity gains of 2020 *in no way* foreshadow gains ahead - as was seen 2021. Indeed, big rises may auger sharp falls soon. A regression to mean, but 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 sympathy for jobs in once-magic fossils waning - mean what's bad for fading coal, oil, gas - is bad for humanity. Wiser, to set out for a once-more stable climate asap. Towards broad sunlit uplands, carbon back down under <300 ppm. This choice is seminal.

30 years ago, the paths forward were not as clear. Solar seemed viable, but can it be cheap? Horizontal, or vertical axis wind turbines win in a red in tooth & claw competition? Electric vehicles possible with better batteries, but *when* might that happen? Is green hydrogen *ever* economically viable? Same for fuel cells? All were obvious questions – no obvious answers. Barely imaginable then, possible now are electric jets, green H_2, ammonia, methanol MH_3OH for ships, ultra-deep geothermal; scaling DAC sequestration for inert carbon mineralized rock. So much yet to see in this important decade. All open to debate. Inherently now unknowable. We recall this is rather like was late in the last century, yet only some 30 years ago.

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

Volatility, though, is a differing beast. We can say with great confidence oil & gas prices will move very sizably ahead. Gas/oil/coal may be in long-term decline - yet events happen: lack of supply or storage; accidents, attacks on grid, infrastructure, drought, floods, hot days, bitter cold snaps, even solar weather, EMPs – for big price changes. To not weatherize against extremes in climate crisis = Unpredictability that's predictable, in a sense. Drought too stalks fossils and nuke plants, those all need cooling water. Stratospheric heat in changing climate may occur say one month, a weaker Jet Stream then lets super cold arctic air dip South for freezing infrastructure. Or a slowing Gulf Stream ironically, may mean dramatically cooler Europe on altered weather patterns. In past a stability of both Streams: the Gulf + the Jet, was crucial. Yet less temperature contrast 'twixt poles vs. equator may mean wind droughts. Fossils seem in for long decline – yet we'll certainly see ongoing volatility there too.

Perhaps in a foreshadowing, disaster hit Texas 2021 when a freeze took down its electrical grid. That US blackout showcased too battles now going on in messaging. What will it take to build a stronger, more reliable grid going forward? More gas & nukes? And/or more renewables and storage? Natural gas has long dominated – yet lately find itself at times a bit on back heels. Case in point is that amidst that crisis: the argument was hastily put out even during this blackout that it was due to clean energy, due to Texas wind turbines freezing up! Whether promoted by uninformed, or instead politically motivated opponents – that tale was widely circulated especially on certain media outlets. An image was spread of a helicopter & vat above a frozen wind turbine – claiming that was recent photo of a flailing Texas attempt to use chemicals to unfreeze turbines. They claimed it proof wind alone was the ***main/ 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 many. In fact, it was an old 2013 photo from a Swiss helicopter company demonstrating tests of hot water off a truck boiler (no chemicals) in Sweden – on a turbine lacking the usual de-icing features. That compelling photo shown at a 2015 conference – made for a powerful but fictional 2021 false narrative. The meme shared widely by a publicist, website, & others was memorable, but clearly untrue. Yet it definitely stoked misinformation and was seized on by wind's opponents as 'proof' of wind's failures. The truth in Texas was very different - but it only arrived days/weeks later, after this memorable photo & tall tale were long-played out.

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

A review of just what in fact happened Monday February 15th – Wednesday Feb 17th 2021 is laid out in Texas Monthly (3/3/21). As recounted there, the key problem was loss of a massive and unexpected 20 GW of natural gas-fired electricity power, due to hard freeze. Reasons included: inability of power plants to even obtain gas; some plants that got it weren't winterized to operate in such conditions and gas lines froze. So regardless of how much gas was 'given', much fuel couldn't be utilized, many gas plants couldn't make electric power.

Some power plants couldn't find enough natural gas fuel, at any price, anywhere. While early premature criticisms were leveled against wind energy by the Governor and Texas Railroad Commission – they barked up the wrong tree. And a fascinating image/tale of a helicopter hovering high bestride a frozen wind turbine only confused matters. Made fascinating Kabuki theater, a one-time narrative that let Texas' political opponents rail against clean energy.

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

Relative 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' in a freeze. Even supposedly unflappable current-generation II nuclear, was down roughly like wind – off 0.7 GW. In all, 55% of the *unplanned* capacity outage was due to natural gas. 22% was wind. 18% was coal. Plus, nuke losses. Thus each source of electricity was hit. Truth is wind energy shortages were but a fraction (near the least) of all disruptions in that crisis freeze over 3 vexing days.

The 1 key shortfall was natural gas. It suddenly fell short hugely 20 GW less than expected – for a gap 16 GW lower than lowest-end case models by ERCOT. How/Why? Texas is a global hub for shale gas drilling! But as temperatures froze, about a third of its own gas production simply 'froze off' Normally it's a warm, oft hot place; much equipment left unweatherized, so tanks that can divert oil from water, from gas in freezes, 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 losses elsewhere. As laid out in that article, many gas producers did Not financially benefit. They simply didn't have the product to sell in this acute shortage. Worse, some couldn't even meet their own contractual gas obligations for volumes promised. So 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 may sell product at around $2.50 per million British Thermal Units (BTUs). Contractually obligated to supply gas which they couldn't then, instead some had to buy (to provide elsewhere) at ridiculous prices like $200/BTU. On the 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 a super-gas-abundant Texas(!) suddenly went to $1,000.

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

Power producers needing the 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 are in one penny amounts; instead, they were dealing then in gaps of $50 & $100 'deltas' in gas prices.

In retrospect, for understanding how to do better, lessons must be drawn. Lesson 1 is that *more* natural gas would have solved nothing. But *winterizing - or better yet *weathering for Cold – and for Summers too in key gas facilities & infrastructure can make a difference. Texas has a long history preferring 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, surprisingly are not always the cheapest.

So, 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 needs to be winterized. There are 100,000 Permian Basin wells, 250,000 are active in State; many just marginal of little consequence. Hence there needs to be some balancing. Or, the State could continue being fully hands-off, like before (with blackout risks/consequences).

More *storage* has been suggested, but of *natural gas*. In Texas' crisis, *gas Storage* was one Hero. It didn't freeze like gas *production*. Another idea, *winterize key power plants. A multi-billion-dollar nuclear plant went down on pump freezing, cheap to prevent in first place, a no-brainer to fix. Ensure *critical infrastructure gets power in crisis. Yet, harder to protect against is drought. Big thermal plants: coal, gas, nukes, all may *have to* be shut on low water – not only hydropower. In Texas, in Arizona and all the West, drought has been 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 small loss of wind! Wind turbines can readily be winterized; adds 10% to turbine costs but is done round the world. Wind works in Arctic, in US Upper Midwest, places 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 were for wind!). After Texas' freeze it later came to light a blitz campaign was fast mounted to call renewables 'unreliable' – and to deem the fossils as 'reliable energy'. Even though natural *gas was the most responsible*.

Texas' disaster, bad as it was, was minutes away from far worse - if frequency stability were lost. It fell from 60 hertz – to a critical 59.25 – nearly crashing the whole system. Had grid transformers caught fire, or high voltage lines been destroyed, it could be weeks, months - not days without power! We don't realize how dependent we are on electricity 'til it's gone'. Only by shedding 7,500 MW of demand (effectively turned off ~1 in every 8 homes in State), were they able to take a first emergency step. That was twice a 2011 emergency shed that had lasted 8 hours, 4x longer than a blackout of 2006. There were 3 emergency load sheds/ rolling blackouts – and still crucial frequency stability had nearly been lost in 2021.

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

Perhaps 'Climate Change' or 'Global Warming', are too benign for what may be calamity. Better might be 'Climate Crisis', or 'Global Heating', even 'Global Weirding' for decades, and centuries and more of a blazing Planet. Perhaps uninhabitable equator, yet its temps not too far different at 'Hot Poles'. Getting there may not even be slow, or incremental. Maybe not a linear, pleasant, 'nice' warming along the way, with gradual gentle changes only.

Slowing Gulf Stream *could* paradoxically mean say, bitter cold. Trace a finger on a globe from lovely Britain/North Europe, westward or eastward. Quickly is frozen, barren away from North Atlantic waters warmed by a Gulf Stream. Should non-linear global heating cause warming Gulf Stream to slow, or cease, changes may alter much we know today. Science is unsure: might it mean cooling? or warming? But the most unlikely, would be no change at all! So more Solar, Wind + Storing clean electricity is needed. Making electricity cheaper with renewables + new green storage is where we must focus and grow. Can be done in myriad ways, but *more renewables, storage, & transmission* is where attention now ought be turning.

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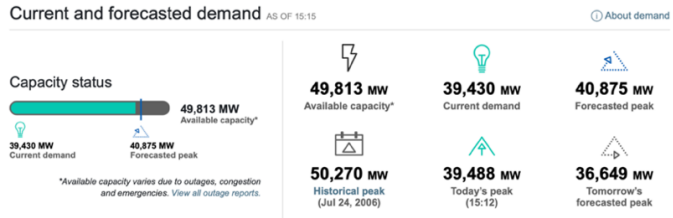
16 months later in Summer 2022 and despite anti-renewables rhetoric from some Texas politicians – ironically it was saved thanks to its fast-growing renewables. Amid record heat, a record 75 GWs(!) demand, its wind/solar had generated 27+ GWs, met near 40% of demand! Plus, kept electricity prices cheaper than would be on gas & coal-fired power. Over 2021, zero-carbon power in Texas (including nuclear) made 38% - nearing its 42% made from gas.

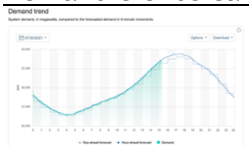
Yet grids in Texas – and so many places are exposed. In July 2022 Texas teetered on edge of new record Demand, nearly 80 GW in total. An attack ahead on grid hardware, or cyberattack on grid software could confound keeping grid stable above critical 59.3 hertz. If its grid goes fully down, then 'black start' may be needed – whether that can be done in 'just 1 week' is unknown. So besides cold/heat, we face aged exposed grids. In sum look forward and more green energy, more storage, along with better transmission needed to decentralize the grid. We fundamentally need a better, greener, modern, stable and more resilient grid, fast.

Texas' situation is roughly similar to California. Energy Demand in California is less – as a less-industrialized State, but renewables generally only met around 35%-45% of demand typically (while 40% was new high for Texas). To ipicture California, consider 2 separate Summer days: July 2021 – and a year later September 2022 on 2 extreme heat/electric grid blackout scares in California. In a sense, both were 'expectedly' hot days – seen next July 30, 2021, and Sept 5, 2022, when the State's grid was in peril. As it looked then, all available power sources were generating first in 2021, roughly 50 GW (or 49,813 MW) of electricity. Demand was forecast to peak on that day 2021 at about 40 GW (39,488 MW). But peril was closer than it sounds, for any US balancing authority must keep at least >6% contingency reserves:



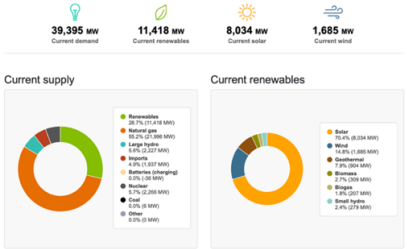
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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



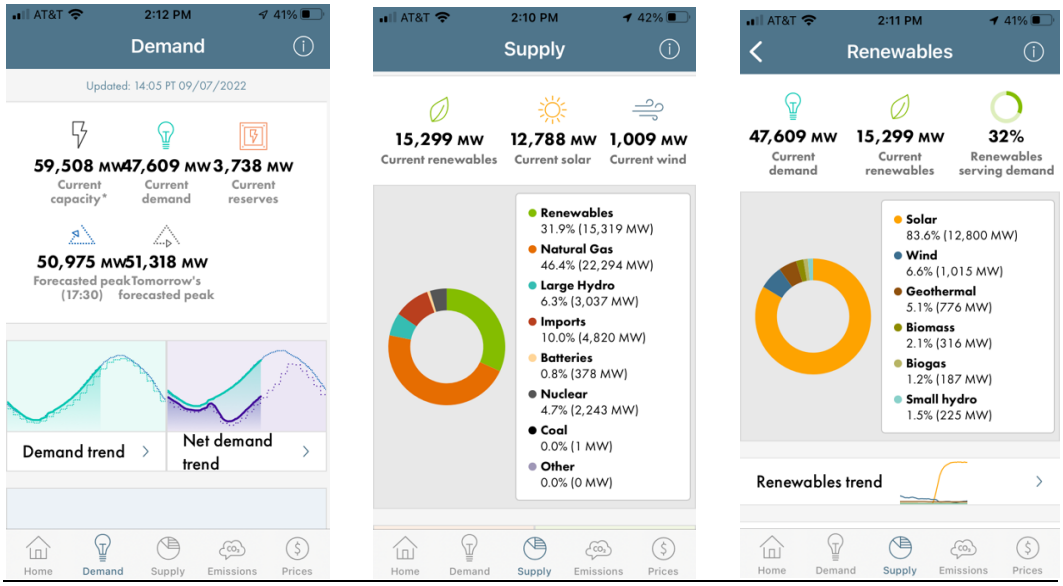
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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



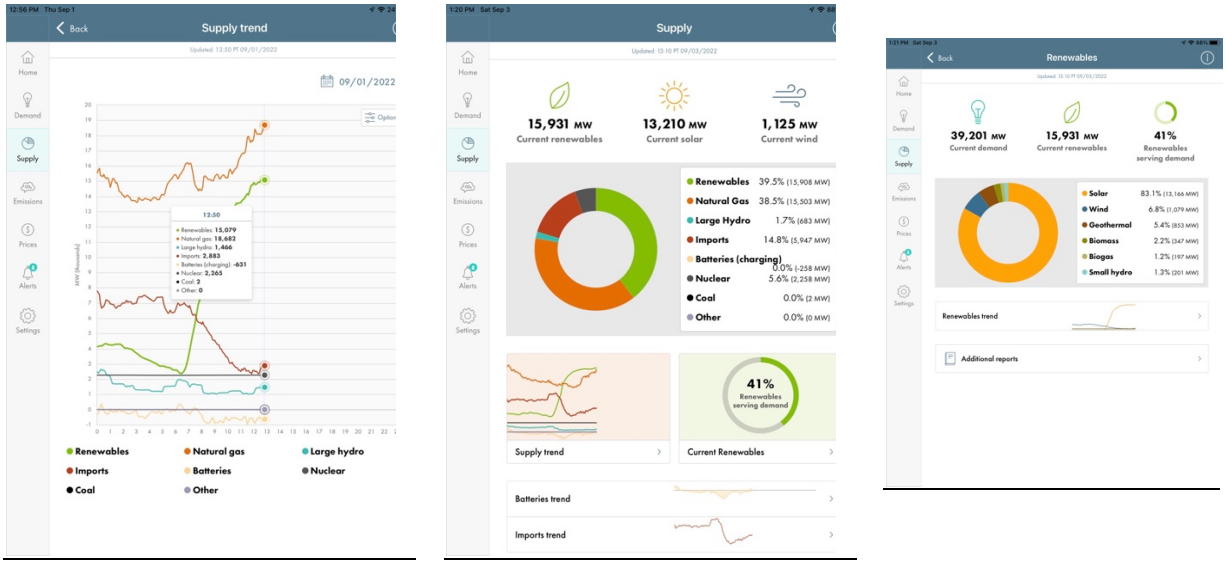
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

1 year later, Sept. 2022 was extreme heat very near blackouts, again, energy producing flat-out (no maintenance), as the State maxed out higher by making 59 GW (threw everything at it but kitchen sink). Peak Demand was higher too than in 2021, here a record 52 GW next day (51,318 GW, seen at left). To meet it, Renewables (middle) maxed at 15 GW for 32%. Renewables mostly then just solar at 2 pm (about 13 GW for some 84% of all renewables):



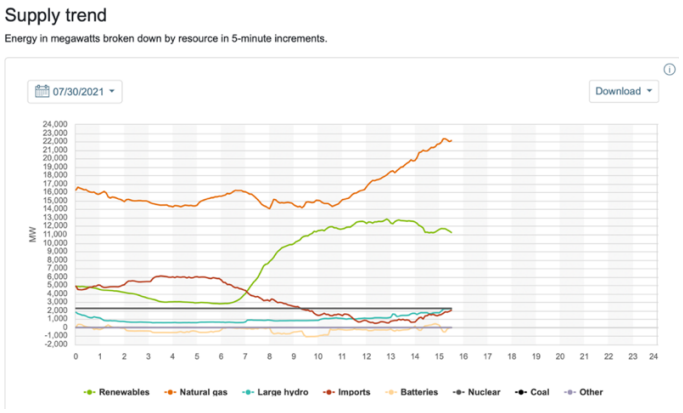
Source: CAISO.com Today's Outlook - On Sept. 7, 2022 at approximately 2 p.m.

In above heat wave, wee wisps of wind a blazing summer day made just 1 GW (7%); geothermal was <1 GW & only met 5%. Thus, renewables NOT Where they Needed To Be! One sees below, Demand ramped fast from 8 am, Solar (left, **green**) to 15 GW nicely coincided with start of day demand. But total Demand ramped faster, so Natural Gas made up 18 GW. Together they meant Imports (in regionwide demand) dropped to 3 GW; current-generation nuclear was firm but not nimble, fixed, costly, here a staid 2.3 GW (some 5%-6%). With an entire Western US maxed out under a heat dome, California just barely avoided dread blackouts Sept 2022.



