WilderShares, LLC

Q1 WilderHill® Quarterly Report: ECO, NEX, H2X, WNX Indexes, March 31, 2023

The Clean Energy Index® (ECO) started Q1 2023 at 80 & ended Q1 at 84, so slightly up by +5%. After fast gaining +25% in January to 100, on mere hopes inflation might slow and Fed pivot - inflation instead stayed hot & ECO plummeted latter Q1 back under where it began the year. Last few years, ECO rose by +58% for 2019. Remarkably it then rose a big +203% for 2020 in about the best performance of any Index or Fund, anywhere. Unsurprising perhaps after such gains 2019 & 2020, ECO fell steeply -30% in 2021, and -46% in 2022 as inflation & recession fears, war & tight supply chains - overcame decarbonizing that may favor renewables ahead. Or since the start of 2017 when ECO was at 38, late Q1 2023 it was up by +120%.

ECO clearly is risky, it can fall hard. Viewed from peak 270s in 2021, down to 80s in 2023, this theme had plummeted by ~2/3rds. History amply shows ECO & NEX, like newest hydrogen H2X & wind WNX themes can & do at times 'drop like a rock'. Jumps up it's true, yet crashes too. A big volatility not only in wind & solar, but also all renewables, hydrogen & fuel cells, electric vehicles, energy storage, decarbonizing, greening of everything; it's always been thus.

Last 5 years benchmark ECO Index® live since 2004, 1st for clean energy, climate solutions, is up +70% to Q1 2023. That over a period when any energy gains might stand out. For same 5 years, despite their huge recent gains, oil & gas are *down by* -40% & -60%; they're *down some* -75% last 10 years. By contrast, decarbonizing as an organizing theme in ECO is *up* +90% last 10 years, showing very differing returns in sustainable energy. The first *global* clean energy Index is WilderHill New Energy Global Innovation NEX live since 2006, with US & European trackers; NEX is up +50% last 5 years, up +140% last 10 years starkly beating fossil fuels.

Still, green themes fell through 2021 and 2022. Here we offer a mere observation: it's counter-intuitive, perhaps, yet clean energy's theme and so ECO Index spiked up in Bush II & Trump - though neither loved green energy. Inversely ECO fell 8 years of Obama & 2 of Biden who favored it. Conservatives took US House 2022; liberals held Senate - for mixed leadership: thus 2023/2024 should be fascinating. In energy more broadly, oil & gas producers once hiked supplies - but after sparse profits they're keen to keep supply tight, prices higher. To be seen ahead if demand grows blazing summers or cold snaps in 2024/2025, even as storage gets countries past highest-use months - is how well supply gets rebuilt. And if inflation begins to cool, we note too ECO soared 200% in 2020, and by +10% on Nov. 10, 2022 on just 1 Report one day of a bit of cooling inflation; swift rises up like January 2023 happen too.

In sum 2 themes Hydrogen Economy (H2X) & Wind Energy (WNX) have joined respected original benchmarks ECO & NEX for 4 pure-play leaders. Meanwhile energy that was mainly fossil fuels dug from deep underground & burned – increasingly is found in the breezes & sunlight gifted freely, renewably and sustainably from up above towards Heavens. Here's ECO in Q1:

Source: NYSE.com

Several clean energy positives did show up with new year. In Europe green shoots began to sprout for whole new industries, green economies that may arise in windy North Sea region. Much scope exists for growth. Not hugely unlike how early hydro power had once, 19th century, led to 2,500 mills built – which in turn made ½ the world's cotton in Lancashire UK in 1860s. Or how cheap hydro led to aluminum making, so aircraft from Washington State in US last century. After all industry follows cheap energy. German Ruhr Valley coal led to steel furnaces, early industrialization. New, better economies *may* yet grow 2020s for green-made electricity, zero CO_2 products like say, green steel, EVs & batteries. Perhaps even green hydrogen (H_2), green ammonia (NH_3) as carriers for a cheaper new renewable power.

Vast European offshore wind has *perhaps* only begun to scale up. Turbines out at sea might operate at nearer 60% rated capacity - vs the 30%-40% for onshore wind on land. Nine North Sea countries lately aimed to install 260 Gigawatts (GW) offshore wind in <30 years to 2050, maybe 5x world's wind capacity as was seen in 2022. A bit like 24,000 biggish turbines. Enough to make electricity for 200 million Europe households. Some firms that once had kitted out for offshore oil & gas, might shift into offshore wind like near Esbjerg Denmark. That small town of just 72,000 souls could boast 2023 of having helped assemble some 2/3 of the region's offshore turbines, enough to power 40 million homes. From 2023 on it may aim to grow its capacity further by 3x to 2026, becoming a European and global wind power hub.

Harnessing resources like Northern Europe's winds might be duplicated say in Spain/Portugal - blessed instead with bounteous solar. Likewise, solar's Northern Africa potential could mean moving green electricity by undersea cable – or green hydrogen by ship, to voracious Europe. As horrid war raged, displacing desire for Russian fuel, one might sense an economic, climate window perhaps opening, better security wanted via wind, solar, EVs, grid, H_2 etc. Fossil fuels have brought us to today – but future (and opportunity) - belongs to sustainable energy.

A US Inflation Reduction Act (IRA) of 2022 was spurring investments too. For new US battery manufacturing, minerals refining, EVs, more. Car manufacturers aimed to 'onshore' battery making – to take advantage of sizable US Tax Credits. No surprise so many sought to build US supply from scratch. Of US battery projects, 1/4th were since 2022. A State of Georgia saw 30 plants announced. US Treasury drafted rules on what counts as US battery minerals, as US domestic EV content. Meanwhile firms looked to get minerals in greener ways, closing loops. One big US-based solar maker enjoyed a nearly 4 cents/watt premium with its supply sorted for tellurium, cadmium. Thus, some optimism in US, Europe, Asia; stock valuations first rose a fast +25% in January 2023, much of that on hopes inflation & interest rates peak, maybe allow Fed to pivot to lower rates. Yet was hard for riskier equities to compete with a 5% from far safer bonds! Stocks then fell latter Q1 2023 given rising inflation & so interest rates, bank scares, debt, and moves towards risk off. A big collapse of global confidence.

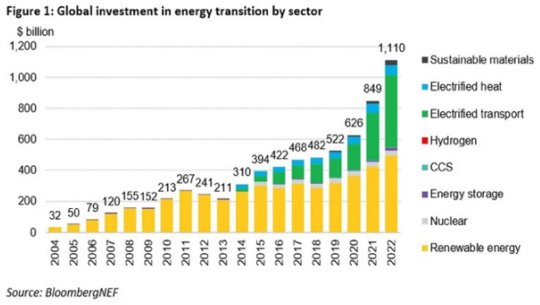
Amidst all that, came energy-specific changes. In 2023 first time-ever, it grew cheaper to *build a* new US solar/wind farm from scratch – than was to get electricity from *already-built extant* coal plants in US - for all but 1 US coal plant! With this 2022 IRA, coal had become the costlier option for 99% of US power plants. More $ than would be to build a new solar or wind farm, connect that to grid on free fuel. Of 210 US coal plants, just Dry Fork Power Plant in Wyoming was still-cost competitive. Marginal costs for US coal plants were $36 per megawatt-hour – vs. a far better $24 per megawatt-hour for well-sited new solar. Coal everywhere in US grew costlier to maintain given its frequent servicing, big staff, plus fuel costs. And there's costs too from its many pollutants beyond climate crisis carbon dioxide: coal's mercury causing brain damage, its sulphur dioxide causing acid rain, or its NOx, its wastes etc.

Green energy growth has been rapid. 3 decades ago, 11 now-tiny turbines were the world's 1st offshore wind farm: 5 megawatts (MW) total in Vindeby, Denmark. Offshore turbines now reach 15 MW – *each one turbine!* 18+ GW models have been unveiled. Just imagine ahead, 100 say, 15 GW turbine behemoths – or why not 1,000 of them, even thousands(!?). Wind in future may make more energy than nuclear. Indeed, China has immense ambitions for its own coming offshore wind – and it also has the raw, sheer ability to make it all happen.

Coal, was once crucial for America – like it now is in China. As one Harvard economist noted of US coal, "We can't shutter all these plants tomorrow; we need to do it in an orderly fashion to support grid reliability but we should be able to do it in fairly fast order. Coal has been on a natural decline due to economics and those economics are going to continue, this is a transition that's just going to happen. We built a lot of coal plants in the US around 50 years ago because we were worried about energy security in the world. That made sense at the time and they made an important contribution. But we know a lot more now about climate change, so now we need to make different decisions." Coal's US future, now, is toast.

A clean energy transition just starting; in 2022 the world invested $1.1 Trillion into low-carbon technologies. Was a 31% increase over 2021, a 1st time >$1 Trillion, to fossil-investing levels. What saw the biggest % gains within green tech – what was not-so-big % gains in 2022? Larger increases came in electrifying transport: jumped 54% year over year, to $466 billion. It gained to near the totals for renewable solar, wind etc at $495 billion – latter only up 17% vs 2021. Other than nuclear which had flatlined most places – these new investments across green energy storage, electric heat, electrifying transport all rose. Hydrogen lately has even drawn some interest, though it received 'only' $1.1 billion in new investments in 2022. Still, H_2 was up 3x over a prior year, 2021. Yet items which can yet stop growth in its tracks, persist – severe global recession, inflation, debt bomb, all were also real fears mid-2023.

<u>Energy (green transition) investments in 2022, from Bloomberg New Energy Finance</u>



So much driving demand, the International Energy Agency (IEA) opined in 2023 that even with war in Ukraine, so efforts to conserve the world's electricity demand still *grew* by 2% in 2022. It forecast in 3 years to 2025, demand may grow 3% per year. Over 90% of that *new* demand, maybe met by renewables+nuclear. Thus renewables may rise from 29% of power generation in 2022 - to 35% by 2025. US (pre-IRA data) may lag in renewables growth making only 6%; the EU may make up a better 15%, while China could be an incredible 45% of that growth.

Thus, China dominates. A recent equivalent USD $546 billion worth of investments, it was #1 – far ahead of a US at $141 billion, or EU led by Germany, France; or UK's $180 billion. For factories to manufacture clean energy technologies, investing rose from $52.6 billion 2021 – to $78.7 billion in 2022. Unsurprisingly, China saw a remarkable 91% of those investments; China has been moving so far farthest, fastest too, with supply chain diversification.

And yet. Note these figures are NOT Anywhere Near Enough. Bloomberg New Energy Finance (BNEF, an early partner on NEX) estimates the world must invest on average, *USD $4.55 Trillion per year – each year rest of this decade(!) to be in line with BNEF's Net Zero Scenario*. IEA says *$35 Trillion more* must be invested in a handful of years still left to 2030; deployment must go from 3,000 to 10,000 GWs – if we're to stay under <1.5 degrees C of heating.

China was, and is the 800-pound gorilla; its growth yes, has made renewables cheaper. Yet, on current trends, while we think of Oil as being way-over-controlled by OPEC – control China exerts on green manufacturing has become greater. In so many ways, its dominance is huge; take cobalt currently needed in many battery types, 95% of world cobalt is refined in China. New battery designs ahead may no longer need any cobalt; so, 1 stranglehold may be broken. But, what of nickel, what of graphite?! Industries like silicon-solar modules, cell manufacturing, global capacity for EV battery production, China leads with 70%-75%. By comparison 14 OPEC nations control 40% of oil's supply; OPEC+ with Russia jumps to 60%. Compare that early 2020s with China, with sole-hold for green tech greater than OPEC in oil. This conundrum grew entrenched last decade. China intentionally became THE global leader in wind, solar etc as it took some 80% of market share. And it aims ahead for EVs too.