Source: CAISO.com Today's Outlook -

Putting it all together, one saw on a hot, yet rather expected summer day in 2022 (middle, above), that Renewables served just 41% of California Demand. Far too low, in a changing climate. Yet great news, is renewables are eminently scalable. Grow solar by a doable 5-fold quickly, so that solar (at right, above) making 13 GW (13,166 MW) – becomes instead solar at 65 GW. True, demand will expand too – so grow firm geothermal too by many, many fold. Wind Energy is oft strongest at night, so grow it 5x. Globally, 94 GW of wind added 2021 had brought world wind capacity to 837 GW; in California new offshore wind should grow many-fold, fast. Couple with new green storage growing fast for nights/and windless days; we can meet all California demand. All this with a modern grid, importing from the deserts sun & Midwest's windy plains. Green electrons, 100% renewables+storage just makes sense. Ponder how supply arcs in green, daily, well-understood to end with expected solar issue: Sunset:



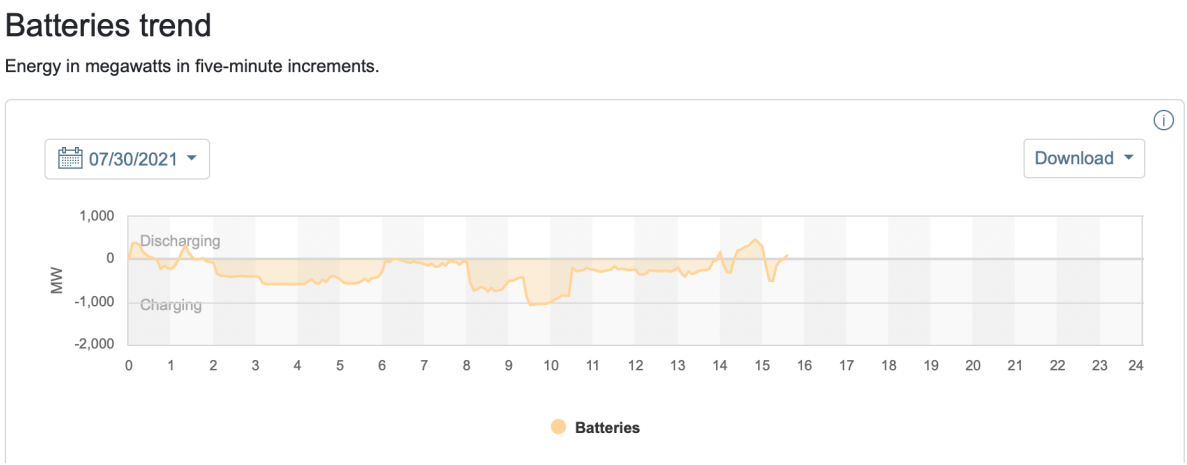
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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

What's key going forward to 'fix' this, is to Not revert to more fossils. Not to more natural gas: especially after we saw 2022 both the impacts of fast-changing climate - and gas used as a weapon. Oil/gas prices are set globally; America's fracking can make much oil/gas – yet is not a low-cost saviour: gas scarcity elsewhere makes prices jump everywhere. In 2022, Europe looked at capping prices fetched by zero-carbon wind & solar; the reasoning was their costs beautifully stayed levels, while all other/fossil energy costs skyrocketed. Meant wind/solar producers derived far more net profit per kilowatt/hour – though they didn't 'deserve it'. Unsaid, the story underneath it all, was how superior the renewables can be vs. fossils.

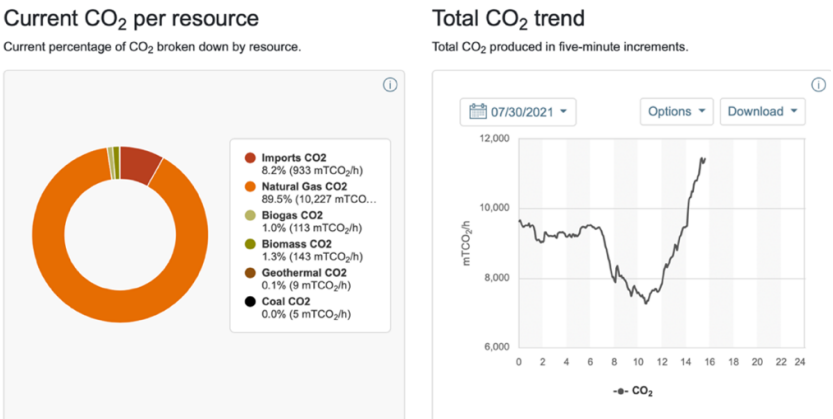
Fast-scaling renewables is the more-favourable path. But not perfect. Drought in a changing climate can kill big hydro. New wind patterns can be tough for wind energy. But distributed generation like new infill solar on rooftops and homes etc – doesn't even show up in attractive figures above for Utility-scale renewables. This Report has been written in a building where 2 solar PV systems fully power 4 electric cars (no gasoline/petrol at all). Solar powers all the cooling - and heating - by heat pump/mini-split AC system. Electricity is from solar; hot water as well, from a large passive hot water tank on rooftop. All this with a big battery backup – linked to solar. When blackouts occur, or gasoline prices spike, we're blissfully unawares. Repeat this, millions of times over, especially as for 20 years it has Saved us $$$!

Back to the grid, and how millions of regular, homes are now being powered in the US. Most folks are Not backed up by such individual, costly home batteries, there's little resilience. In theory one might think much energy storage must exist throughout grid; that it would/should kick in fast as sun begins to set. After all that's an infinitely predictable happening every day! To foreseeably make up for lost solar after sunset, the grid could store excess green power during the day, to replace 100% the GWs once from natural gas. But ... reality 2022 was energy storage was almost entirely… non-existent. Batteries did help in puny temporal ways - delivering bits from renewable power at times - and then only for brief time gaps to 4 hours. Hence this keen need now in 2020s for Vastly More Storage – and more/better Grid transmission to help spatial ways too given frequent far-off winds. Batteries could become heroes, but they show below a meager 1 GW at play pre-2022 – when we really needed 50x that – 50 GWs+ (50,000+ MW) storage! Shows as negative this day (a bit of charging) – only scant power thus available soon, when the sun (no surprise!) goes down for discharging:



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

Wickedly Insufficient, poor storage early 2020's meant we go on suffering ongoing dependence on fossils. So needing natural gas like in California, Texas and US, Europe, Asia etc etc – huge carbon emissions. Big hydro can't scale; indeed, once-great reservoirs Lake Powell, and Mead may become dead pools. Natural gas isn't quite as awful as coal's CO_2 per MWh, but its methane leaks are badly vexing Earth nonetheless. We *know* its *measured* CO_2 is a big issue – while unmeasured methane leaks make it a climate killer given methane is potent GHG.



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

Insufficient Electricity Supply, Now is A Given, on hottest days say in wealthy Texas, California, now much of Europe. Even in a once-hydroelectric-rich Sichuan China. A game of catch as catch can, blackouts threatening, pollution left to go up wildly on hot days. There's been No solution! It has been left to hopes, as was seen Hot days in 2021 and 2022, when California's Governor had to give an Emergency Proclamation to shed load – and upping generating capacity. Shed 3 GW of power to industrial customers, who'd thus lost their power but were paid handsomely. Dirtier backup generators could be used freely. Ships were allowed to burn dirtiest fuels in port, rather than use far cleaner shore electricity. Ugh.

It gets worse. California grid issues include that in Flex Alert, CO_2 Emissions can spike to get Supply high as possible, now over >50 GWs. Gas peakers flat-out 100% and no maintenance, with imports needed from out of State. Demand in a very foreseeable Heat Wave like eg in Sept. 2020 had outstripped State capacity. **So** California's Demand shows there's need right now for far more Renewables – and Batteries/Storage to grow fast. Given efficiency strides made, look to supply. Yes, California is ever-adding (yay!) more electric vehicles – those will charge at night, leveling out Demand (so not the threat some might worry about). But in less than 7 years to 2030, that one lone (2nd gen) nuclear plant making 2.3 GW will close; that will mean a big 5% loss soon in firm generating capacity. Blackouts sure are ever-looming.

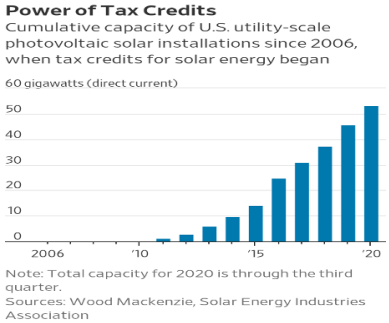
The State is breaking out band-aids. Importing electrons from power elsewhere in the West, even in times of regionwide need. Imported power that may be generated by dirty sources – coal, gas, or costly 2nd gen nuclear hit by cooling issues, all suffering more so than renewables from heat waves. Droughts with lack of water for cooling, a growing threat. As Texas showed in 2021, Cold too can knock back all fossils & nukes. And the grid can be knocked out, by a deliberate attack – or nature. Hence what will help: new grid with links to windier Midwest that profitably exports its bounty to California, Texas etc. A modern, resilient grid, one better protected from wildfires, and making more electrons available. All with more storage + resilience in the 2020s. Especially as droughts loom over hydropower, gas, nukes, coal plants! Global changes will hit our planet with new extremes. Smaller are exo-planetary risks too; CMEs (like a Carrington event) all mean look to renewables+storage+resilient grid!

In sum, war in 2022 complicated all, for energy prices are set globally. As Europe scrambled sans Russian gas, it paid record high prices for gas from elsewhere than Russia. Costlier gas for India, Pakistan, etc who all paid 'discounted' but high prices. They in turn burn more coal oil (and that 'discounted' Russian gas). All threatened by cold winters, hot summers 2023, 2024 2025 etc. More gas is no answer; takes many years to build terminals for LNG – years too for renewables, yet they solve much. Crises may possibly stretch over this-whole-decade.

Used to be, proponents of US natural gas pointed to it as energy saviour for America. But what they didn't understand, was gas crisis in distant Europe - raises prices worldwide. Fracking in an American interior can't prevent a spiking of prices in US. Take say, Sept. 2022: US natural gas already had more than doubled that year – hitting utilities hard. US electricity nationally Fall 2022 averaged near 15 cents/kWh, up 7.5% over year earlier. The CPI for electricity costs was up a big 16% over a year prior; largest spike since 1981. In some regions was much worse. In parts of New England, residential electricity went from 10.67 cents to 22.57 cents/kWh. Due to gas, that utility's wholesale costs tripled since 2020, to $130 per megawatt-hour. And Winter is coming. Renewables, can be far less costly! Recall the Bidding's cleared prices in UK, in £GBP/MWh 2022: offshore wind 37.35 pounds; onshore wind 42.47; solar 45.99. How better!! So on war, weaponized gas became a new Achilles Heal, worldwide. But take-away, is it doesn't need to be this way – not a reliance on gas, nor China for minerals.

That 1 Senator who shaped the IRA in 2022, had strong thoughts on moving sourcing & processing of vital minerals to the US, building green industries at home. Like energy storage (now vital) – it's a theme that China especially, yet even lugubrious Europe has led on. That Senator thus wanted a new pro-US trajectory: mine & process here; the IRA reflect that. It gave a 30% tax credit for stand alone energy storage (had needed to be coupled to solar, so in 2021 fully 93% of storage was tied to solar). Developers could now benefit from extra 10% ITC if 40% or more of components were made in US. Another 10% if located in areas once heavily in coal, oil, gas. All that was foreseen in previous draft bills. But now with the 2022 IRA incentives, key minerals should also begin to be sourced in US. Biggest US EV maker may be expected to soon build US plants for processing lithium (even if its mined elsewhere).

This took a page partly out of solar's handbook, which grew 10,000% since 2006 thanks partly to tax credits. Tax credits, once crucial to solar – can help grow storage, batteries, grid per an IRA of 2022. True an earlier bigger 'omnibus' BBB bill over $ trillion had failed. But some language carried over from BBB. Solar had once needed both ever-cheaper panels & favorable (tax) policies to light a fuse, prime a pump. Both. This chart shows how fast solar grew after, thanks much to tax credits available post-2006. Solar stands better on its own now – but like all else in energy, earlier tax policies for solar had once greatly mattered:



Sources: Wood McKenzie & SEIA

Storage credits that previously needed links to solar, were of little help. With the 2022 IRA, it unleash storage alone, much can change. In 2020 there were just puny megawatts (MWs) of deployed storage in the US – while hundreds, thousands of gigawatts (GWs) were/are needed. No doubt storage will scale more speedily post-IRA. Repeat for batteries & storage - what recently happened in fast-growing solar and it can be of great benefit to, and for, all.

Just one upstream example is tax policy may help to bring about a moderately greener 'lower-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, needs no sulfur. Co-locate battery/EV makers – like poly plants+solar PV makers - decarbonizing one organizing principle; that can build lower-costs and efficiency. Ever better, is a circular economy with new zero-CO_2 solutions.

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

Last Few Years … a useful non-Correlation of our Indexes to old Fossil Energy

ECO/NEX plus H2X/WNX themes have shown good non-Correlation vs fossil energy. What an example of diversification! There's been robust differences: sometimes, clean alone gained. Sometimes clean has fallen hard - as dirty fossils were up like in 2021/1H 2022! Yes, all themes are *energy* – yet clean has marched to pretty distinct different drummer vs. coal, oil, gas. Take say, a 2020 vantagepoint and look back in time from there: an interesting thing had happened. Dirty energy in years to 2020, was THE worst performing sector of S&P500 in 4 of prior 6 years; it was down -30% in 2020 as clean energy roared. (In S&P500, 'energy' mainly is still fossil fuels). In sharp turnaround, fossils jumped 2021 after long doldrums. Still, last few years were remarkable for all energy, so look a bit more deeply starting in 2020.

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

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

Drilling deeper let's consider US oil & gas behemoth Exxon. In 2020 the Dow Jones announced it was dropping Exxon from its leading 30-stock Dow basket. Why? Apple was splitting 4-1, and the price-weighted Dow needed new component/s to better keep up with other baskets. (Dow had sizably lagged in its performance then). New representation was chosen - but wasn't from the fossils. Instead, they added in 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. (That was due to a prior decade perhaps when dirty energy fell – yet it would rise big 2021/2022; indeed energy became a bigger slice of S&P500 after 9 of its 11 sectors fell, and energy gained +14.3% in eg Sept 2021. In retrospect then, they maybe should have kept in the fossil fuels – which really jumped up 2021 and 2022).

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's Dept. of Labor on ERISA law had wanted to know if there were 'discernable trends' in how retirement funds were invested in energy (FAB 2018-1). There'd been sizable outflows out of fossils – and into sustainable energy themes. It's been reported fossils industry & climate skeptics were an impetus in 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 moved in 2021 away from such aims and even explicitly pointed towards newer green themes as important. Still, it's useful to recall how a stealthy attack from the top, had recently had occurred (and failed) against clean energy in 2018-2020.

Real-world Returns for clean energy in a 2018-2020 period, up hundreds of percent, are hardly 'non-pecuniary'! Within that clean was up +300% (ECO)! - while traditional Indexes were up a more modest +85% (Nasdaq), +40% (S&P500), +25% (Dow). And fossils, oil & natural gas were then *Down* some -60% - although they'd soon spike hard up 2021 & 2022. Interestingly fossils AND clean energy both non-correlated vs broad Indexes last decade. Thus, maybe was No surprise at all to see billions of dollars flowing into ESG, breaking records. ESG assets 2020 more than 2x in 2019, & $246 billion early 2021. Q1 2021 inflows at $55 billion, vs. $41 billion in Q1 2020. Assets in ETFs/ETPs topped $6 Trillion for first-time in 2021. As ESG in particular may grow, it will be surely very volatile, oft down. And yet. Attention to climate (IB 2015) not long ago fell under unworthy Federal attack 2018-2020 reportedly by fossil interests and skeptics under ERISA. 2022. It resumed at a State level 2022 when Texas moved to divest from funds 'boycotting' oil – even for funds with clean/new energy in their name (like NEX)!

In sum if proposed rules 2018-2020, then Texas 2022, sought to prevent a look at climate, as deemed 'non-pecuniary', then that's a bit curious given glaring Performance facts:

2018-2020, Clean/Climate theme (at top) - Left the Traditional Fossils far behind:

Source: finance.yahoo.com

The period 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 crashes in clean like 2021/2022 lay ahead. Yet in 2021 China aimed to go from 11% solar/wind power generation – to 16% by 2025. Wind developers jumped then on soon-expiring subsidies – they installed 72 GW of wind in 2020, 3x that of 2019 (solar up 60%). But because that government's fund for subsidies early 2021 hit cumulative 320 Billion yuan (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 after once that proposal was dropped. Regardless of for sure the drops to come, ongoing volatility, decarbonization has begun to figure in with good reason, even though 2022 supply chains vexed globally.

In a 2021 and 2022 smitten by diseases, wildfires, temperature extremes and blackouts, we increasingly saw mounting evidence that the economy is a wholly owned subsidiary of the environment. Yet, to just notice the fact of climate crisis, doesn't mean smooth sailing; no nation has risen to the occasion. And for a host of reasons, volatile risky ECO, NEX, H2X, WNX will all fall at times, *very hard!* Take one item getting new attention: US batteries & metals production – where China clearly is 'eating our lunch'… well, not just beating the US, but also all would-be competitors worldwide. Europe is lately ramping. Yet a question is, whether US industry in battery & minerals production ramps up fast, so it can begin to better compete in the 2020s. Having fallen so very badly behind over many years and decades.