Ok only in a sense its affordable PV panels are exported. Cheap solar is global, a win in climate crisis. From 2010 to 2021, solar-electricity costs fell 90%. To build a solar factory in China might cost 1/5th of in US, Europe. Conversely electrolyzers may cost 5x more to make in US or Europe 2023 – than China - so catching up isn't easy! But there's issues too in China's product. Some PV panels from there were intercepted, held at US border over concerns on a number of fronts (discussed ahead). In first days of 2023 US Customs released meaningful numbers of solar panels once withheld, for a bounce in some Chinese solar stocks. In 2023, US looked to maybe lessen restrictions on China's accounting (non)transparency – on an HFCAA Law that threatened delisting from US exchanges; so, another dark cloud may dissipate. Yet new issues appear. Aims for energy security, diversification, decarbonization, onshoring green jobs: all argue for new green production – outside China. Even if costly short-term. In related matters new studies show even dirty-coal China might reach its own domestic zero carbon power aims in <30 years by 2050 – at costs less than 1% of its GDP(!). Wow. So, there were some causes for optimism. And clean energy stock P/Es fell 2021/2022, to make some equities perhaps more akin to value, than high P/E growth. *If* inflation is tamed some, *if* capital gets cheap, *if* supply chains loosen, perhaps animal spirits *may* return. But other side concerns over near US default on debt, war in Ukraine, global recession, cast dire shadows too.

China, very soon, will make EVs so innovative, they'll challenge the world's very best. Its firms work hard & work smart, with policy support: China is determined not to miss this EV chance. For a scale of their EV embrace (like in renewables, batteries too) – consider: 650,000 new public EV chargers were built in China 2022 – that was 10-fold the USA. Four million EVs were sold in China 2022 – over 4x the USA. Hundreds of thousands of chargers installed each year in China, 1.8 million at end 2022; though low-utilization rates, they dwarfed a 30,000 China total only a decade prior. In 2022, 380,000 EV chargers were placed just in Guangdong Province, China - 2x whole USA. Doesn't count the 2.6 million private home chargers into China 2022. They have 1 standard EV plug by design; contrast that with USA's several plugs. Or compare USA J1772 to a far-better plug designed by America's biggest US EV maker. Plus, China has standardized its apps for payments, less range-anxiety in its cities. Meanwhile, for US to even keep up with its own slower pace of American EV sales, so reduce range anxiety, America's EV charging stations must still grow by four-fold in number by 2025.

Other side of coin, juxtaposed, are strong reasons for a bearishness in clean energy, too. True, billions, or even a $ Trillion+ dollars may go into USA solar/wind/EV tax credits due to an uncapped IRA – but many renewable projects in 2022 were slowed, or halted. Supply chains in solar, wind, EVs stayed chock full of difficulties. For instance, approvals to connect to grid are taking too many years, sometimes a decade! Local regulations & local protests all vex as opposition builds to what's been proliferation in wind/solar/EVs/grid. In US, big wind project starts fell by a dramatic 77.5% in 3rd Quarter 2022 – vs the 3rd Quarter 2021. New big utility-scale solar projects fell 40% in 2022 – vs in 2021. Despite clear demand for green electrons from green projects: importantly that demand remains rather gigantic in size.

Investors early 2020s had *wanted* to pour $ billions into renewable energy. But solar panels mainly were imported from China; those were often held back by US tariffs battles. America's President did temporarily suspend tariffs to avoid impasse on 4 Asian nations circumventing, by finishing the panels – but it ends 2024. Some China panels were held at US border too over lack of transparency on whether forced labor was used in their manufacture. Furthermore, troubles arose as well over non-transparency in the scrutiny done by China's Accounting firms. A US law perhaps may lead to some of China's solar & wind stocks even being delisted off US exchanges, so deprive them of capital; that last issue was maybe avoided in 2023.

Then came other troubles. California, once a solar leader, cut back dramatically in the value of home solar 2023. Also, as new wind turbines globally grew in size, unreliability there caused some wind makers' warranty costs to double. Industry needs improve the reliability in its huge say 15 MW turbines – before turbines grow further in size. The US Treasury was slow to proffer details on how tax credits are implemented. A Senator who'd diminished the IRA, was surprised by criticisms of it aired at Davos 2023 over incentives to build green in the USA. Europeans, more accustomed to sticks – than carrots – (rightly) feared it was driving Euro-companies to USA. That miffed European leaders, so EU-wide calls grew for a European Green Deal Industrial Plan mimicking America's own IRA, a new deal with carrots to draw firms back to old-world continent, race to top. Largely thanks to IRA's passage 2022 – America in Q4 2022 did see $40 billion in new projects announced for US solar, wind, battery storage; about as much as all of 2021. Private companies & public entities alike contracted for a record 36 GW clean power in 2022, up 18% over 2021. Many firms clamored to invest in clean energy. Whether wanting sincerely to decarbonize – or just show merely virtue signaling – either way, the demand to contract for clean electrons in early 2020s was enormous.