One big problem 2022, was the US lagged behind badly in lithium, nickel etc for batteries. In producing rare earth minerals that in fact aren't very rare, yet needed in motors, turbines & for 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 is critical for batteries, electric cars, grid; yet 2022 it spiked on a short squeeze from $20k - to $100k/ton. It is a problem the 2022 IRA seeks to address, but doubtful the US can move fast enough.

This 'ain't our first Rodeo' seeing US fall badly behind, when it needn't have. We saw solar manufacturing decamp too from Japan/US/Germany – to China 2 decades ago - then cheaper Vietnam, Malaysia, Thailand. By 2020, the 3 biggest PV makers were based in China (PV on those economics was made by only a very few very tiny US firms). To be overtaken is an issue seemingly happening again in crucial batteries. Such needn't occur. But the US in 2021 had only 3 big battery factories. Tesla's Gigafactories could point a way, yet we might see, say, only 10 big battery factories in the US in 2030. There should be many more. And a term 'US factories' includes S. Korean etc-owned factories, just merely built within the US.

By 2030, so less than 10 years, China is smartly on track for 140 big battery factories! Europe looks to have 17 big factories. On projected US electric vehicle demand, there should be 20+ US battery factories 2030. Not inspiring that 2021, saw only half that, 10 – on track. To be up & running say by 2026, such factories should already have been in initial planning back in 2021, with construction having started 2023. Here too, the IRA in 2022 aimed for better.

All underlined need to act pre-2025 to *Cut CO_2 emissions - yet the world failed badly. US is clearly far behind China, even behind a more committed Europe. If the US has as is expected 200+ electric & hybrid car models in 2024, it should also be producing far more needed, rare earths minerals for motors. Rare earths are needed in quantity for wind turbines too. Lithium for batteries is a different beast; rather abundant in Earth's crust it's not to be confused with rare earths (also, not so rare). Differing rare earths are necessary eg for magnets to generate electricity from spinning wind turbine blades. Or to take amps of (clean) electricity & convert that into lovely electro-motive power pushing new EVs, fast aircraft, ships at sea etc.

As said by Mr. Nikola Tesla regarding his & later amazing inventions that would become potent magnets, wind turbines, AC electric motors, *"I would not give my rotating field discovery for a thousand inventions, however valuable… A thousand years hence, the telephone and the motion picture camera may be obsolete, but the principle of the rotating magnetic field will remain a vital, living thing for all time to come."* Unlike pedestrian, electric parlour tricks by comparison, the rotating fields exhibited by rare earths are awesome, making possible unmatched blue-sky advances. Like batteries that need lithium, or even basic iron, so too do clean energy's applied technologies especially need rare earths to work their magic.

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

Sens. Manchin, Capito, Murkowski wrote bills to get rare earths from coal wastes of which they've got rather a lot. So wasn't a surprise to see echoes in the IRA of 2022. Studies have shown vast greenhouse gas methane is coming now from Appalachia's old coal mine regions. In places unemployment is high like coal country, arguably special attention should be given to local jobs in minerals. Legislation prior to (passed 2022) IRA, considered 2021 incentives for domestic US solar & semiconductor manufacturing, a proposed LIFT America Act to include domestic battery-making incentives and support for US critical supply chains. Given how far ahead China is already, how fast Europe now is moving too it's doubtful the US can get to what's needed fast enough in producing minerals, rare earths, batteries without a huge push. IRA is a start. But sadly, US will stay dependent near-term on imported strategically-vital materials. Often buying them from more ambitious (and at times goals-conflicted) China.

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

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

Yet IEA criticized too rich nations for so much in cumulative emissions, & puny Pledges nowhere close to what's needed for a 2 degrees goal. Calling them out it stated: "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 typically for vague pledges by corporations combined often with very distant target dates.

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

Change is afoot. In 2020 an oil tracker did crash -70% *down* as oil fell, rebounding strongly of course 2021/2022. A few words about that oil index. Quite unlike ECO/NEX/H2X/WNX, that oil Index was instead based on a commodity - rather than equities. 'Worse' it was based on the 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' into contango 2020, at near tank tops, limited storage tanks, that oil index went down very fast - unlike further out 12 months Oil Futures. It's been amply shown there's a floor beneath which oil prices cannot easily fall – unlike solar or wind power.

We'll discuss it ahead, but a point is, oil's crash in 2020 *was a crisis* for it. Until an oil rebound, only then could prior production levels be restored. By contrast, green themes like solar/wind - can & do move very differently. Clean's future is thankfully different too. Key drivers differ in green energy, amid some consolidation. 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 made panels, and installed/serviced them too. Split by a spin and newly specialized, the parent refocused downstream on selling PV/storage in North America. That's a big market with thin margins: storage allows it premium branding and can get bigger. It's is in-country work that can't be outsourced nor done overseas by cheap commodity competitors elsewhere. While there was rising PV inflation both in 2021 and 2022, longer-term, solar PV should once again see *declining* prices.

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

Upstream, that spinoff premium PV maker in 2021 enjoyed China patent protection & pricing power (2-4 cents/Watt commercial, ~4-8 c/W residential). But margin pressures are unrelenting; it shipped cells rather than panels to shave costs. There's a commoditization across PV upstream ('just get good panels, least cost') as module pricing was down ~80%, in 2012-2020. Module capacity rose, then was hit. Downstream, efficient premium back contact panels may help hurdle razor thin margins. 2021 module prices were near $0.20/watt on price inflation - and spikes *may* subside. It will be interesting to see how performances of two solar 'cousins' unfolds. In 2022 their mutual exclusivity softened, one as a 'new' premium solar product maker – and the other now separately focused on PV solar sales & installs.

Roller-coaster recent past, exhausting & thrilling. Stock chart remarkable; little like it. ECO Reports now 100+ pages. Overshadowing much was a pandemic, now endemic. Job losses. A Great Lockdown. Many markets cratered – may do so again ahead. Oil imploded to places not seen in 100 years, then bounced back hard. Attention to climate and clean energy solutions that was briefly derailed by pandemic – resurged especially 2022 on war and new weather extremes. Fresh action from Europe too, to also get past depending on Russian fossil gas.

Moving on let's consider past 5 years. Here, fossil fuels stand out for a long decline - then rocketing up in 2021/2022. Until a few years ago, an ECO picture past 5-years in-2010s, was generally *down*. Breaking that at end of 2019, ECO (alone) had left a long spell of negative past 5 years. At first clean energy alone was positive, returning +50%. By end of 2020, past 5 years became a striking divergence: clean alone was then up +300% as green jumped – while fossil themes were down -30% to -70%. 1H 2022, as dirty had shot up, clean was far down.

At any rate 5 years captures a small sliver of time. Corrections happen, trees don't grow to the sky. Clean, once well *down* for past 5 years in prior Reports early-2010s, had shifted. After a once monolithic early 2010s of 'All energy far down', following that clean had changed in 2020 - by a lot. Clean was up 6-fold in the 1st year of this decade, 2020. Then clean plunged early on in 2021, as fossils enthusiastically instead jumped. Despite all the gains in dirty, for a Past 5 years to 2021 or 2022 - dirty was only back near nil, and still far below clean.

In this 5-years Chart to mid Q3 2022, below, clean ECO/NEX have left down 2014-2016 period. In big Positive up years 2019/2020, with gains in clean in absolute ways – plus huge wins relative to major Indexes too. With clean ECO briefly up +500%, it had left major Indexes 'in the dust' even with 2021/1H 22 falls. Past 5 years shows ECO tracker is strongest of all up +145%; global NEX is up +83%. Performance by a best major Index 'bogey', NASDAQ has tied NEX; the S&P500, and an all country world basket are just half that or less. Normally, up +50% in 5 years is bit of a 'Win' so absolutely, the 3 big bogeys, especially NASDAQ did well. Just relative to clean themes ECO/NEX, did Dow and S&P500 flail – with one able to tie NEX. Farthest at bottom, are fossil oil & gas themes, underwater, or just barely positive.

ECO/NEX trackers vs. fossil fuels themes & major Indexes, Past 5 years from Sept 2017 to start of Sept 2022. Once a past 5 years was 'tough' for All energy; now it's Differentiated - and Clean ECO/NEX at top move far differently vs. traditional & fossil Indexes:

Source: finance.yahoo.com

Clean energy certainly plunges at times. For sure when the broader markets are declining – and/or when clean energy more narrowly is declining too such as on fears of inflations, or of recession, or supply-chain bottlenecks and more – one should that ECO, NEX, H2X, WNX themes having many smaller pure play, risky volatile components – with fall more than clean energy competitors, too. Times too like late 2022 as threats of nuclear weapons over losses in Ukraine, had put the world on edge; all these can be very strong headwinds for volatile smaller caps found here. Plus, after tremendous gains in 2019 & 2020, drops in 2021 & 2022 weren't so surprising. On the other hand, jumps/gains in our themes may at times outpace other Indexes, by going up more. Consider August 2020 as Dow gained +7% in its 7th best August since 1984; an S&P500 was up +7%, its 8th best August since 1986. Meanwhile same month ECO was up August by +20%, NEX was up +15% (nor were these greatest monthly gains that year: November then Dec. 2020 saw larger ECO gains, before Feb. 2021 peak- and plummet).

Next page is a past 10 years rolling, again still positive for clean. Until recently, clean's 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 having left the steep declines long ago in early 2010s. Those were final legs of steep renewables plunge; including any bit of that in 10 years, since, would bend performance downwards. In sum clean energy at times can relatively outperform vs. dirty - but obviously it Did Not 2021/2022! Still, the plunges warrant ongoing attention. Thus, next is a rolling chart for the rough past 10 years, 2012 - to 2022. For a change of view too, in place of a broader S&P500, Dow, and an all country world theme – there is instead an active managed alternative energy theme, and a passive solar-only theme.

Here interestingly, for past 10 years, now a passive excellent solar-only theme is far at top: up some +393%(!). And the passive *Global* NEX tracker is still well up 2nd most at about +193%. While ECO is 3rd best up +161% - that's after falling greatly 2021 & 2022 and that has allowed an active-managed alternative energy fund that for years had gotten beaten badly by ECO – to at least close in a bit on passive ECO this time window – though still trails ECO at +140%. The Dow Jones trails all the names above, falling just below active alternative energy.

This period leaves behind a Great Recession that thunderously dropped all 2008-2012, that had put in bottoms at many tech stories, some moving well up after. But not so for energy, which got hit harder, stayed down longer. Especially as seen here in the dirty energy themes, falling terribly. So much energy went on falling the 2010s, no immediate rebounding up.

Rolling Past 10 Years from start of Sept. 2012 to the start of Sept 2022:

Source: yahoofinance.com

Harder to see for being so far down, underwater and rather absurdly far down over the past 10 years - are oil and gas in orange and yellow. They are down here around -60% and 70%! Of course, they would jump later, in 2021 and 2022. But put in context here of past 10 years, that did not make up for an arduous, prolonged decline they've suffered for a decade!

2 other major broader Indexes – S&P500, and an all country world theme are removed here as noted for better visual clarity (keeping just Dow). As we see, all 2010-2019 was tough for energy: an independent ECO tracker at start of 2010 was 55: it ended 2019 at 34 so down. An independent global NEX tracker in 2010 was at 16: it ended 2019 at 14 so down. Tough for dirty energy; and true clean energy. Tough too, for global 'cleanish' energy, shown next.

Notably, clean has starting to do well, even 'best' here from 2020. Solar-alone, and clean new energy innovation NEX are the most positive of these 5 themes last 10 years, up near +400% and near +200%. NEX light blue, and excellent solar-only basket in green rise above. ECO in darker blue fell of late – but still well up – is an active alternative energy. All good – versus fossils! A tale of 2 cities for Past 10 Years: there were first Big Declines in Dirty energy – vs Clean all Well-Up to varied degrees. Until of course, 2021/2022 gains in both oil & gas - as clean then plummeted - that *might, possibly* begin a new narrative. Gains for clean could all evaporate tomorrow! As time rolls on, earlier tough years for green Indexes *may* begin telling a new story. As shown next, just how a theme like NEX captures global new energy, the theme's very definition, is no backroom matter; it's very consequential.

NEX: the 1st Global Clean Energy Index – vs. a younger narrow not-as-clean theme:

Consider next key differences between our Global NEX with its trackers in US & Europe – vs. a differing, younger other global 'cleanish' energy Index with trackers too in US and Europe. That other global Index has several characteristics that have set it well apart from NEX. One long had been that other Index was maybe a fine choice if wanted a very concentrated basket made of biggest caps only, narrowly with little/no energy storage, nor electric vehicles, green H_2 etc. Because that other basket was highly concentrated, skewed, plus not-as-clean - it has differed much from NEX that's instead clean and with diverse with solar, wind, EVs, energy storage, hydrogen, decarbonization etc. There's also several more contrasts too.

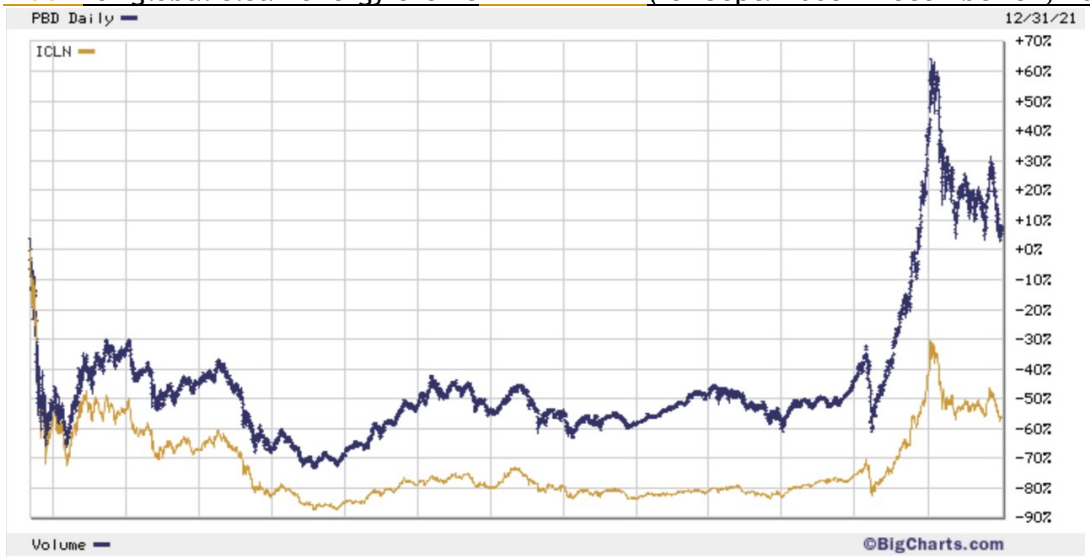
For example, the NEX is clearly clean: it has a rating for low & zero-carbon that's far better, more deeply green – than that other 'cleanish' Index. NEX also steeped in diverse new energy innovation – so it's unlike old GICS (Global Industry Classification System) 1999 nomenclature that puts the other global basket heavily in brown, what GICS calls power "Utilities". If one had aimed for not-so-clean, narrowly concentrated, liquid other theme of biggest names, little in new energy storage, or EVs – then that other basket was maybe a fine choice.

Yet consider too, their most key divergence has been: Performance. Briefer periods, NEX vs. other Index traded leadership back & forth a bit. Shorter-time-horizons, one Index might lag the other either way. Brief time frames only, has mostly been a wash, no clear leader.

But most longer periods, this key fact stands out: **Global NEX (seen here in bold)** has well Outperformed that other Index, that's also for global clean energy **(seen here in brown).** This is for the 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 live trackers for over 13 years, Sept. 2008 - to end of December 2021. It's interesting to see how divergent their performances are for the two Indexes/ in tracker funds. *In sum the **global NEX tracker (bold)** clearly has had far, 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 has far Outperformed by well over +50% more. Why might that be? Five factors may help to explain why other global theme has been so far behind leader **NEX** for global clean energy. Perhaps it's because that other non-NEX basket was, or it is:

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

Nothing was wrong with that other *per se*. Also is good contrast as between 2 global energy Index themes! For other differences between global NEX – vs. other global energy basket, the NEX launched/went live first, 2006 – before that other Index. Seen in early 2021 the NEX had 125 components. The other global basket instead & for years since inception, had then only just 30 components to 2021. Just 30 didn't allow it true clean energy scope at all. So, wasn't possible for it to well capture the stories across EVs, green hydrogen, storage etc etc.

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

Shorter periods, say past 1 or 5 years - these 2 Indexes at times trade leadership back & forth – but over longer periods, NEX does very significantly better. Equal weighted NEX, eg in early 2021, had much greater 125 names with far wider reach. And helpfully, its equal weighting lets more & smaller names be included, heard: each one has a voice. Given such a huge performance gap long periods, it seems equal weights may allow passive NEX (& tracker) to better capture more - especially small & mid cap inherently clean purer plays. *Please note though neither approach is 'right': they're simply 2 differing methodologies.* 2 varied ways for global clean stories to be captured. Other's been concentrated, 'cleanish', allows in dirty names, is biased to big – while the NEX is notably always clean and is much wider-ranging.

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

After a useful public consultation early 2021, that other Index made numerous understandable changes for Q2 2021 & going forward. From a fixed 30 only components, it added at first big 52 more – and it could go on towards 100+, total unlimited. With an unlimited ceiling it was again becoming more like the NEX; that made sense as the new energy's story grows ahead. It could allow too for that other Index to better reflect an evolving story over time.

However problematically, that other then could & did then add *Non-Pure-plays - outside true clean energy*. That can mean less closely adhering to *clean* energy theme, instead being only 'kind of' global 'cleanish' energy, less pure. So, a big new difference from 2021, vs. the consistently purer NEX - was that the other Index previously with some fossil fuels, some natural gas, some nuclear, changed following 2021, so it could become even browner.

Mid-2021, that other global Index then could & did hold non-clean names. For just 3 examples 1) that other Index added at big 5% weighting 2021 a utility getting only 8% of its earnings from renewables: fracking natural gas with near enough pipeline to go New York to Paris and back, it can't be either clean or sustainable for decades at the soonest. 2) They added another dirty energy name too that also can't be in NEX, heavily natural gas and long in nuclear too; so not eligible for NEX that's for global *clean* energy. And 3) that other Index added in 2021 another utility also ineligible for clean NEX as generating electricity from oil, even 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, that other Index did another market consultation to allow more changes but notably, it explicitly still allowed for much gas(!) just weighted a bit less. And it kept unfortunately a Carbon 'Intensity' scoring metric. That faulty metric can allow for the inclusion of dirtiest fossil fuels, by a distorted false numeracy. Clearly fossil fuels don't belong in an ESG basket. Nor should they be in an genuine global *Clean Energy* theme. So, that Index though fixing some distortions, arguably made changes post-2021 that allowed itself to become even dirtier. It did so again 2022 with more gas and nuclear – becoming arguably only sort of, 'kind of' clean energy.

We recall years back as small caps grew popular, how big inflows made it hard for active funds in general to hold smaller equities. Even a $1 billion(!) market cap was a liquidity risk from inflows. So their 'small cap' definition inched up, 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' was it got harder to hold any 'not-huge' equities as inflows grew, in active Funds – or passive Indexes. Consider now then ESG thinking today. Green 'words' seeing tremendous interest. There's an upswing of activity. Of 'net creations' especially for ETFs in ESG themes. One result may be that as investors open their Prospectus up to see their Holdings, what's in ESG funds, they're very surprised by what's inside! Confoundingly, many ESG funds hold oil or gas companies! Perhaps even names steeped-in-coal!!. That failure can, clearly should & must be fixed. Greater truth, and understanding of ESG arguably ought to prohibit any dirty inclusions.

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

What 'carbon intensity' wickedly does, is lend fossil fuels a fig leaf. Sounds quantitative, yet lets polluting firms claim 'green' say going from oil – to gas. Sadly clever marketing, it enables fossil firms entry point to 'kind of clean' (really, brown) baskets – ESG funds. On ill-conceived notions like 'revenues'/per ton of CO_2 – that makes carbon 'intensity' slippery indeed.

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

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

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

Source: The Economist (2021)

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

Describing how 2020s inflows are increasingly into green & ESG themes, they 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 2 very good relevant points: it's dismaying to see huge oil & gas names - in any ESG fund. Likewise in global clean energy Indexes or funds. Beyond this, Europe SFDR 'dark green' article 9 aims to rectify that. And for NEX, the floor $1m average daily trading value (ADTV)/$750k continuing components, may look at ESG severe risk ratings, and carbon. In sum the NEX/ECO & the H2X/WNX being much greener avoid the 'greenwash' pitfall.

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

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

Of maybe interest understanding this volatility: in 2021 the International Renewable Energy Agency wrote a startling $131 *Trillion* might be needed in clean energy by 2050 to avoid heat >1.5 degrees C. (More than the $100 Trillion suggested earlier). Nothing to do with the war. Gas spiked up in Europe 2022 on horrific war; yet gas use *may* peak latter years this decade. In its place, electrolyzer capacity for green hydrogen *may* go from puny 0.3 GW 2020 – to 5,000 GW. Green H_2 feedstock for 'green ammonia' - or methanol/CH_3OH, - but not green if from fossils; that's greenwash. Europe potentially *may* latter 2020s be a green H_2 leader. And China may ramp nuclear – while it only reduces its coal use by a bit (if at all) before 2025.

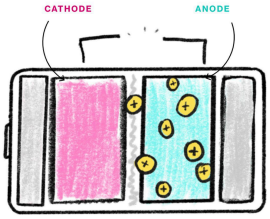
So great uncertainties abound, giving rise to volatility, tremendous risk. Myriad sub-themes *may* see advances: some incremental, some may be non-incremental, perhaps disruptive. Advanced green energy storage & batteries plainly merit focus 2020s, areas ECO & NEX have had exposure to since 2004. New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

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

First, what's called 'lithium ion' battery may have constellation of materials besides lithium. Such as Iron, Nickel, Manganese. And there's much effort at using little to no cobalt. While different chemistries favor varied characteristics, all batteries basically consist of a *Cathode, *Anode, *Separator, *Electrolyte. The anode was largely settled as graphite, maybe silicon – maybe say, nickel niobate (NiNb2O6). But that too changing too in a shift by some away from any nickel; maybe towards say pure lithium anodes ahead also replacing graphite.

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

a) 4 basic battery parts:



Source: Bloomberg Businessweek

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

Source: Bloomberg Businessweek

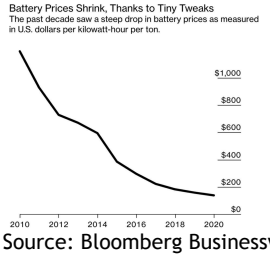
c) NMC as seen in a Nio:

Source: Bloomberg Businessweek

d) Tesla 3 has used NCA:

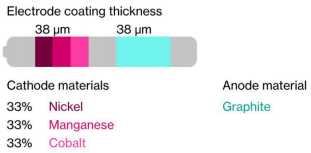
Source: Bloomberg Businessweek

Battery prices are falling hard:



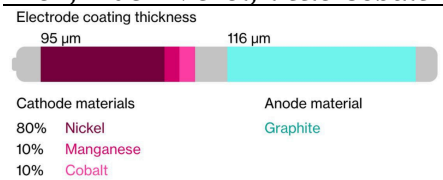
Source: Bloomberg Businessweek

NMC Composition back in 2012:



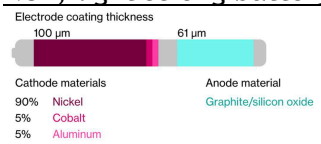
Source: Bloomberg Businessweek

Then, much Nickel, little Cobalt = thicker:



Source: Bloomberg Businessweek

NCA, light strong battery, no manganese:

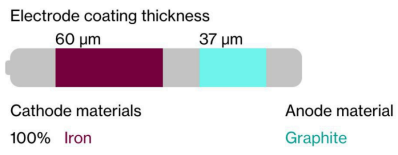


Source: Bloomberg Businessweek

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

e) Electric Buses using LFP lower-cost iron:

Source: Bloomberg Businessweek



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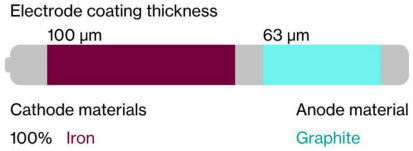
f) Modern LFP, a bit less-energy dense:

Source: Bloomberg Businessweek

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



Source: Bloomberg Businessweek

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

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

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

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

Iron is so key in our planet's backstory likely life was fated to use it abundantly. A star like our Sun, burns by fusion. That starts 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. One interesting idea may be iron-air batteries to discharge power as they take in oxygen, making rust. In turn charging by using electricity to change back from rust to metallic iron – releasing oxygen. On a super-abundant benign iron, they may be cheaper & readily recycled. Anyway, recyclability of lithium-ion batteries is an area too where so much progress is needed. Of interest perhaps ahead zinc-ion batteries to resist degrading. Or a zinc anode. If we reverse engineer, Design for X with benign, abundant, low-cost, eco-friendlier materials most prioritized, that helps win a storage game especially in big ramp up.

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

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

First a little point re: Charts. Another issue with **rolling** Charts past 5, 10 years ahead, is these *may* show very different returns in future for ECO, NEX, H2X, WNX. As charts leave big falls 2008-2012, tough energy times in 2014, & 2021, relative drops removed, ECO/NEX/H2X/WNX *may* show far greater relative gains. For that reason, a view is needed too with great ECO declines like in 2008 etc preserved: hence this Chart below. From a fixed (not rolling) 2008, it looks onwards. A long-running ECO+tracker could have begun in 2005, yet those other trackers didn't commence until later – and so an earliest feasible start was 2008.

In 15 years & growing, this *non-rolling* chart will always show at times Big declines. A period fossils lagged behind green sizably too. But relative to rolling 10 years, one vibrant difference is that global green plummeting 2008, 2021 etc is highlighted and forever preserved.

Farther back we'd note ECO predecessor, an original Wilder-hill Hydrogen and Fuel Cells Index was informally run 1999-2007. It was the world's first – calculated in-house and posted Online with Commentary, original worldwide. It differed from, yet informed work we subsequently did for the formal live Hydrogen Economy index (H2X) from 2022. Given ECO chart below picks up from 2008 we've uniquely been capturing hydrogen & fuel cells over 20 years, since 1999! For H_2 & FCs one can visit our 20+ year-old 'predecessor site' at the Hydrogen Fuel Institute, http://h2fuelcells.org Now as noted, this chart below preserves like in amber, some big drops latter 2000s. Like 2009 as some trackers commenced, near peaks, all soon plunged. That 2008/09 crash hit countless themes globally. Bog & deep mire afterwards stretching across clean and dirty energy for years mid-2010s, is brightly preserved below forever.

Note at the start, that Everything in this Chart is Down, Negative, and so underwater! Starting from bottom, fossils oil & gas are Far Down here some -90% and more(!). 'Above' them/down less is that excellent solar-only theme here off -73%. An active managed alternative energy fund is off -61%. 'Above' yet still well down, up steeply at times with big falls is ECO at -51%. Clearly 'highest'/least down energy theme is the global NEX though down -24%. Broader major Indexes (Dow removed, not seen here for clarity) all did *far* 'better' – though differ sizably – energy is but a sliver there. Generally speaking volatile ECO/NEX/H2X/WNX may really rise in climbing markets. Clearly, they can/do *plummet* hugely, in declining markets:

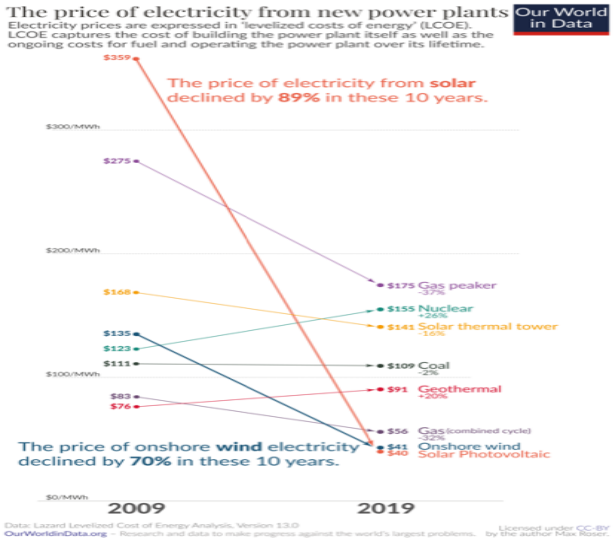
<u>Roughly Last 15+ Years starting from a Fixed June 1, 2008 to start of Sept 2022:</u>

Source: yahoofinance.com

So that's looking backwards a decade or more to the past, when clean energy was just born. Flip side to US having had nearly-zero-green power in 2010 - is despite some growth - where we stood on renewables absolute terms in 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 *Could* Have Met All US electricity demand. Instead, electrified cars, trucks, ships, airplanes were but a tiny rounding error in 2022. It may feel like we've come a long way – *but that's due to how dismal we began*. Look at Our World in Data figures: dirty fossils made 79% of energy production worldwide in 2019. Vexed fossils were bloody cheap so that was no surprise. Being low-cost meant all. Plus, they alone, along with current-generation nukes uniquely offered firm, dispatchable power. But not for 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 wind & storage too dropped hard. 2021 was an exception given inflation, and coal, oil, gas by contrast grew relatively-(much) costlier: they all pay for fuel. Fossils are bound to be costly to operate on their fuel costs - plus they must pollute and are powerless to reduce 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's 6-fold more than all annual war deaths, terrorist attacks, and murders combined!!

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



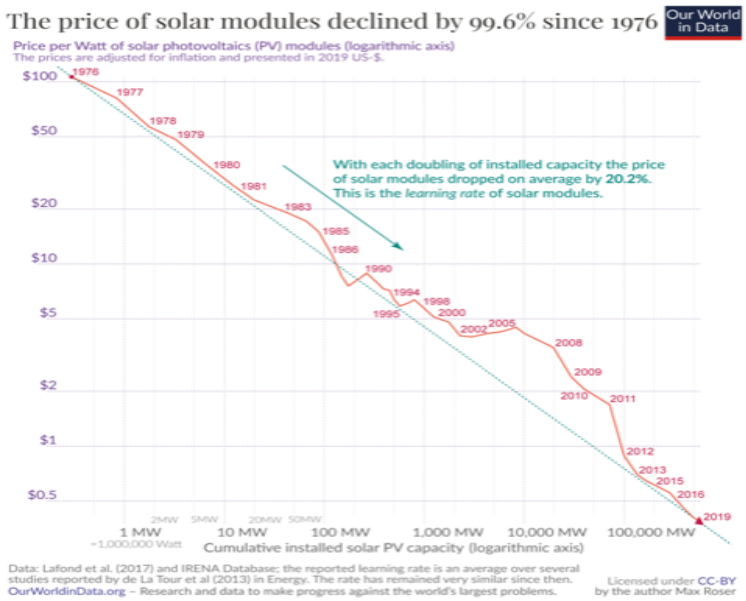
Source: Roser, Why Did Renewables Become So Cheap So Fast? Our World in Data (Dec. 2020).

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

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

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

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



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

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

Very meaningful are initial choices 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 is made of the 100 largest blue-chip firms on London Stock Exchange. Bit of a prosperity gauge for the UK's economy, it's among most widely used short-handed measures for how well the British stock market and 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 tracker 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 recent periods, tech, energy & innovation outperformed. So much so, one must be very wary of a bubble – and recall NEX – same as risky very volatile ECO & H2X & WNX baskets - can and will at times surely 'drop like a rock':

5 years: 1/2017 - 12/2021; FTSE 100 & FTSE 250 at bottom - vs. NASDAQ & **NEX** both 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% & 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." And tastes change; Britain's Statistics Office in mid-2022 removed coal, and men's suits from its basket for the consumer price index, putting in antibacterial wipes, and sport bras. In sum, Index rules & construction, & goals - like definitions vitally shape a theme. They matter. Next, let's look at a few possibilities for clean new energy ahead 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 big money was a bit late to the party. Their bid with German partner Energie Baden-Wuerttemberg was well outside norms for bids in wind. It meant they'd pay the British Crown Estate near £231 million per year over 5 years, for each of 2 sites end of which they'll only then decide whether to proceed. It was £150,000 per megawatt/per year. Compare that with £93,000 MW/year paid by a differing winning bid for Crown-ocean property by Cobra Instalaciones y Servicios alongside its British homegrown offshore venture partner, Flotation Energy. It surpassed too £83,000 MW/year by joint Total & Macquarie to another site. And it was way more than £89,000 MW/year & £76,000 MW/year in 2 bids made in 2021, won by big German company RWE for big wind farms at Dogger Bank.

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

Problem is, BP paying so much at start makes it harder to reap high returns later. Arguably 10% returns are a very tough target, anytime, especially aiming for low-risk. Too, oil & gas had earlier 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 gone. Hard to think of a job matching what fossils had once paid, lets 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, in $80Ks. Solar with some years of experience, $70Ks. But unionization rates have dipped everywhere including in fossil production. In work like pipefitters, unionization rates are relatively higher, and it come with sizably better Wages and Benefits. Hence the fossils have been hard for most anything else to beat.

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

In sum a number of serious bidders lost out to BP. Shell for instance offered nowhere as much. Yet in offshore wind, Europe's supermajors: BP, TotalEnergies, Shell may at last be starting to genuinely transform towards 'energy companies' (not mere greenwash) That puts them well ahead of US supermajors – who have instead made clear they do *Not* wish to venture into renewables. For contrast, take Orsted, of Denmark. It has divested out of 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 supply cuts, then modest increases as demand rebounded, oil/gas/coal leapt up in 2021/1H 2022. But look back, further, and Big Oil stock valuations mostly Declined a past 5 years. That's important. Perhaps more US fossil behemoths defy change, the more they *may* head long term towards being 'Not-Such-Huge-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 Q3 2022. With big Oil's Gains in 2021 & 1H 2022. Even after rising, here's **BP in yellow for Big Oil at bottom, down -11%**; bit up is carbon-heavy **ExxonMobil, in light blue +25%**. In sharp contrast is **Orsted, in deep blue, highest at around +125%** (once in oil & gas, but sold & now in clean renewable offshore wind). Well up, too, is a tracker for decarbonization in our **global new energy innovation Index (NEX) in orange**, 2nd from the top, and up +87%:

Source: GoogleFinance

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

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

UK lessons learned from offshore wind can assist US too like in undersea cables. Facilitate off-taking in the first-place. In this and more, US has badly trailed behind the UK in offshore wind. In 2021 there was just 10 GW offshore wind in UK – and yet it was a world-leader. UK since aimed in 2022 to more than quadruple this decade, offshore wind – a good start. They could do more. The US by contrast, in 2021, had pathetically nearly-zero offshore wind power. Despite being a vast country with also windy, and 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 etc - so consider a key obstacle has been US regulations. All America 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 huge; it is growing a bit – 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 has just started 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 had 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 EU-27, wind, solar, hydro, bioenergy then made 40% of electricity overall. Fossil fuels were 34%. With some notable standouts: Austria then had made 93% mainly thanks to 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 moves away from coal. Its wholesale electricity prices went *down* near just 3 cents per kilowatt/hour (kWh). By contrast at 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 – as renewables & natural gas got far cheaper. Thus did renewables (and natural gas) become leaders. Especially in 2020, pre-war, on demand loss, Utilities turned 1st to their low-cost sources, the 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 2021, it went to $6. In 2022, to $8! But still, 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'.