That demand though had had to contend with long lead times for high voltage equipment - gone from 30 weeks – to 70 weeks. Proposed standalone-battery projects suffocated by wait times for grid connections stretched places to 2030s. Far more interconnection requests were made, fossil fuel plants as well - than built. Lately only 23% of requests, were built. 19 GWs of wind farm proposals were later withdrawn (only 20% completed). 60 GWs of solar was requested - 16% completed. In 2020 there'd been 5,600 connection requests. 2021 saw a grander 8,100 requests: clear how grid operators who didn't up capacity got overwhelmed. Back in first decade of the 2000s, wait times had then averaged a big 2.1 years/per project. But 2011-2021 that rose to 3.7 years. It only got longer and worse in 2022 then 2023.

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

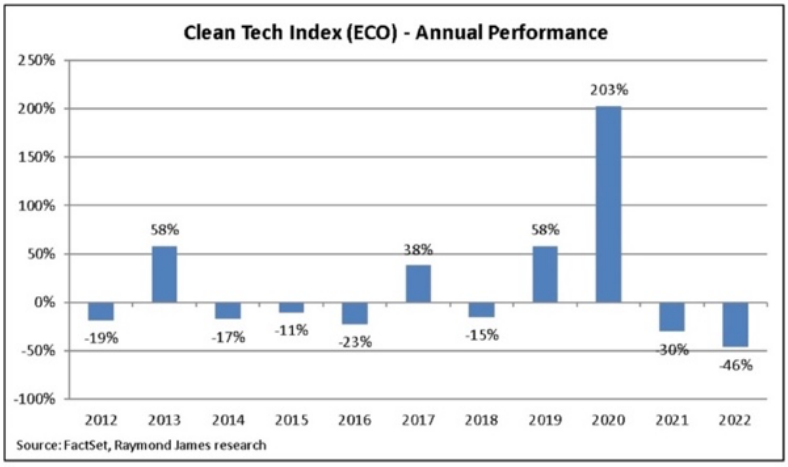
At times, local anti-renewables sentiment, opposition went hard against renewables in 2023. For example, Poland looked to potentially revise its earlier 10H requirement which earlier had stated new wind turbines must be sited a distance at least 10-fold height of wind turbines from houses - to instead from 2023 maybe require a much bigger >700-meters buffer be substituted in, with discussions in lower House of Parliament. Its prior 500-meters buffer had once allowed a 25-fold greater land availability for potential new wind projects. Poland long had been it still is coal-reliant; fossils are not simply going gently into that good night.

Fights brewing too as to what constitutes 'green hydrogen'. In US some fossil-tinged players are claiming that they can generate H_2 (hydrogen) from regular electricity mains (the grid) that's typically run too on fossil natural gas and/or non-renewable nuclear power – via the 'trick' of buying RECs (renewable energy credits) from wind & solar, even if it was generated distant places and times. They'd still call that 'green H_2'. So combine not-really green RECs - with electrolyzers making H_2 – and calling offspring 'green H_2' no matter the power source. They might then market that H_2 as 'clean' – as if it were made from just wind or solar.

Europe in 2023 responded by drafting new rules-to ensure green H_2 is well & truly made by, connected to real renewables locally sourced. Guarantee green H_2 really is generated by solar at same time sun is shining, or wind is blowing. That H_2 is made from 'additional' truly-green-electrons. Rules too for the renewable fuels of non-biological origin (RFNBOs) were drafted. Unsurprisingly France pushed of course to add nuclear into defining low-carbon H_2. Some championed biomethane, to capture 'renewable natural gas' from landfills or ag wastes; this makes some sense as avoiding methane release is a useful, fast way to limit greenhouse gases. Whether Europe, or US, a big issue early 2020s was the gray H_2 from fossil (dirty) natural gas - was still much cheaper @ €1.50/kilogram - while green H_2 had cost 2x-3x more. Yes, by end of 2020s it's very possible *Green* H_2 will then be cheapest. Helping then make brown or grey H_2 obsolete. But, in early/mid-2020s this higher cost for green was a problem.

In short, much uncertainty reigned across clean energy in a prior 2010s decade – and then early 2020s. Much in flux. It's been no surprise then to see great volatility dominating this stocks theme for clean energy. There's been many big falls, yes - at times some big gains too. This chart captures the theme first & best defined by ECO Index live since 2004 (Global clean energy NEX since 2006) for the high-beta nature of ECO in 10 years, 2012 to 2022:

10 Year Performance of WilderHill Clean Energy Index (ECO) to 2022; Volatility is clear:



Source: Raymond James Research; Factsheet.

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

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

Yet rarely, is news 100% good; no exception here. Last decade, wind & solar got ever-cheaper near-every year – vs. a year before. But that ended at 2020s. Instead, 2021/2022 saw *rising* costs to buy green energy. Wind power prices in 3rd Quarter 2022 were *Up* 37% year over year; solar was *Up* 30%. A lot! To be sure everything else was up too; higher prices for fossil gas, oil/ diesel, coal, nuclear etc. Still, no looking away from the higher-prices in renewables too. Higher wind/solar 2022 didn't kill green demand. Rather on gas costs, tight supply chains, coal demand rose 1.2% in 2022, set a sad new world record of 8 Billion metric tonnes.

Inflation had meant = higher costs for everything. Solar panels start of 2022 had cost 35 cents/ watt. By mid 2022, nearer 45 cents, then 50+ cents. European power purchase agreements (PPAs) for blended wind & solar generation 3rd Quarter of 2022, jumped 11.3% to €73.54 per megawatt-hour (MWh), 51% higher than 3rd Quarter 2021! Europe beleaguered by over-reliance on (Russia) gas, saw fossil-electricity prices some cases hit €500 per MWh(!). Among renewables prices rose 2x faster for solar - than wind in Q3 2022, solar rose 15% to €68 per MWh, wind rose 8% to €78 per MWh. Still, prices were much better than for gas in 2022 which saw more coal, clean energy bottlenecks, rampant Permitting delays, long waits to connect to grid. Windfall profit taxes proposed for renewables, failed energy auctions. Highly volatile gas prices would soon fall hard early 2023 – but that was more so in the US, than Europe.