Like old Newtonian Physics, what was once 'known' - misled. Semiconductors at nano-scale display quantum strangeness: at smallest scales space/time and gravity differ from Newtonian suppositions; we now make use of that. Weirdly different Quantum theory, once so bizarre, better explains reality. On understanding weirdness, technology usefully harnesses truth like how quantum entanglement might allow charging EV batteries hundreds of time faster in future. A physics essential to cell phones, GPS, Lasers, MRI Imaging, LEDs, and ubiquitous computers from quantum effects not-before known prior centuries. Ahead may be speedier computing, after 2022's quantum kernel algorithms. Revolutionary ideas; superposition in 2+ states at same time. Einstein-Podoleky-Rosen paradox of 2 entangled particles, though far apart, seeming linked in real-time so appear to share information - inconceivably faster than light (entanglement & the Copenhagen interpretation solved thorny quantum puzzle)! We've progressed as we learn. So Einstein built Not on Newton – but on Mr. James Clerk Maxwell, pointing towards electromagnetic waves & constant speed of light. Space not a true vacuum: virtual particles may briefly snap into & out of existence. Photons may act 4 possible ways, 2 observed, 2 options just cancel each other out. Wonderful Mr. Richard Feynman's Rules of probability are weirdly, profoundly deterministic – and Hong-Ou-Mandel effect.

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

Lashing new lithium batteries to new AC motors for electric cars, one recent example. So too ahead, novel thinking about solar: oversizing renewables may actually save money – thanks to advanced storage! This might seem weirdly brain-spinning, oversize solar farms. Yet there's room for it: just 0.3 per cent of world's land, 450,000 sq km of 150 million sq km could power the globe 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 may compensate for costs of storage. 'Oversizing' solar – given fuel's free – may mean No penalty like over-sizing a coal, or nuke, or gas plant. Moreover, solar power may in time be shared widely via grid, green H_2. Ever say, over-size a nuclear plant? 'Fuggetabouddit'!! That nuke plant would be so costly and inflexible, so vexed by wastes needing to be stored for centuries /millennia, that it is a cul-de-sac of an idea like for any fossil fuel, or all current 'old' 2nd generation nuclear.

Intriguingly solar/wind *will* get very-cheap. And since electricity must be used immediately when generated – we've avoided oversizing and thus costly 'curtailment'; wasted wind power had cost UK consumers GBP 806 million (USD 1Bn, EUR 942m) in 2020/2021; 82% was 'excess' wind in Scotland. But long-duration storage – or possibly green H2, could avoid overcapacity sunniest/windy days issues. Prevents brown electrons with their downsides. If clean abundant renewable electricity is already at no/zero cost, then H_2 & fuel cells ('fool sells') also once so staggeringly foolish only a few years ago, *might* just begin to make sense.

Leaving academic musings, let's return to applied capital markets & needed decarbonizing. ECO/NEX saw sharp gains in 2020 – then fell hard as fossils rose by comparison in 2021 / 2022. Moreover, even solar with its many green credentials, like much else new, has suffered from unneeded, very undesirable, emotionally-trying applied setback and risks. We'll address one sad, emotionally-fraught risk next, both unnecessary and shocking of late. This is a possibility of acutely-unwanted, not at all needed, maybe forced labor within a unique region.

A solar issue lately come to light is allegations of forced labor in Xinjiang Uyghur Autonomous Region northwestern China. Xinjiang is big in silicon manufacturing for solar: polysilicon is in solar PV made worldwide including US. Poly prices plummeted for years to cheap commodity; 3/4s of 2021 global PV polysilicon was from China. Of that, over ½ in 2020 was from Xinjiang. In 2021 there was no clear evidence of forced labor in silicon manufacturing. But allegations are grave, must be looked at very seriously; lately there's been a US legislative response.

Several companies were listed in a 2021 report as having maybe Xinjiang-region content. And a couple with US listed shares were also widely in US and global Indexes – and in a many active funds. One in 2021, was in some 135 mutual funds; another 165 mutual funds. Again, without any doubt, this mere possibility warrants serious attention. What's tough is there'd been then no independent confirmation, one way or the other. Solar companies as for themselves all had strongly denied any connection. There's surely No need for any forced labor, anywhere. In response a US Solar Energy Industries Assn. sought 2021/2022 to ensure no forced labor in any part of solar chain. SEIA aims for strong protocols ensuring zero forced labor.

Nonetheless 1 firm was downgraded 2021 to a Neutral rating on possibility. Again no evidence, but without clarity, US and others can & did act, given gravity. 2 solar firms did emphatically condemn forced labor, said don't use it in their factories, is "morally repugnant", that they have "zero-tolerance" for forced labor in Xinjiang factories & across supply chain. While the US did not at first call out specific Xinjiang manufacturers, possibly-abusive labor rightly was raising warning flags. Just a possibility of such labor has got to be of great concern. By 2022 GWs of solar PV were withheld from release at US border; several named firms were then being called out specifically in varied industries, https://www.dhs.gov/uflpa-entity-list

On forced labor, the rebuttable presumption language of 'guilty until proven innocent' was passed into law 2021 in a UFLPA (Uyghur Forced Labor Prevention Act) – but with a long lead time to prove Absence of forced labor. Which may create traceability protocols, or moves to source materials all outside of the Uyghur region. In a somewhat related non-transparency matter, the US in 2022 named companies non-compliant with 2020 Holding Foreign Companies Accountable Act (HFCCA); facing delisting from US from 2024 – if their auditors aren't subject to inspection by Public Company Accounting Oversight Board; several relevant may be removed. https://www.sec.gov/hfcaa Side-note separate: China's control of supply of Rare Earths was also raised, elsewhere – but for far different reasons; given Rare Earths are vital across clean energy: solar, wind, electric vehicles, batteries etc – other reports have looked at China's sizable dominance across strategic rare Earths, and at policy responses.

In conclusion, burden on Xinjiang-based materials: solar, wind, quartz, textiles etc may be to prove Absence of forced labor. Plus, in Indexes, companies have been removed – and others not added - on possibility of forced labor; indications of such can lead to removals. It's an unnecessary risk to be watched closely, with moral implications. Xinjiang products now have positive burden to prove No Forced Labor in supply chains. Some firms may choose to relocate away from that dirty-coal-powered region. Likely, traceability services, 3rd party Independent Audit Verifications and in 2022 GWs of solar PV were kept from entering US on UFLPA law. Europe is looking into issue as well. And auditors must be subject to inspection – or may lose access to US capital markets. https://www.sec.gov/hfcaa In sum forced labor mustn't ever seep into supply chains, anywhere. Looking ahead, important too is moving to *non-coal-use* manufacturing, decarbonization and sustainability in upstream manufacturing, everywhere. This has just begun of late, with battery manufacturing in Nordic regions.

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

Musing on dynamics from 2022 and the IRA, onwards, backdrops change. Mainly incremental. Yet new $ Trillions *may* be spent globally 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 of the 2020s, new attention is being paid to greening Europe. Stolid economies, once-long dependent on foreign (Russian) gas imports, fast reassessed. 2 things seem certain short-term. One is as Europe moves away from Russian natural gas, it will see repeat energy crises in this decade – *but not due to a fault of renewables*. The UK for example, had earlier on shuttered much of its gas storage capacity. Little's now left. On less natural gas supply to Europe – and the UK in 2022, it engendered high gas prices on little storage. This meant in turn that heating, cooling and power generation there can at times get very costly.

Spiking gas costs on sparse gas storage, is far more an issue about gas – than renewables. And such crises would have happened anyway, had solar/wind never existed. Yet, clean renewables will be blamed – rather than vagaries of gas markets. So a gas draw-down – with little energy storage – risks price spikes and a populist backlash when all energy prices spike. Yet around the world, people are on a steep energy learning curve. Mis-directions like done in Texas where blame was first put on wind, *when natural gas* froze – in time face the truth. Still on China's voracious demand for coal, oil & gas, and Europe's early moves from fossils - whilst it can't set energy prices - means new energy crunches & crises are certain ahead.

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

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

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

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

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

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

So, we'd started in 2020 on just 104 gigawatts of wind power. 36 gigawatts 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 the 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 climate science is correct. We must then act far faster to cut CO_2 emissions by ½ by 2030, for 'only' 1.5 degrees C ravaging warming. Yet we're nowhere near 50% cuts. Actual global trends in 2022, still went on languidly, for decades before decarbonizing. That creates much, much too hot a world, with genuine zero-CO_2 goals realized far too late.

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

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

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

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

The study allows for all known 'zero-carbon' generation options. As expected its focus is on 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.

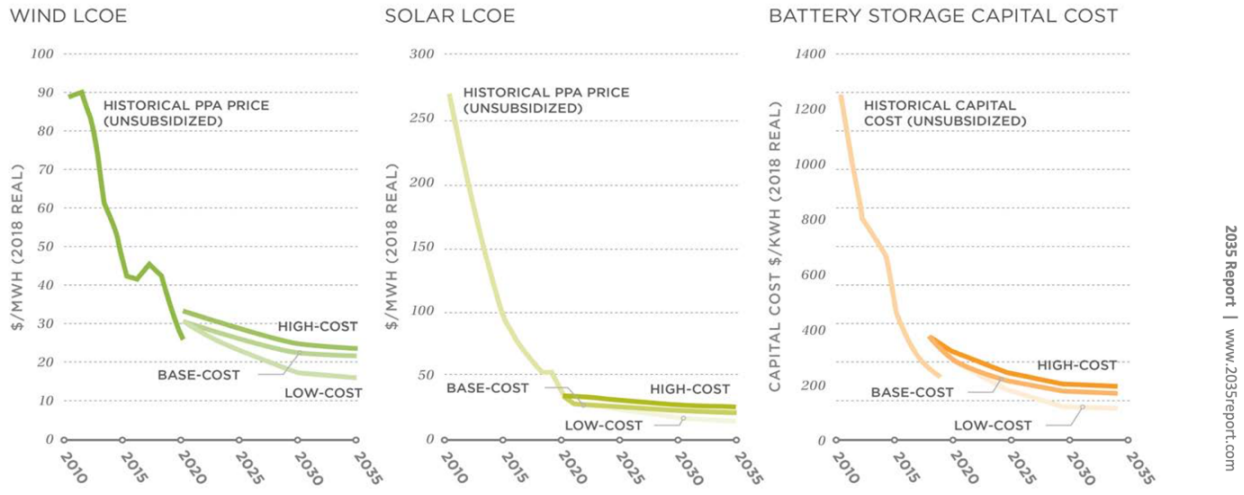
US energy generation growth had gone big before; natural gas grew by 65 GW in 2002. Now what's needed, changed: *energy storage* is 3rd leg triad to solve intermittency of renewables. Key new storage deployment needs to grow by 25% each year. Starting from a measly 523 megawatts storage in 2019, it should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

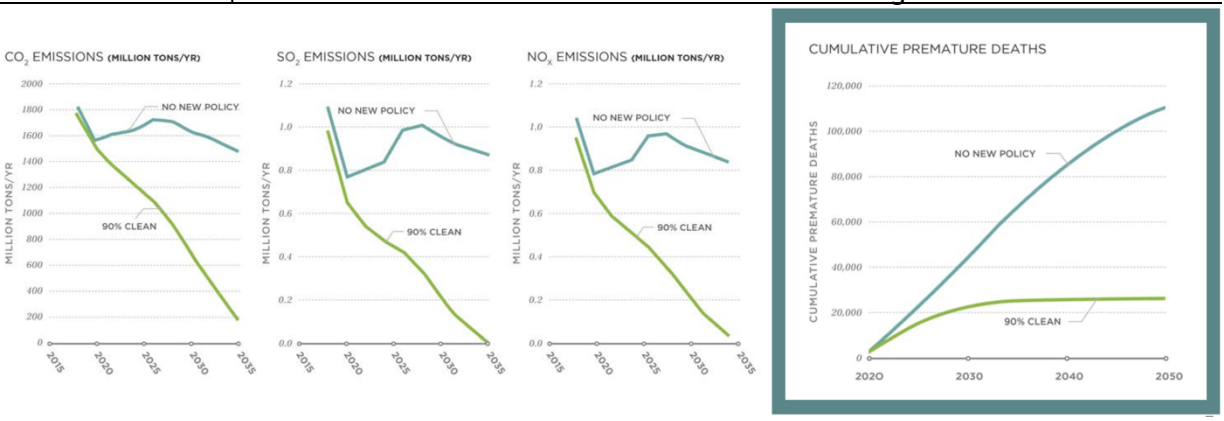
<u>Dramatic Declines in Costs Have Arrived 2020 Far Sooner than Expected:</u>



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!

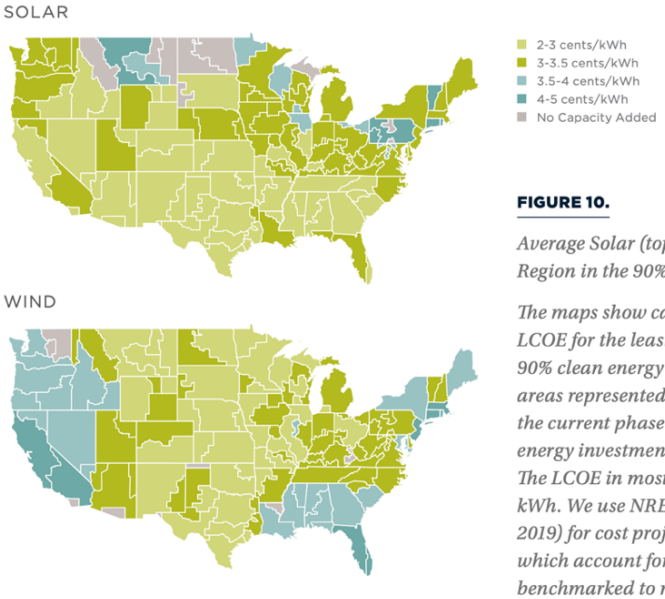


FIGURE 10.

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.

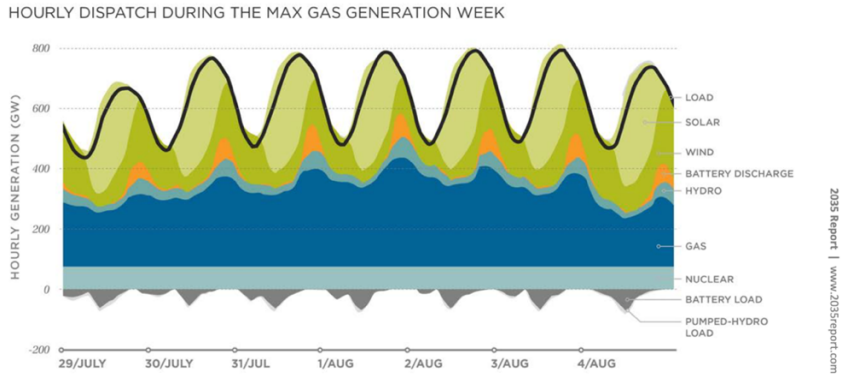
Over 7 weather years modeled, in normal conditions, wind, solar, battery storage generally, regularly provided 70% of annual generation; hydropower & nuclear provide 20%. But when there's very low generation by renewables solar/wind – and/or unusually very high demand, existing natural gas plants, hydro, 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.

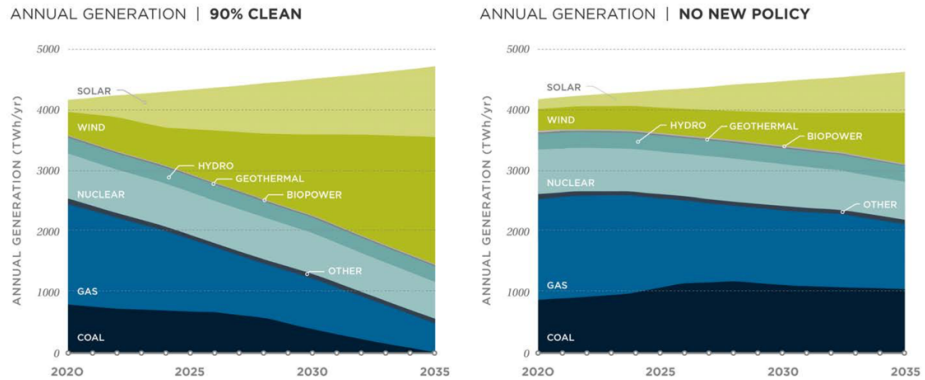
A Worst-Case Generation Period for Renewables: Still Moving Off of Fossil Fuels/Nuclear:



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).

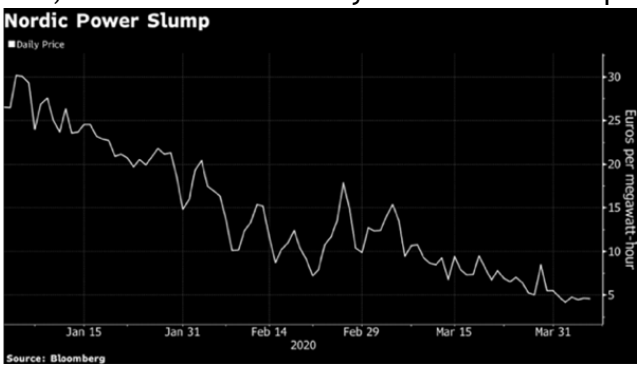
Recall some 'normal', pre-Covid, *applied* clean energy trends back early 2020. As renewable prices were falling in good & snowballing ways (unlike oil/gas). Start with Solar; costs had then hit a new record low: *only 1.35 cents per kilowatt/hour* at a big 1.5 GW solar farm going up in Abu Dhabi! True, 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.

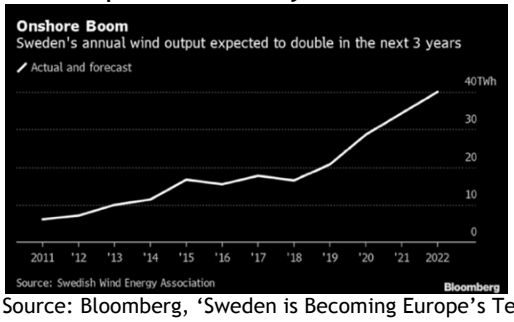
Yes, renewables wind/solar are intermittent. Winds not always blowing, no sun (night), or no rains for hydro. Yet at such times, then other renewables may be tapped. For instance, geothermal might possibly grow well as firm power. Especially when oil rig counts drop, geothermal may grow attractive. Idle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

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

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

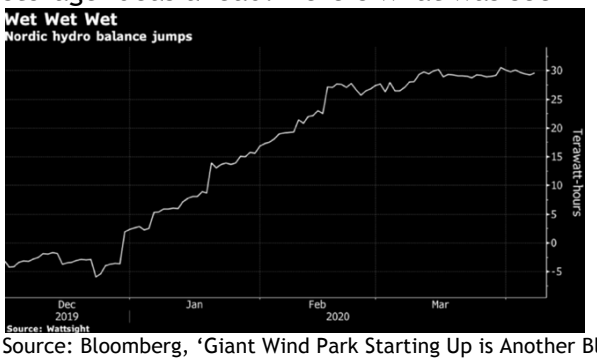
Dirty cheap northwestern China coal, had long attracted industries like PV; cheap electricity eg Liuzhou was an incentive to make EVs too. Yet Northern Nordics may potentially do it one-better ahead! If cheap/er renewable power can make green steel, aluminum - industries shall welcome that – as low embedded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

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



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

Energy-intensive industries in mountainous Northern Nordics 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 pulled ahead of nukes. In 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 its 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 produces 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 this decade. 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 under $1/10^{th}$, maybe nearer $1/100^{th}$ of what we'll need - to build PV fast enough. In 2020 we'd made around 100 GW/year worldwide. (Better than a puny 0.250 GW in 2010!). We saw PV manufacturing becoming more 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 was in Anhui, China. Perhaps capacity for 60 GW modules by end 2023, each & every year. But given economics, it's going up in 4 phases, to $2.5 billion. From a standpoint of where we need to be on CO_2 in 2035, that's but a start. Just is a beginning. Still is wildly small, if we'll 'need' some 60% of global electricity demand to be met just from solar.

Without vastly ramping, on today's trends, current growth rates, global PV capacity may be just 400 GW/year ahead. That may seem strong – yet is only an incremental increase in global PV installed capacity. It means we're growing far too slowly. On that rather 'meh' 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 soon become very, very cheap energy. Wind too. So arguably, we need Policy now as well, for still faster ramping. It's a hand that CO_2 forced on us all. On carbon levels already over >420 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 world's greatest existing installed solar capacity; European Union was 2nd and growing; the US a sad 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 exceptional innovator. Oil & gas, yes, but Texas say, is at least open to clean energy innovation – with its less regulation/more flexibility - and it's very vulnerable to climate. CO_2 *may* cause stratospheric heating, weakening a polar vortex usually bounding the Arctic; so ironically global warming *may* mean bitter Arctic air reaches briefly down to Texas. Record cold snaps, once just every 100 years, may need to be regarded as every 20, even 10 years or less. Weather extremes hitting all fossils hard.

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

Or, to focus on say new solar in Europe, consider a 2020 Report (so pre-2022 war in Ukraine) from Solar Power Europe and LUT University on: "100% Renewable Europe: How to Make Europe's Energy System Climate-Neutral Before 2050" (2020). https://www.solarpowereurope.org/wp-content/uploads/2020/05/SolarPower-Europe-LUT_100-percent-Renewable-Europe_Summary-for-Policymakers_mr.pdf

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

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

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

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

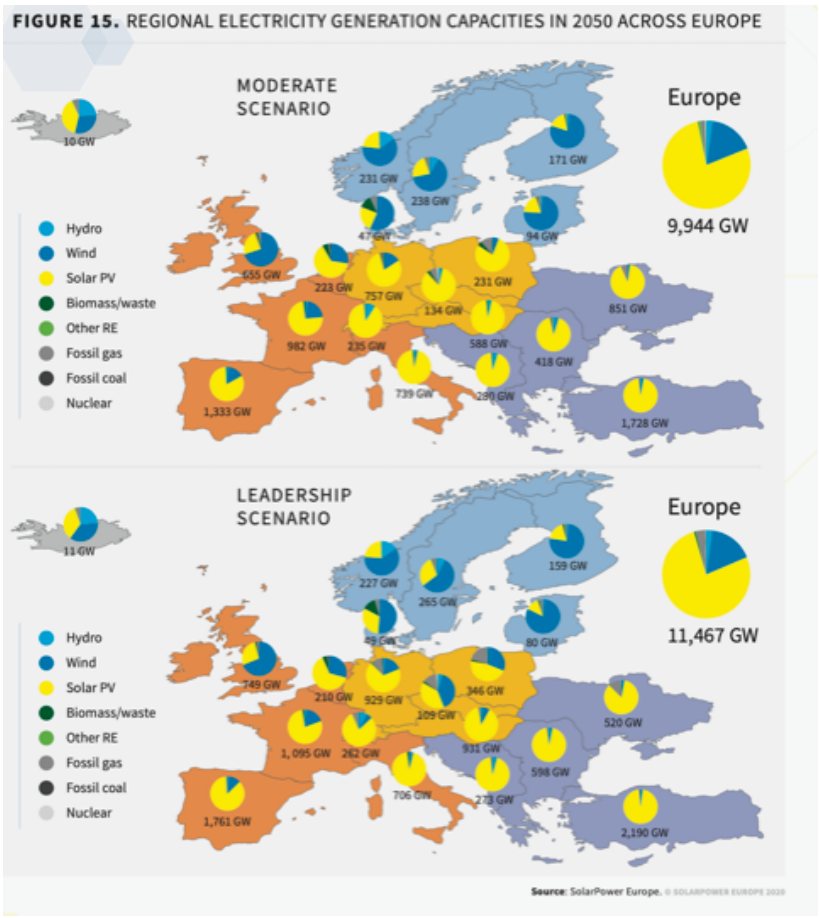
This Report recommends that policymakers should begin immediately creating a framework targeting installed 7 TW solar power – plus 1.7 TW of wind to be reached before 2040.

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

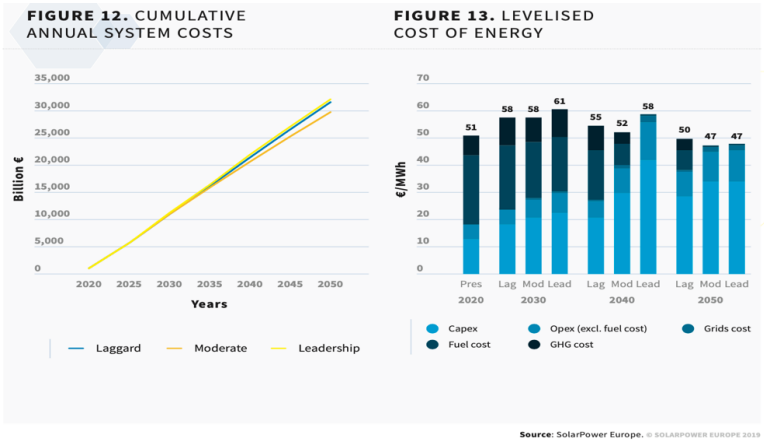
2 scenarios presented were Moderate approach – and Leadership one that's quicker. Former meets only 2 degrees C heating goal of Paris. Latter meets a more robust, better 1.5 degrees C goal. Again, it's a matter of when this ramp begins, so the angle of departure. But interestingly, the stronger and sooner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

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

Seminally, Europe has enough renewables potential to meet its entire needs by 2040. Electrification of everything. About 63% 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 Oil Crash Happened in 2020 – followed by Oil Spike Up 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; shale reserves which might one-day bounce-back strongly put something of an upper cap on prices WTI oil might fetch.

Playbook might have been, a 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 went <$20. To quickly revive economies & get oil demand back up was essential. Oil-rich nations might ideally want higher crude prices nearer $70 - $100. Or, over $100 like in 2022. In theory it lets them better balance their own books and national budgets. But then regaining firmer demand came first. Proposed conventional new oil projects were anyways uneconomic, without oil at least well above the $50s.

Plus, for nations it's important to realize/pump crude's intrinsic vitality, while its still richly valued. Vast underground reserves held too long, look increasingly like maybe stranded assets. As such might in time be of sharply diminishing value whether due to CO_2/ climate crisis concerns, or 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 may mean dreaded tank tops. In Canada for instance inland wells far from ports were lifting heavy crude that's then hard to move; suddenly, mounting product upended all, raising fears of runaway cratering. Vast demand destruction further benighted industry's fast evaporating total storage, and that was changing everything. This was a 'logic' to oil's fears and to a crisis that was back then in Spring 2020.

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

But the U.S. can't cut production by diktat. Anti-cartel laws mean apart from say, a Texas Railroad Commission (rather like a mini-OPEC, long before OPEC) ordering rare cuts as in proration, it's not an option. So, with wink and nod, Saudi & Russia agreed to 10 million cut. Even that unprecedented big move, was just a (necessary) patch-up fix. Yet it made headlines. Concerns of some technical oil-watchers, was it was 2x smaller than hoped-for. And didn't start until May 2020 - so made possible the April 2020 scenario when lower-grade crude went narrowly, briefly cost-negative, at less than zero. Even at desirable light sweet crude, cutting 10 million barrels/day did Not match up exactly to ~25 million barrels/day suddenly no longer needed. But it was hoped demand would rebound hard in 2021. And WTI Index with 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, with 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 (+ fuel) for 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. Oil's crash had uncomfortably gotten near to upending more in the oil patch. Key hub Cushing's 4 huge tanks nervously had grown full-ish. Pipelines to forward crude, had slowed to closer to like storage that could have meant a kind of oil constipation backing-up to producer. Had 5,500 miles of pipes for refined product from Gulf Coast to mid-Atlantic, stopped accepting gasoline, no contracted-buy off-taker, a fascinating and scary April 2020 - might have yielded a much different 2021. It didn't: for as many in the oil patch fervently hoped, oil demand rebounded latter 2020. On fast-reviving economies, and production cuts by OPEC+ largely complied with (Iran pumped freely). So, a 2020 that began with oil tops on lips, gave way to a 2021 with tops largely unnoticed. Then to war in 2022, demand surging - or at least, prior oil/gas surpluses no longer any concern.

In 2022, everything changed as oil, especially gas went in new directions; Russia's shutting supply changed a great deal. Before that big change 2021, renewables were rather unaffected by oil & gas crisis. Now, to grow more clean energy/storage fast was at issue. Storing electricity may be simple if little is in play; push water high up, release it as power is needed; with some batteries etc. But 2022, changed everything. Vastly more storage would mean far more batteries, huge infrastructure for innovative storage, H2 etc. For immense scale of what's needed, consider Texas. In 2019 it had just 5.5 GW of solar, met only 1.35% of State electricity demand, a healthier 17.5% wind power; that 5.5 GW of solar in 2019 was a start. If Texas were a nation, its PV would rank 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. Then, 2022, Texas' wind+solar soon made 35% of needed power at 27 GW and growing fast.

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

Consider CO_2: A Topic Gaining Importance

For 20 years an emphasis in an Clean Energy Index® Reports was on *Solutions*. Not focusing on CO_2 nor on climate *per se* – but rather on solar, wind, electric cars etc as new, ecologically & economically better paths. Climate Crisis was a big driver - but that CO_2 wasn't a core theme in these Index Reports. Lately however, heating and weather extremes have come in at a worse end of what models foresaw. In short, CO_2 dearly matters, so let's address it.

For just 1 acute sample of remarkable science here, in 2020 an 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 next 50 years, than in a past six millennia! See Chi Xu, Timothy Kohler et al, *Future of the Human Climate Niche*. PNAS (4 May 2020). https://www.pnas.org/content/early/2020/04/28/1910114117

So, we take an increasing look in these Reports at climate issues so relevant to clean energy's story. And consider too 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 0 C surface temperatures. Instead, a heating thanks to CO_2 in tiny concentrations under 400 ppm, has meant greenhouse gases naturally gifted us average temperatures near ideal for us 59 degrees F. We'd habituated into that over ten thousand years plus.

Late 1950s when regular CO_2 monitoring began, modern readings had already risen from what long prior was near 280 PPM, to 315 PPM. By 1988, scientists became alarmed by planetary warming due to increasing CO_2 had reached 350 ppm. Worried, a world conference held that year called for reducing from a 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 2090 although with much fudging like with 'sequestration' claims, and hopes that the Earth still has thriving 'natural sinks'.

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

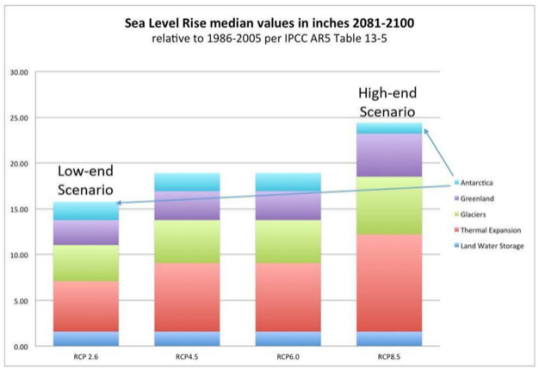
Imagine say, just 80 years hence. Note aspects of projections by an Intergovernmental Panel on Climate Change (IPCC) for sea level rise in 2100, may be a bit misleading. End of this century, rise may be unwinding at more rapidly accelerating rate, than what had seemed projected by IPCC. Getting that 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.

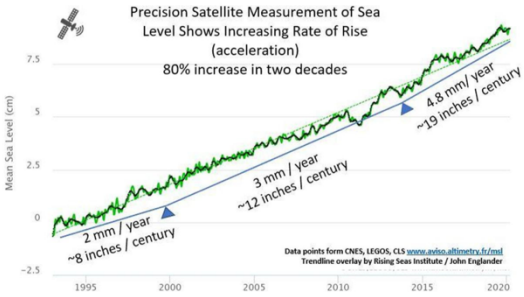
That actual sea levels seen in 2100, could be greater than IPCC projections is well laid out in 2020 piece, 'Twenty-first century sea-level rise could exceed IPCC projections for strong-warming futures' by M. Siegert et al., One Earth, 3 (Dec. 18, 2020). Their first paragraph nicely lays out cogently 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, & the State of Florida no doubt want their home to exist for centuries ahead. Same for New York City, Boston, Washington D.C., London, Shanghai, Amsterdam, Mumbai and so on. Yet their leaders are still discounting the staggering losses these places *may* face ahead. That's due in part, to relying on a nearterm and distorting 2100 horizon.

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

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

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

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

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 at CO_2 already over 420 ppm in 2022 & rising fast, think first Pliocene. About 3-5 million years ago, a hot Earth had a 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 to come then along with mass-extinctions. But those temps existed a couple million years before humans later evolved (in a more comfortable world nearer 230 ppm). We can get hotter still, like Miocene, 400-600 ppm. Perhaps coasts submerged. Interestingly, at 'just' a 400 ppm Pliocene much of Greenland's ice sheet was gone; glaciers may be sensitive to 'modest' warming. Millions of years ago, CO_2 changes occurring naturally took thousands of years to unwind, maybe tens of thousands of years+ to slowly rise or fall. By contrast in a 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 also the Extreme Pace of Change, that's deadly.

Post-Pliocene 3 - 5 million years ago - or Miocene 5 - 23 million years ago, it was long periods - millions of years of hot Earth before humans appeared that 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've evolved at 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, lowering CO_2 allowed glaciers to form. Today's flora & fauna evolved over the hospitable, cooler Earth we've known until very recently. Yet millions of years it once took to go from hot Pliocene, are being explosively undone. In just 250 years of fossil fuels, we're dramatically destroying cool. Vanquishing glaciers. Ending ice sheets that once had required a vast period of cold temps to form in the first place. There's no reverse switch, so this may become (or already is) 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 in first place to prevent pollution, there's a variety of potential (some not so awful) ways to do this – and if done right – sadly may make sense. Of course, it mustn't be done in ways extending fossil fuels. And mustn't be done say, by treating deep oceans too like as an open sewer, injecting carbon there we've been treated the air for centuries.