Where it gets interesting, is what plays out ahead within this decade. Europe now sees big imports of Russian gas as unacceptable. Natural gas, once-so-cheap-in-Europe, may not re-appear as-cheaply, least not right away. Yes, Europe gas prices coming down off record spikes ahead. And, barring recession, war, it may be a while before <€45 megawatt-hour (MWh) gas is again seen at the Netherlands hub like 2021. A once-crazy €300, or €135 MWh seen 2022 could re-stabilize much lower ahead – but, maybe not near its low 2019 fossil prices. Those perhaps not seen again soon, if China re-opens and with it, new global demand for energy - that again may make renewables even more desirable. Barring recession. A 2022 Report from one energy analysis firm had laid out a few possibilities ahead. One was that French nuclear comes back late 2023, corrosion fixed. Despite drought 30 GW of firm power back (this was not on track 2023). By end 2023 it saw wind & solar at 50 GW, though intermittent. If Europe really kicks in renewables, stays keen on security/inflation/and climate risk concerns, it could have new 100 GW of renewable generating capacity online by around 2025.

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3 years on, latter-decade they saw Europe with maybe 333 GW green generating capacity. Enough to replace roughly entire gas-fired electricity fleet as was seen 2022. (Thank you key green energy storage). Europe, by continuing to invest and install renewables, also has then pushed down its own capital costs for new green energy capacity to just $1.30/watt. Even if European natural gas as fuel re-stabilizes at lower cost late this decade, costs falling to under €30 per MWh – that still means levelized cost of energy (LCOE) for gas-fired electric power is too high. *By that point, electricity from solar late 2020s can then be just one-third the cost of using gas in Europe!* Gas thus becomes non-sensical. Gas futures need to sell at just €17 per MWh (or less than Dutch TTF Futures at €17.35 seen say Jan. 2021) - to compete with solar, a level that report understandably, regarded as unthinkable. Back under €100 sure, maybe – but to go under €20 No sure thing at all! If once-cheap Russian gas no longer makes EU electricity, much changes. Poland, Estonia, Czech, Netherlands, UK, re-up nuclear power. Renewables solar and wind win on Security & Climate concerns. Remaining natural gas plants can/do linger, yes, but more as backup power, or used in weather extremes.

Compare that to US in 2022, as gas-fired electricity has long led, it met 39% of US demand. Gas prices rose some on war and export demand – then fell on tighter storage. Abundant US gas+shale+fracking kept prices cheap/er - than Europe gas. Overall, US renewables in 2022 met 24% total US electricity demand, a record. Jumped from 20.6% in 2021, US renewables as wind, hydro, solar – and bits of biomass, geothermal. First 8 months of 2022 US wind energy grew 22% YoY to new high, met 10% of US electricity demand. Solar grew 27% to meet 5% of US electricity demand. Given US natural gas is far cheaper than in Europe – US renewables are still becoming best choice given their low cost, but not by so great a distance.

Yet all energy suffered 2022 from inflation. Blended US wind/solar power costs rose in 2022 to $45.93 MWh, up 34% from 2021. Compare that, to US costs in 2018 near $30. Cost rises *may* slacken ahead – especially if steel, labor, shipping stabilize, fall. Or may fall a bit, plateau fairly high and stay a while, not falling yearly as before. Needed is no war, much looser supply chains, far lower inflation, better predictability/support; all much-desired in clean energy.

That said gas too in Europe/UK may stay pricey; its gas storage (1,129 TWh) only meets 21% of its demand (around 5,000 TWh). Which EU nations moderated their own cost electricity increases 2022? Which, *relatively*-successful? All Europe struggled on gas electricity & heat. As gas jumped continent-wide, it did so too of course in Spain: Europe's biggest LNG plant is in Barcelona. Note then, Spain & Portugal stood out for relatively-better priced electricity. How? All European nations looks 'first' to best/cheapest power, so oft to wind & solar; they'll also first turn to at home-hydro, coal, nuclear. But they rely most important of all, on costly natural gas to meet a key remainder of demand. Natural gas is firm & dispatchable. It ensures the overall grid stability: gas is thus what determines the overall 'price for electricity'.

This energy-pricing system birthed 1990s, is a bit absurd today. Means that now-costly natural gas is key fuel to determine what all power plants are paid, per megawatt. Hence for nuclear & renewables (latter with free fuel) as fixed-cost generators – it meant that in 2022 they got financial 'windfalls'. These 2 zero-CO_2 sources, clean+nuclear benefitted in 'unforeseeable' ways, from spiking gas costs. As for Spain & Portugal, they'd cleverly asked the EU early in that year to allow a different pricing mechanism. As they'd used relatively a lot of renewables solar/wind, and had fewer connections to pan-European grid, relatively less reliance on Russian gas, they were granted Exceptions. Spain was already importing much of its gas via LNG vessels (not pipes) and that came more conveniently from Algeria, US, etc.

That change separated € paid for gas which might rise to €100, €200, even €300 per megawatt – from a set €40 'fixed cost' for zero-carbon hydro, nuclear, wind, and solar. In effect this kept better, deflationary, zero-carbon generators from enjoying greater profits - as gas-costs soared. Much natural gas still was being used – yet it proved relatively less-inflationary for these 2 Iberian sister nations, Spain & Portugal. There were interesting consequences.