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

Conceivably, innovations might arise. 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 MISI mechanisms may be much more extensive across the Antarctic. Enormous Pine Island Glacier in Antarctica, for example, looks to be currently thinning, 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 those big rates and scales of change mean. A difference of 'just' 7 degrees F had separated a recent "ideal" climate - from extreme conditions of an ice age. In a refresher, that Ice Age not long ago had led to ice sheets over Canada, Northern US, Europe, Asia. Great Lakes were born of those great sheets retreating. Meltwater retreat shaped Long Island NY, Cape Cod MA. Huge impacts were thus wrought by a 7 degrees F 'delta'. Ice stood a mile tall over some of North America, making the continents we know today.

Just imagine then, another 7 degrees F change – but instead – global *heating*. Certainly, that 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 higher. Drowning so much today, like the State of Florida. In a thought experiment, adding 5 degrees F warming is very imaginable, on current CO_2. So, it is reasonable to see seas fast going 60+ feet higher. No seawall could stop that. It renders the shapes of whole countries as we know them, today, a distant memory.

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

On CO_2 plus inertia, we're heading to conditions unknown in human history. Earth will exhibit changed states that only can be guessed at. For instance, melting is making Earth slightly alter movement on its polar axis. Length of days is changing, as ice melt redistributes mass of water towards bulging equator. Small changes in Earth's spin may not seem troubling, yet it shows magnitude of change possible from tiny CO_2 molecules. The Gulf Stream helping keep Northern Europe far warmer than 'it should be', may already be slowing significantly.

Just a century from now, even decades ahead, the science implies people may soon look back on our recent 2021 with record-breaking heat, ironies of both flooding and droughts, bitter cold snaps, rapidly disappearing sea ice, gradually rising sea levels - as a much cooler, far more desirable past. One that can never be recovered. Tiny sea level change/s now – only 1 or 2 inches per decade (so considerably faster than 50 years ago) can be a spike just beginning. Maybe an irreversible collapse in Greenland, or Antarctica, so *considerably more rapid rise would be* in store. Jet stream, gulf stream changing. It's impossible to say exactly when things occur. But ever-more certain, given fast rising heat at poles, that change shall happen.

The Inflation Reduction Act/IRA of 2022 had 'felt' to many like fast progress, as a bit more than we were prepared to give in a US. Felt clean energy was replacing fossils fast enough – though it wasn't. Not given the physical CO_2 budget, yet world burning coal, gas, oil. The few hundreds of billion dollars in that 2022 IRA were dwarfed by scale of planetary efforts needed, maybe over $100 trillion in spending. So we're in for unbearably hot future. Killing Most Life. Maybe lasting well under a million years – and ending us. Our societies, maybe species. Silly really. For no good reason, we chose not to make enough fast use of renewables. Now, climate promises fresh horrors of catastrophic change. Maybe in everything, everywhere, all at once. Our rampage burning of oil, gas, even coal, has become a mutual suicide pact for we know the outcomes. It's as if we humans have become determined to wage an intended war against all other life on this planet – making it very hard to cheer our own species on.

Conclusion:

The Clean Energy Index® (ECO) started Q3 near 95, and late in volatile Q3 was near 100. Or, the last few years ECO rose by +58% for 2019. Remarkably it then rose by +203% for 2020, about the best performance of any Index, or Fund anywhere. Perhaps unsurprising after such gains 2019 & 2020, it fell by -30% for 2021 when a climate bill failed, pushing the theme down, plus inflation fears overcame recent decarbonizing trends that might favor renewables ahead. After falling again sharply Q1 2022 by 1/3rd to 100 - war brought a fast shift away from Russian gas and in war's first few weeks, ECO had jumped +40% on the better alternatives found here. It fell harder in Q2 to an 84 low on supply chaos; rose mildly on European green hopes; jumped in Q3 on passage of a slimmed-down climate law, then fell down fast on broad recession fears. Since start of 2017 when ECO at 38, by late Q3 2022 it was up some +210%.

Decarbonization as an organizing theme in ECO is up +155% last 10 years, showing notable returns for sustainable energy. The first *Global* clean energy Index is WilderHill New Energy Global Innovation (NEX) live since 2006: it also has a European tracker and the NEX is up +85% last 5 years, up +200% last 10 years starkly beating fossils. There's also now 2 new WilderHill themes for Hydrogen Economy (H2X), & Wind Energy (WNX): all four are pure-play leaders.

4 Additions to ECO for start of Q4 2022 were 5E Advanced, Altus, Polestar, Vertical Aerospace – 3 Deletions were Daqo, Infrastructure & Energy Alternative, REE. At Global NEX for Q4 2022, 16 Additions were Abalance, Altus, Bumhan, Dae Myoung, Energix, Fugro, Hyundai Energy, Navitas, NFI, PNE AG, Polestar, REC Silicon, SebitChem, Sungeel, TECO, Tianqi Lithium – and 10 NEX Deletions for Q4 2022 were AFC Energy, Cadeler, Daqo, Eolus Vind, Hexagon Composites, Infrastructure and Energy Alternatives, Lilium, Lion Electric, Tritium, Xianjing Goldwind. Adds/Deletes for H2X & WNX Indexes are in their Appendixes below.

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

Rob Wilder
rwilder@wildershares.com

Appendix I: ECO Index (via independent tracker PBW) Descending Weights in late-Q3 on 9/13/2022, or about ~2 weeks before the rebalance to start Q4 2022. 81 Stocks:

Name	Weight	Name	Weight
Stem Inc	2.12	TPI Composites	1.27
First Solar Inc	2.09	QuantumScape	1.27
Fluence Energy Inc	2.07	ReneSola Ltd	1.25
Enovix Corp	2.02	Joby Aviation	1.24
Wolfspeed Inc	1.99	ReNew Energy	1.23
Plug Power Inc	1.91	Brookfield Ren	1.22
Ameresco Inc	1.84	FuelCell Energy	1.21
Maxeon Solar	1.79	ESS Tech Inc	1.21
Infrastructure and	1.78	MYR Group Inc	1.21
SunPower Corp	1.76	SolarEdge Tech	1.20
Array Technologies	1.72	Itron Inc	1.18
Sunrun Inc	1.71	Workhorse	1.14
Enphase Energy Inc	1.70	Universal Display	1.13
Bloom Energy Corp	1.67	SES AI Corp	1.11
Lithium Americas	1.61	MP Materials	1.10
Shoals Tech	1.57	Solid Power	1.10
Livent Corp	1.56	Tritium DCFC	1.09
Sigma Lithium Corp	1.55	Wallbox NV	1.08
Sunnova Energy	1.52	Gentherm Inc	1.08
Blink Charging Co	1.48	Fisker Inc	1.07
Albemarle Corp	1.47	JinkoSolar	1.04
Ormat Tech	1.45	Li-Cycle Hold.	1.00
Piedmont Lith	1.43	Daqo New	1.00
Canadian Solar	1.43	Sunlight Finan.	0.97
ESCO Technologies	1.42	Lilium NV	0.97
Rivian Automotive	1.40	View Inc	0.96
ChargePoint	1.39	Gevo Inc	0.95
Quanta Services	1.38	FTC Solar Inc	0.94
Standard Lithium	1.37	Lion Electric	0.94
EVgo Inc	1.36	NIO Inc ADR	0.90
Tesla Inc	1.35	Archer Aviation	0.88
Ballard Power	1.35	REE Automotive	0.84
Advanced Energy	1.33	Gogoro Inc	0.83
Canoo Inc	1.31	Lightning eMot.	0.76
Sociedad Quimica	1.30	Eos Energy	0.69
Navitas Semi	1.30	Heliogen Inc	0.65
Lordstown Motors	1.28	Hyzon Motors Inc	0.61
		Azure Power	0.57

XPeng Inc ADR	0.56	ElectraMeccanica	0.43
Energy Vault	0.45	Beam Global	0.36
American Super.	0.43	Arcimoto Inc	0.26

There's strong representation above from *Batteries/Storage; *Solar, and *Power Conversion.

Appendix II, ECO Index for the Start of the New Quarter:
INDEX (ECO) SECTOR & STOCK WEIGHTS FOR START OF Q4 2022. 82 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 - 17% weight (12 stocks @1.41% each)
Altus Power, AMPS. Large utility-scale & rooftop solar PV, community solar.
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.
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 (20 stocks @1.27 each + 1 *banded)
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
SES AI Corp, SES. Li-metal anode battery, may be safer, faster-charging.
Sigma Lithium, SGML. Lithium, in planning & pre-construction, sites in Brazil.
Solid Power, SLDP. Solid electrolyte battery, Earth-abundant materials.
Standard Lithium, SLI. Lithium, from brine in U.S., vs. traditional ponds.
Tesla, TSLA. Electric vehicles, pure-play across EVs, advanced energy storage.
Workhorse, WKHS. Electric Vehicles, large electric delivery trucks, early-stage.
Xpeng, XPEV. Electric vehicles, advanced mobility, swappable batteries, China.

Power Delivery & Conservation - 24% sector (18 stocks @1.25% each + 3 *banded)
5E Advanced Materials, FEAM. Boron & Lithium miner, wind, EVs, batteries.
Ameresco, AMRC. Energy saving efficiencies, net zero CO_2, decarbonization.
**American Superconductor,* AMSC. Wind, grid conditioning; superconductors.
**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.
Gogoro, GGR. Electric scooters, swappable battery stations, Taiwan-based.
Itron, ITRI. Meters, utility energy monitoring, measurement & management.
MYR Group, MYRG. Grid transmission, distribution aids solar & wind farms.
Navitas Semiconductor, NVTS. Gallium Nitride GaN fast charging EVs.
Polestar, PSNY. Electric vehicles pure play, global, and is based in Sweden.
Quanta Services, PWR. Infrastructure, modernizes grid & power transmission.
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.
Wolfspeed, WOLF. Electrifying power, Silicon Carbide SiC, converters.

Energy Conversion - 23% sector weight (18 stocks @1.25% each + 1 *banded)
Advanced Energy, AEIS. Power conditioning: inverters, thin film deposition.
Archer Aviation, ACHR. Electrifying aircraft, vertical takeoff & landing.
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.
Joby Aviation, JOBY. Electric aircraft, cleaner, more energy efficient.
Li-Cycle, LICY. Battery Recycling, closed-loop of lithium, other materials.
**Lightning eMotors,* ZEV. Electric powertrain conversions, heavy vehicles.
Lilium, LILM. Electric jet aircraft, eVTOLs for vertical takeoff & landing.
MP Materials, MP. Rare Earths, domestic U.S. source Neodymium, NdPr.
Plug Power, PLUG. Small fuel cells, for eg forklifts; drop in replacements.
SolarEdge Technologies, SEDG. Inverters, solar optimizers, inverters.
Tritium, DCFC. Ultra-fast EV charging networks, Australia and worldwide.
Vertical Aerospace, EVTL. eVTOL aircraft, urban electric, is UK based.

Greener Utilities – 8% sector weight (6 stocks @1.25% each + 1 *banded)
**Beam,* BEEM. EV Charging, rapidly deployable portable PV power platform.
Brookfield Renewable, BEPC. Renewables hydro, wind, solar; energy storage.
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 – 2% sector weight (2 stocks @1.00% each)
Gevo, GEVO. Biofuels, lower-carbon liquid fuels from renewable sources.
Heliogen, HLGN. Concentrating solar mirrors, hydrogen with no fossil fuels.

Appendix III: **WilderHill New Energy Global Innovation (NEX)** late-Q3 via independent tracker (PBD) on 9/13/22, about ~2 weeks before Rebalance to start Q4 2022. 124 stocks:

Name	Weight	Name	Weight
Stem Inc	1.67		
First Solar Inc	1.48	Nexans SA	0.76
Plug Power Inc	1.37	ReneSola Ltd ADR	0.76
Maxeon Solar Tech	1.28	Mercury NZ Ltd	0.76
Wolfspeed Inc	1.23	Gevo Inc	0.76
FREYR Battery SA	1.21	AFC Energy PLC	0.76
RENOVA Inc	1.21	Vestas Wind Systems A/S	0.75
Array Technologies	1.20	Neoen SA	0.75
Eolus Vind AB	1.15	Itron Inc	0.75
Sunrun Inc	1.15	LG Energy Solution Ltd	0.75
Infrastructure and	1.13	Proterra Inc	0.75
Enphase Energy Inc	1.13	Acciona SA	0.75
SunPower Corp	1.13	Tritium DCFC Ltd	0.75
Bloom Energy Corp	1.09	Landis+Gyr Group AG	0.74
Ameresco Inc	1.09	JinkoSolar Holding Co Ltd ADR	0.74
Lithium Americas	1.05	Aker Horizons ASA	0.74
VERBIO Vereinigte	1.02	Energiekontor AG	0.73
Nibe Industrier AB	1.02	Solid Power Inc	0.72
Canadian Solar Inc	1.01	United Renewable Energy	0.72
Sunnova Energy	1.00	Doosan Fuel Cell Co Ltd	0.71
CropEnergies AG	1.00	Iljin Hysolus Co ltd	0.70
Shoals Tech	0.97	Motech Industries Inc	0.70
Livent Corp	0.97	Samsung SDI Co Ltd	0.70
OX2 AB	0.92	Orsted AS	0.70
ChargePoint	0.92	Solaria Energia y Medio Amb.	0.69
Enlight Renewable	0.91	Novozymes A/S	0.69
Ballard Power	0.90	Fisker Inc	0.68
Rivian Automotive	0.90	Canoo Inc	0.68
SMA Solar	0.90	Sino-American Silicon Prod.	0.68
JL Mag Rare-Earth	0.89	Yadea Group Holdings Ltd	0.67

Scatec ASA	0.89	Hexagon Composites ASA	0.67
PowerCell Sweden AB	0.88	MP Materials Corp	0.66
Ormat Technologies Inc	0.88	NIO Inc ADR	0.66
Nordex SE	0.87	Universal Display Corp	0.66
FuelCell Energy Inc	0.86	Verbund AG	0.65
Piedmont Lithium Inc	0.86	China Datang Corp Renew.	0.65
Lordstown Motors Corp	0.85	Li-Cycle Holdings Corp	0.65
Alfen Beheer BV	0.85	Lilium NV	0.65
NKT A/S	0.84	Terna Rete Elettrica Nazionale	0.65
Ceres Power Holdings PLC	0.83	Xinjiang Goldwind Science	0.65
QuantumScape Corp	0.82	Grenergy Renovables SA	0.64
Sociedad Quimica y Minera	0.82	L&F Co Ltd	0.61
Arcosa Inc	0.82	Signify NV	0.60
Corp ACCIONA Energias Ren.	0.82	FTC Solar Inc	0.60
TPI Composites Inc	0.82	Lucid Group Inc	0.60
CS Wind Corp	0.82	Iljin Materials Co Ltd	0.59
NEL ASA	0.82	Kingspan Group PLC	0.59
Dongkuk Structures & Const.	0.81	Ganfeng Lithium Co Ltd	0.58
Encavis AG	0.81	Flat Glass Group Co Ltd	0.57
Cadeler A/S	0.81	Lion Electric Co/The	0.57
Joby Aviation Inc	0.81	Xinyi Solar Holdings Ltd	0.56
SolarEdge Technologies Inc	0.79	Archer Aviation Inc	0.56
Daqo New Energy Corp ADR	0.79	Ecopro BM Co Ltd	0.55
ReNew Energy Global PLC	0.79	Unison Co Ltd/South Korea	0.54
GS Yuasa Corp	0.79	McPhy Energy SA	0.53
Boralex Inc	0.78	BYD Co Ltd	0.52
Innergex Renewable Energy	0.78	ITM Power PLC	0.52
Prysmian SpA	0.78	Xinyi Energy Holdings Ltd	0.50
Brookfield Renewable Corp	0.78	SK IE Technology Co Ltd	0.48
SFC Energy AG	0.78	XPeng Inc ADR	0.41
Hannon Armstrong Sustain.	0.78		
West Holdings Corp	0.78		
EVgo Inc	0.77		
EDP Renovaveis SA	0.77		
Elia Group SA/NV	0.76		

There's strong representation above from *Batteries, *Solar; *Power Conversion, and Fuel Cells.

Appendix IV:
WilderHill New Energy Global Innovation (NEX) - for start of Q4 2022. 130 Stocks.

Name	Description	Sector	Currency	Activity
Abalance Corp	Solar, new hydrogen & fuel cells, energy storage.	ROH	JPY	JAPAN
Acciona SA	Sustainable infrastructure, separate renewables.	RWD	EUR	SPAIN
Aker Horizons	Offshore / onshore wind, solar, clean hydrogen, grid.	RWD	NOK	NORWAY
Alfen NV	Electric Vehicle charging, smart grid, energy storage.	EEF	EUR	NETHERLA.
Altus Power	Large-scale, rooftop & community solar, EV charging.	RSR	USD	US
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
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
Brookfield Renewable Corp	Hydropower, wind, solar, energy storage, H2.	ROH	USD	US
Bumhan Fuel Cell	Fuel cell manufacture, H2 in excavators, ships, subs.	ECV	KRW	S. KOREA
BYD Co.	Electric vehicles, batteries, rail, and more.	ENS	HKD	CHINA
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
Corporacion Acciona Ener.	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
Dae Myoung Energy	Wind energy, solar, energy storage, EPC, O&M.	ROH	KRW	S. KOREA
Dongkuk Structires	Wind towers, growing wind energy emphasis.	RWD	KRW	S. KOREA
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
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
Energix Renewable Ener.	Wind & solar, producer in Israel, Poland, US, elsewhere	RWD	ILS	ISRAEL
Enlight Renewable	Solar & wind power, energy storage infrastructure.	RSR	ILS	ISRAEL
Enphase	Inverters, micro-products for solar panels, storage.	RSR	USD	US
EVgo	EV charging, an early leader in fast charging.	EEF	USD	US
First Solar	Thin film solar, CdTe low-cost alternate to polysilicon.	RSR	USD	US
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
Fugro NV	Geo-data, subsea offshore wind construction, cables.	ROH	EUR	NETHERLA.
Ganfeng Lithium	Lithium, production of compounds, metals, for batteries.	ENS	HKD	CHINA
Gevo	Biofuels, lower carbon liquid fuels, renewable sources.	RBB	USD	US
Grenergy Renovables SA	Solar projects, and wind, batteries, Spain, Latin America.	RSR	EUR	SPAIN
GS Yuasa	Battery technologies, also lithium for EVs, Japan.	ENS	JPY	JAPAN
Hannon Armstrong	Energy efficiency, capital & finance for infrastructure.	EEF	USD	US
Hyundai Energy Solutions	Solar, commercial, residential, floating panels, EPC.	RSR	KRW	S. KOREA
Iljin Hysolus	Hydrogen tanks, for fuel cell cars, trucks, ships, planes.	ENS	KRW	S. KOREA
Iljin Materials	Rechargeable battery materials, elecfoils in 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
JL Mag Rare-Earth	Rare Earths, magnets in EVs; wind turbines; Nd-Fe-B.	ECV	HKD	CHINA
Joby Aviation	Electric Aircraft, more efficient transportation.	EEF	USD	US
Kingspan Group plc	Efficient Buildings, insulation for conservation, Ireland.	EEF	EUR	IRELAND
L&F Co.	Cathode active materials, closing battery loops.	ENS	KRW	S. KOREA
Landis+Gyr Group AG	Advanced meters, modernizing grid, Switzerland.	EEF	CHF	SWITZERLAND
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
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
Navitas Semiconductor	Gallium Nitride GaN, for grid, fast charging EVs, more.	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
NFI Group	Fuel cell and electric drivetrains, for large buses.	EEF	CAD	CANADA
Nibe Industrier AB	Heating & cooling, sustainable technologies, Sweden.	EEF	SEK	SWEDEN
Nio	Electric Vehicles, design, manufacture, premium EVs.	ENS	USD	CHINA

NKT A/S	AC/DC cables, grid infrastructure improvements.	EEF	DKK	DENMARK
Nordex SE	Wind turbines, based in Germany/Europe, worldwide.	RWD	EUR	GERMANY
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
OX2 AB	Wind and solar farms, from design to development.	RWD	SEK	SWEDEN
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
PNE AG	Wind, site exploration to construction and operations.	RWD	EUR	GERMANY
Polestar Automotive	Electric car manufacturer, based in Sweden, global.	ENS	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
REC Silicon ASA	Solar, greater high-purity silicon focus PV, Norway.	RSR	NOK	NORWAY
ReneSola	Solar, project developer and operator, worldwide.	RSR	USD	CHINA
Renew Energy Global plc	India renewables, wind, solar energy Utility scale.	RWD	USD	INDIA
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
Sebitchem Co.	Lithium battery recycling, for precursor producers.	ENS	KRW	S. KOREA
SFC Energy AG	Fuel cells, direct methanol (DMFC) technology.	ECV	EUR	GERMANY
Shoals Technologies	Solar, electric balance of system, wiring, combiners.	RSR	USD	US
Signify NV	Lighting, systems increasing efficiency, Netherlands.	EEF	EUR	NETHERLA.
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
SolarEdge	Inverters, panel-level solar optimizers, micro-inverters.	RSR	USD	US
Solaria Energia	Solar, renewable power generation, Iberia.	RSR	EUR	SPAIN
Solid Power	Towards solid state batteries, sulfide electrolyte.	ENS	USD	US
Stem	Smart battery storage, AI energy management.	ENS	USD	US
SungEel HiTech	Lithium battery recycling, also battery raw materials.	ENS	KRW	S. KOREA
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
TECO Electric Machinery	Motors, converters, in wind, EVs, electrifying everything.	ECV	TWD	TAIWAN
Terna Rete SpA	Transmission of electricity, increasingly is renewables.	EEF	EUR	ITALY
Tianqi Lithium	Lithium products, in EVs, energy storage, etc, China.	ENS	HKD	CHINA

TPI Composites	Wind Blades; also light-weighting for transportation.	RWD	USD	US
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
West Holdings	Solar, Japan-focused residential and commercial PV.	RSR	JPY	JAPAN
Wolfspeed	Electrifying high power systems, SiC, GaN.	EEF	USD	US
Xinyi Energy Holdings	Solar Farms, a spin-off from Xinyi solar glass, China.	RSR	HKD	CHINA
Xinyi Solar Holdings	Solar, ultra-clear glass products, China.	RSR	HKD	CHINA
Xpeng Motors	Electric Vehicles, internet and autonomous features.	ENS	USD	CHINA
Yadea Group	Electric scooters and motorcycles, electric bikes.	EEF	HKD	CHINA

130 stocks/100 = Indiv. Weights for Q4 2022

WEIGHT EACH COMPONENT = 0.769230769

130 Stocks for Start of Q4 2022.		#	% Approx. Weight
Energy Conversion	ECV	16	12%
Energy Efficiency	EEF	24	18%
Energy Storage	ENS	28	22%
Renewables - Biofuels & Biomass	RBB	4	3%
Renewables – Other	ROH	8	6%
Renewable – Solar	RSR	30	23%
Renewable – Wind	RWD	20	15%
		130	100%

16 Adds to NEX for Q4: ABalance, Altus, Bumhan, Dae, Energix, Fugro, Hy. Energy Solutions, Navitas, NFI, PNE, Polestar, REC, Sebit, Sungeel, TECO, Tianqi.
10 Deletes: AFC, Cadeler, Daqo, Eolus, Hexagon, Infra., Lilium, Lion, Tritium, Xinjiang Goldwind.

Appendix V: 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%

Appendix VI: Comparison of the 4 WilderHill Indexes for clean, green themes:

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

[i] See the latest Solactive List of Developed Countries, https://www.solactive.com/documents

[ii] For details on fields and thresholds applied for exclusion, please refer to individual Index at, Methodology

ECO Index® is owned by WilderShares. NEX, H2X, WNX Indexes are owned by WilderHill New Energy Finance. ECO Index is calculated by the NYSE. The NEX, H2X, WNX are calculated by Solactive AG in Germany.

Appendix VII:
WilderHill Hydrogen Economy Index (H2X) for latter Q3 2022:

Hydrogen Economy H2X - Component	Theme	Sector	Activity
5E Advanced Materials	Boron, in storing hydrogen, also used in fuel cells.	HS	USA
Abalance	H2 storage, also has Birdy Fuel Cells group, Japan.	HS	JAPAN
Abb	Electrification systems and engineering for green H2.	HS	SWITZ
Advent Technologies	Fuel cells, high temperature for diverse fuel sources.	FC	USA
Aker Horizons ASA	Decarbonizing, diverse sustainable energy themes.	GH	NORWAY
Archaea Energy	Landfill waste to renewable natural gas, and H2.	HI	USA
Ballard Power Systems Inc	Fuel cells, H2 in buses, trucks, trains, backup power etc.	HT	CANADA
Bloom Energy Corp	Fuel cells, SOFC high temps can use variety of fuel sources.	FC	USA
Brookfield Renewable Energy	Teaming to produce green hydrogen from hydroelectricity.	HI	USA
Bumhan Fuel Cell	Fuel cells in submarines, H2 fueling. Offshore cables.	HT	S. KOREA
Ceres Power Holdings PLC	Fuel cells, high SOFC temperature allows variety of fuels.	FC	UK
China Datang Renewables Corp	Wind & hydro in China, that's developing H2 projects.	HG	CHINA
Chung-Hsin Electric	Fuel cells. Hydrogen, methanol reformers.	HG	TAIWAN
Compagnie Plastic Omnium SE	H2 storage in high pressure tanks for vehIcles, fuel cells.	HT	FRANCE
Corp. Acciona Energias Renovables	Green H2, new GreenH2Chain to ensure green H2 origins.	HI	SPAIN
CropEnergies AG	Renewable H2 from ethanol, also a co-product, Europe.	HI	GERMANY
Doosan Fuel Cell	Fuel cells, high temperature for a variety of fuels.	FC	S. KOREA
Fuelcell Energy Inc	Fuel cells, high temperature operate range of fuel sources.	FC	USA
Gevo Inc	Biofuels, energy dense net-zero carbon liquid fuels.	HG	USA
Greenvolt Energias	Biomass to hydrogen without need for combustion.	HG	PORTUGAL
Hyosung Advanced Materials	Advanced composite materials for hydrogen tanks.	HS	S. KOREA
Hyzon Motors Inc	Hydrogen powered commercial trucks run on fuel cells.	HT	USA
Iljin Hysolus	Compressed hydrogen tanks for fuel storage.	HS	S. KOREA
ITM Power PLC	Fuel cells, PEM; also electrolyzer manufacturing green H2.	GH	UK
JL Mag Rare Earth	Rare earths, in fuel cells & SOFCs, electrolyzers.	HI	CHINA
Linde PLC	Industrial gases production, including hydrogen.	HG	UK
Lotte Fine Chemical	Green hydrogen production launch, ammonia.	GH	S. KOREA
Mcphy Energy SA	Hydrogen production, use, and storage; H2 in industry.	HI	FRANCE
Montauk Renewables	Captures methane, CH4 from landfills, biogas RNG uses.	HG	USA
Navitas Semiconductor	GaN showing more-efficient carbon-free H2 production.	GH	USA
Nel ASA	Electrolysis for H2 from water, using alkaline and PEM.	GH	NORWAY
Neoen SA	Water Electrolysis and renewable energy for green H2.	HG	FRANCE
OCI N.V.	Green Ammonia, building up from biogas, hydrogen.	HG	NETH.
Orsted A/S	Green hydrogen directly from wind power, early stage.	GH	DENMARK
Plug Power Inc	Green hydrogen, and fuel cell systems in development.	FC	USA
PNE AG	Power-to-X, wind power directly to make green H2.	GH	GERMANY
Powercell Sweden AB	Fuel cell systems, both clean H2 and fossils for fuels.	FC	SWEDEN

Proterra	Heavy Bus electrification systems, early H2.	HI	USA
Scatec ASA	Green Hydrogen produced by solar power.	GH	NORWAY
Schneider Electric SE	Gas analysis, automation for advanced H2 storage.	HS	FRANCE
SFC Energy AG	Direct methanol and H2 supplied small fuel cells.	FC	GERMANY
SGL Carbon SE	Polymer electrolyte membrane in PEM fuel cells.	FC	GERMANY
SK IE Technology	Converts low-purity 60% H2 to high-purity 99% H2.	HI	S. KOREA
SKF AB	Advanced bearings, for H2 by compressed transmission.	HS	SWEDEN
SMA Solar Technology	Electrolyzer converters, green H2 from renewables.	GH	GERMANY
Toray Industries	Membranes for H2 purification, generation, fuel cells.	HI	JAPAN
Varta AG	Hydrogen gas generating cells, ultrapure.	HG	GERMANY
Verbio Vereinigte Bioenergie AG	H2 from biomethane, biofuels, agriculture.	HG	GERMANY
Wacker Chemie AG	Green H2 from water using renewables, into methanol.	GH	GERMANY
Weichai Power	Hydrogen uses in forklifts, fuel cell buses, Asia.	GT	CHINA
Workhorse Group	Has done H2 fuel cells work on electric trucks.	HT	USA
Yara International	Green hydrogen catapault, aims for H2 <$2/kg.	GH	NORWAY

Weight each component: 100/52 = 1.92307%

H2X For Latter Q3 2022 - 52 Components

8 Deletes: Siemens Gamesa, United Renewable Energy, Xebec, 2G Energy, Hexagon Purus, Hyster-Yale, AFC, Hexagon Comp

9 Adds: 5E Advanced, Abalance, Advent, Bumhan Fuel Cell, Montauk Renewables, Navitas, PNE AG, SKF, Workhorse

WilderHill Hydrogen Index H2X
Sector

FUEL CELLS (FC)	9
GREEN HYDROGEN (GH)	11
HYDROGEN GENERATION (HG)	10
HYDROGEN INNOVATION (HI)	9
HYDROGEN STORAGE (HS)	7
HYDROGEN in TRANSPORTATION (HT)	6
	52

Appendix VIII:
WilderHill Wind Energy Index (WNX) for latter Q3 2022:

Wind Energy WNX - component	Theme	Sector	Activity
5E Advanced Materials	Boron, can be used in wind blades, motors.	WM	USA
Abb Ltd.	Wind turbines, generators and converters.	WM	SWITZER.
Acciona	Sustainability infrastructure, engineering.	SG	SPAIN
Aker Horizons	Sustainable energy includes wind, hydrogen.	WI	NORWAY
Arcadis NV	Engineering, EPC, develops wind projects.	WI	NETHER.

Boralex Inc	Development and operation of wind farms.	WF	CANADA
Brookfield Renewable Corp.	Pure plays renewables wind, hydro, solar.	WF	USA
Bumhan Fuel Cell	Offshore cable systems, grid. S. Korea.	WM	S. KOREA
China Datang Corp Renewable	Among largest listed wind operators in China.	WF	CHINA
China High Speed Transmission	Wind turbine gearboxes, heavy duty.	WM	CHINA
Corporacion Acciona Energias	Wind, global energy exclusively renewables.	WI	SPAIN
CS Bearing	Bearings, slewing rings used in wind turbines.	WM	S. KOREA
CS Wind	Wind power, both onshore, and also offshore.	WF	S. KOREA
Dongkuk Structures	Wind tower steel structures.	WM	S. KOREA
EDP Renovaveis SA	Wind, among the world's largest generators.	WI	PORTUGAL
Elia Group SA	High voltage power transmission, Europe/UK.	SG	BELGIUM
Encavis AG	Wind energy plants across Europe, solar too.	WF	GERMANY
Energiekontor AG	Wind Farm Developer, and group ownership.	WF	GERMANY
Energy Vault	Energy storage, re-purposing old wind blades.	WI	USA
Enlight Renewable Energy Ltd	Builds and operates wind, also solar sites.	WF	ISRAEL
FREYR	Wind used for new green battery manufacture.	SG	NORWAY
Fugro NV	Marine geoconsulting, subsea offshore wind.	WI	NETHER.
Greenvolt Energias	Wind, residual biomass & urban demo waste.	WF	PORTUGAL
Grenergy Renovables SA	Wind projects in Chile, Peru, elsewhere.	WF	SPAIN
Innergex Renewable Energy	Independent renewable producer, wind.	WF	CANADA
JL Mag Rare Earth	Rare Earths, in wind turbines, EVs, fuel cells.	WI	CHINA
Navitas Semiconductor	Inverters, power efficiency, newer GaN vs SiC.	SG	USA
Neoen SA	Wind, a lead French independent producer.	WF	FRANCE
Nexans SA	Subsea cables for offshore wind farms.	SG	FRANCE
NKT A/S	High voltage DC offshore wind, cables.	SG	DENMARK
Nordex SE	One of world's largest wind turbine makers.	WI	GERMANY
Orsted A/S	Renewable energy - transitioned from fossils.	WI	DENMARK
OX2 AB	Wind power generation, Europe.	WF	SWEDEN
PNE AG	Wind in Power to X, including direct green H2.	WI	GERMANY
Prysmian SpA	Cables for new offshore wind and grid.	SG	ITALY
Renew Energy Global	Utility scale wind farms, India.	WF	INDIA
Renova Inc	Independent renewable power producer.	WF	JAPAN
SBM Offshore NV	Offshore wind energy installations, wave too.	WF	NETHER.
Schneider Electric	Advanced grid, wind energy management.	SG	FRANCE
SGL Carbon SE	Composite and graphite materials in wind.	WM	GERMANY
SKF AB	Wind gear rolling bearings, seals, mechatronics.	WM	SWEDEN
SMA Solar Technology	Wind power conversion; green H2 from wind.	SG	GERMANY
Stem	Software, optimizes wind + battery + grid.	SG	USA
Subsea 7 SA	Offshore wind installations, also Seaway 7.	WI	UK
TECO Electric & Machinery	Turbines for wind energy, and EV motors.	WM	TAIWAN

Terna Rete	Europe's largest independent grid operator.	SG	ITALY
Toray Industries	Carbon fiber for wind turbine blades.	WI	JAPAN
TPI Composites Inc	Wind blade manufacturer, assemblies.	WM	USA
Unison Co Ltd	Wind turbine manufacturing, S Korea.	WM	S. KOREA
Vestas Wind Systems A/S	One of first, largest, wind turbine makers.	WI	DENMARK
Xinjiang Goldwind Science	Wind turbine maker onshore & offshore, China.	WM	CHINA

51 components = 100/51 = 1.96078% Weight each component

WNX For Latter Q3 2022 –
51 Components

8 Deletes: Infrastructure & Energy, Siemens Gamesa, Azure, Cadeler, Fastned, Gurit, Hexagon Comp., Voltalia

11 Adds: 5E Advanced, Arcadis, Bumhan, CS Bearing, Fugro, Navitas, PNE AG, SBM, Stem, Subsea 7, TECO

4 WilderHill Wind Index Sectors	#
SMARTER GRID (SG)	11
WIND FARMS (WF)	15
WIND INNOVATION (WI)	13
WIND MATERIALS (WM)	12
Total =	51

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
A prior, live OCEAN Index for cool climate was terminated latter 2022, https://climateandclean.com
1990s antecedents to H2X; original WilderHill Hydrogen Fuel Cell Index is at http://h2fuelcells.org

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