Spain, first 4 months 2022 reduced its consumer bills by a big €3 billion. Spanish electricity bills were then 35% lower vs. Germany, 70% lower vs. Italy. Portugal's consumers saved 18% vs had it not been done. But problems arose too; Portugal imported *more* Spanish electricity from drought at dams. France bought *more* cheap Spanish power. So in turn Spain had to buy & burn more gas. All in, Spain found itself burning 2x as much gas ironically in 2022, as year before. Electricity prices in 2 Iberian nations were lower, yes, than rest of EU – but higher than in past. As EU gas was costly, renewables/storage not yet big, troubled fossils prevented truer solutions. Then EU 2022 proposed a twist: a windfall profits tax on 'inframarginal' generators: renewables and nukes would see revenues capped at €180 per MWh – on grounds those generators saw higher profits than expected. On revenues "never dreamt of". But then such windfall profits tax also *Discourages* new investments – opposite of what was wanted! Spain 2022 capped all renewable energy bids in Auction at under <€45 MWh – when most project costs were nearer €60+ MWh given inflation. That led to failed auction results.

Globally, spiking gas prices hit nations in diverse ways. China pulled back off early promises to move off coal soonish. Yet some locales planned enormous renewables. Chaozhou City, Guangdong China began planning for a 43.3 GW offshore wind farm from 2025. 50 to 115 miles off China, this windy sea could run turbines 43% to 49% of the time, or 4,000 hours/year. Notably China alone 2021 added more new offshore wind capacity at 17 GW or 80% of world's new 21 GW – than rest of world past 5 years, together! Of global 54 GW offshore wind 2021, China was half. One 43 GW farm could make more electricity than all Norway's power plants made in 2021! Thanks to China's subsidy of 850 yuan (USD $134)/MWh (then ending). And that also fully put to shame America's puny plans for 'just' 6 GW new offshore wind by 2029.

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

So some big points are, war perhaps "triggering an unprecedented momentum": IEA made its "largest ever upwards revision" of a renewables surge, 2,400 GWs next 5 years, renewables to overtake coal as world's biggest electricity source by 2026. Elsewhere, beyond IEA: we may be nearing end of a 'Great Moderation' of both long-declining inflation, plus growth 40 years … left in shambles by carbon-laden fossil prices. Meanwhile better renewables have not yet grown enough to fill that hole. Far more impactful, maybe, can be end of a Great Moderation of last 7 millennia too, in climate; that once let civilizations flourish. If next lost to a hothouse Earth, that may challenge the ability of our cultures, even our species to survive.

In equities, a few factors help explain why green themes were so down 2021 & 2022 – except July 2022. July was on a Yes by 1 Senator to begat an Inflation Reduction Act (IRA) of 2022. Its $369 Billion a smallish yet notable step on climate and CO_2; still its uncapped aspects may lead to over $1.2 Trillion in federal outlays. $3 Trillion more in investments by businesses. Note: wind/solar won bids 2022 in a UK auction reaffirming they're best-priced utility-scale electricity; obliterated costlier legacy fossil fuels. French nuclear was slammed by surprise corrosion 2022 that took ½ its capacity offline to levels 3 decades ago; summer heat/drought made cooling dire too. And on war Europe was hit by little Russian gas, undependable fossil fuels (fossils) & nuclear. Thus, energy (in)security spiked all 2022. Fossils spewing the CO_2 linked to weather calamities, lost lustre - vs. intermittent, yet many-ways better renewables. Green energy may get robustly-more-firm, thanks largely to fast-improving energy storage.

In an energy transition begun badly, gas & winters weaponized, weather mimicking extremes once felt decades out, seemed 'center might not hold'. Some societies especially if used to stabler climes, may yet be rent asunder. Climate collapse *possible*, shortages of gas/power, food/water; attacks on grid. Climate whiplash ironies of droughts and flooding, record heat and cold snaps – cast sustainable energy in new light. India maybe soon in heat, in extremis. Meanwhile rich & poor forced in places to blackouts, some to burning coal & wood.

Hence July's-jump was on 1 Senator getting what they'd demanded, far less $ spending: 1/5th what the President initially wanted, 'just' $369 billion. Fossils & nuclear got new incentives; a gas pipeline promise, and try to streamline Permits for all energy; cut prescription drug costs, Obamacare subsidies extended. Revenue-side, big US corporations will pay >15% tax. Some Deficit Reduction. Much was slightly Deflationary; the Senator so named the Act. And Senate majority leader got desired Chips Bill, a minority leader had before held hostage. Smaller items too like a top White House Aide apologized for heated words half a year prior. Thus was a weak and much-slimmed-down, totally defanged IRA birthed mid-2022. After a tough and draining 18 months-long labor. Delivered in hot weather in extremis.

In that brief result, green stocks jumped July 2022. Seen too in competing Indexes born after ECO Index® like one for global 'clean-ish' energy big-caps only; or one smartly for solar-alone; or one for EVs & Batteries, etc – capturing narrower bits & pieces. The ECO Index live since 2004 is the 1st & most comprehensive Clean Energy Index® - and it briefly jumped. 1 day before Senator's change of heart (was a bit foreseen, discussed ahead), ECO had closed at 100 (99.95). Just 8 trading days later it was 125, up +25%. Then like in Q1 2023, it fell back.

That carrots-only 2022 IRA, was far short of avoiding emergencies: CO_2 is rising fast. Its $360 billion only felt big for it barely got the 1 needed vote. But note: on greenhouse gases, $100 *Trillion in Climate investments* may be needed globally! Yes, uncapped IRA *is* a tailwind. Compared to last decade, just one renewable – big hydro had once met 10% of demand, but big dams can't grow – and so with an IRA we turn to wind & solar. Wind & solar growing vastly better, fast. End of last decade wind had met just 7% of US demand & growing; solar met 3%. So 10% from wind + solar plus 10% hydro – then met 20% of US demand end of last decade. Another 20% was met by nuclear – as 40% zero-carbon sources. But other side of ledger, gas & coal had met all other US electricity demand. That natural gas & coal is firm & dispatchable; it took care of ~60% of US needs end of last decade. Transportation & heat too were met by oil, diesel, gas, coal last decade: thus electrifying all will take years. A long-ways to go! Hence a 2022 toothless IRA maybe felt like progress, but in truth, we're early innings. We'll discuss ahead throughout this report, where new clean energy may be headed.

First look wee bit forward. At US electric generating capacity-built say, 1st six-months 2022, since that helps show where US electricity may head soon in 2020s. My, that's changed! 2/3rds new US power capacity built 1H 2022 was solar/wind. Wind led at near 6 gigawatts (5,722 megawatts) of newly-installed utility-sized wind (>1 megawatt). New solar was 4 GW (3,896 MW): they together were 67.01% of all power built 1H 2022. But, bigger picture alarms for they aren't anywhere near 100%. Of 14 gigawatts (14,352 MW) US generating capacity built in 1H 2022, near 5 gigawatts (4,695 MW) or 1/3rd of that, was still natural gas.

Geothermal, should now be a big, firm, dispatchable renewable. In future, gyrotrons might dig ultra-deeply anywhere – for steam used to run say, relic thermal plants. But for now, it's far too costly, a puny 26 MW capacity was built. Biomass can be dirty, albeit renewable; just 2 MW was built. In a US then hit by drought, just 2 MWs hydro. Unsurprising, no 2nd generation costly risky US nuclear fission plants were built – nor any new US coal. Unlike other nations in 2022, when even a rich Europe became forced due to war, back to burning coal & wood.

We're locked into natural gas plants until retired. Flip side, is a fast-coming new solar & wind pipeline. The US Federal Energy Regulatory Commission had early in 2022 estimated ~200 GW of new US solar was in pipeline to be built in 3 years to June 2025. 66 gigawatts were a 'high-probability' to be completed. And solar isn't hit by retirements - unlike coal, oil, gas, nuclear, all hit too by fuel costs, breakdowns, maintenance, shorter lives. Just on solar's most-likely new projects alone, it could soon double what was 2022's US utility-scale solar capacity, to 74 GW (74,530 MW). And, if all solar pipeline seen in 1H 2022 gets completed, it might raise solar capacity near 4x. Plus those figures were compiled just before IRA was signed 2022; the IRA law will no doubt stimulate more new US solar building ahead, even faster.

US wind capacity to be built to June 2025 may be 70 GW (70,393 MW). To 2025 a high-probability is new US wind & solar capacity together may pass 2.3 GWs being built/month, not including distributed solar on homes, or geothermal. Watch geothermal later this decade; for years US geothermal (most of any place) was stuck at around just 0.4% of total electricity mix: but deeper wells could expand that. Much US solar/wind is expected first ½ this decade. Much new offshore wind later on ahead. Pretty good. Yet still, not nearly enough.

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

As natural gas costs spiked in 2022, many burned more coal, devastatingly moving us all past already-burst global carbon budgets. No chance for 'just' 1.5 C degrees hotter. Physics & chemistry are well known, the heating by CO_2 has been well-understood by scientists for decades. Look ahead, on present trends we're rushing past a worse, 3+ degrees C of heating. Then hotter busting past unprecedented gigatons of CO_2. With global blazing summer temps, we humans will flee to cooler climes, a 'Cold Rush'. Nearer-term there may be gas-rationing in war; warmer & vanishing-shorter Winters, plus hotter Summers = despair. We've written for years about the Thwaites Glacier and melting ice sheets, sea-level rise, e.g., https://blogs.scientificamerican.com/guest-blog/exposed-the-climate-fallacy-of-2100 Or look back, for clues as to what's maybe ahead: drilling 2 miles below Antarctica's ice lets scientists look far back in time. Peer at past climates, air bubbles in ice reveal that CO_2 has generally hovered within a rather narrow range, over a past 'just' 1 million years.

A bit of geology helps looking back over vast eras – far longer than vs. last few Quarters in a Financial Report! CO_2 had dropped very hard in a past Ice Age to 160 ppm (parts per million). Such naturally bitter cold times, long before we humans, are explained by the fact that Earth moves very predictable ways around the sun, in varied not-perfectly-round, elliptical orbits. Over tens of thousands of years plus, this globe also moves changing ways too by 'precession' and 'axial tilt' like a top spinning on a table. 3 predictable changes explained by Milankovitch cycles, varying amounts of warming solar energy hitting the Earth over time.

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

Earth's CO_2 levels had varied little in a most recent 1 million years. From around 160 ppm in Ice Ages - to some 2x so near 280 ppm by start of Industrial Revolution. Weren't then higher – for one must go back 4 million years for much hotter Earth, over >420 ppm, like today. When CO_2 did start to rise hard, it generally took thousands of years. Vast CO_2 that we now spew in a compressed 2-3 centuries, means huge heating is baked in, that's just begun. Much, much, much more heating & so long sea level rise unfolding over millennia+ ahead. May become normal to see lethal temperatures in tropics of 50+ degrees C (122+ F). Normal Arctic Circle temps over 30+ C (86+ F); hellish hothouse *conditions,* far sooner than a hothouse *state*.

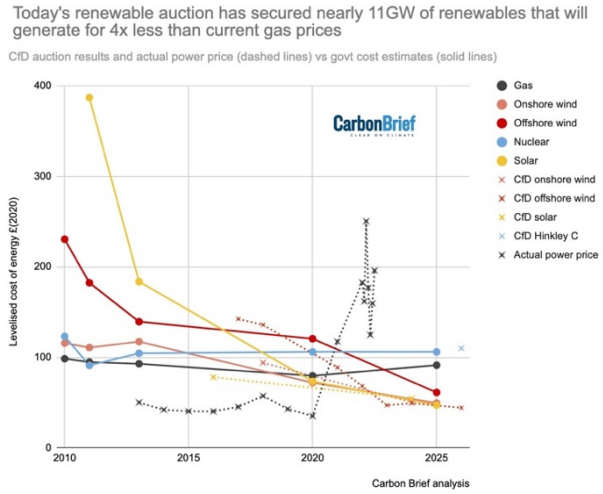
Hence our problem: massively burning fossil fuels, we've put in our atmosphere 'old' carbon that was safely locked away for millions of years. To go on for decades. Natural gas is 4 parts H per each carbon C atom, the most hydrogen/least carbon atoms, 4:1 ratio, CH_4. For marketing, that industry likes to call itself 'clean' (it is Not!). Burning that molecule is only bit less-horrid, per ton, for carbon & other pollutants, than burning oil / coal. Or take black coal, anthracite. Nearly all it is carbon C, very carbon dense. Burning just 1 ton of that poison for electricity makes 4 tons CO_2 – far more per ton than gas. Coal spews 67% more CO_2, plus toxic mercury, particulates, sulphur dioxide, awful ways to make power! Young wet brown coal full of impurities is burned; incredibly, it's worse. For wet-bulb temps that will kill.

So it's remarkable that war in 2022/2023 spiked gas prices – and so more coal was used. In June of 2020, US natural gas had cost $1.48/million BTUs; but in Aug. 2022 it hit $9.00+, up +500%: up more elsewhere! China rationed electricity in 2022. A Europe that 2020 was near off coal, returned to it. More global coal a death knell for climate health. Short-term, coal did give warmth & power. But there's a price burning that carbon gathered only over millions of years, releasing it at once. Yes new EVs & renewables helpfully meant overall CO_2 emissions could hold near steady (despite that coal), or drop a bit mid-decade – but, *sizable reductions in CO_2* and in GHG concentrations in air were/are needed. And for electricity to be made far more sanely than burning fossils - or a Zaporizhzhia nuke being shelled in war, where ability to keep cool & safe was under threat(!). Tsk tsk, all silly ways to boil water.

A UK power generation auction 2022 pointed maybe towards paths to come. In Europe/US much electricity is gas-fired; the big infrastructure means not much changes fast. But, auction results 2022 showed far-cheaper wind, solar, & tidal, can/will displace much UK gas-fired power ahead – a record 11 gigawatts/GWs of new green electricity won bidding – at just 1/4th cost of gas! Put another way, mid-2022, green-power Bids were 4 times cheaper than then-current gas-fired electricity! Consumers' bills can *drop* thanks to renewables which are deflationary. But only if more renewables (thanks, free fuel!) can be grown fast enough.

That 11 GW = enough to power 12 million UK homes. Yes, 2022 prices for all, wind, solar, oil, gas, coal, nukes, did jump. Yet remarkably 2022's 4th UK Contract for Difference (CfD) offshore wind bids were near 70% lower, than 1st Round in 2015! Last 7 or so years to 2022, offshore wind got far cheaper. Electricity from fossils+nuclear all jumped in costs – while new energy wind/solar in a long 7-or-so years to 2022 saw huge cost *decreases*. (Then gained 2022/2023). Good, for all (but fossils)! Bidding cleared prices £GBP/MWh were very low: offshore wind was just 37.35; onshore wind 42.47; solar just 45.99. Frankly those 3 bids blew away all 'once-cheap' fossils, and thus certainly they beat priciest nuclear power too.

All indicative of what's happening, globally, a factor for green stocks. Of UK projects bid in 2022, a largest share, 7 GW with 93 winners was offshore wind. UK could grow offshore wind capacity about 1/3rd, reach near 50 GW+ by 2030. With a notable low-price bid of €37.35/MWh, offshore wind then nicely was near cheapest electricity of all. Nearby European Ports like Danish City of Esbjerg were ready to ramp wind on EU-side too. Increase offshore wind to targeted 150 GW by 2050. On 2 Nov. 2022 the UK sent a record 20 GW (20,896 MW) wind energy to grid; met 53% of UK electricity demand. Wind/solar/nuclear/ hydro/storage, together had met 70% that day. In a global-war-emergency, here was a spot of happy news. UK consumers could pay less, get more abundant, secure domestic electricity, jobs too. All thanks to welcome growth this decade in *deflationary* wind & green energy:



Source: CarbonBrief

Startling above is how swiftly wind & solar costs plunged 12 years. As natural gas' story went from relatively 'lowish' costs 2010 – nuclear too – to both being ghastly expensive in 2022. It's a tale we'll tell pages ahead. Not so much about volatile costs for fossil fuels, nuclear – as about lovelier cost-reductions in clean, innovative renewables. Wind & solar fast had become, simply put, the most affordable electricity. 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 vs. in the US. Why? For starters Europeans didn't pay solar tariffs like US buyers have had to do for clean energy kit from China. Didn't have America's state by state added net metering costs. Nor the same restrictions on China. Plus natural gas is a core competing fuel in Europe, and natural gas has been very expensive there, in mid-2022 at $40+ per Mcf. So, that gas option there was oft 3x or more than in US – helping make any pro-clean energy decisions far easier in Europe. In short it was easier & cheaper to install new wind energy & solar in Europe - than was in the US back in 2022.

Per IRENA data 2021, Europe already had cut its average all-in installed utility-scale solar costs by 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 more costly 2021 at $1.09/watt. Europe had shaved $0.10/watt to install PV relative to US. Surely in a world facing unending climate crises ahead, one may think decarbonizing fast is priority. But No. US had long championed less regulatory burdens: but lately the US had higher soft costs on solar – for design, permitting, installation – vs. Europe's burdens. Comparing a like 2 systems of similar size, even putting aside costs for PV hardware (lower as well in Europe), America by 2023 was much less efficient.

Step back and cost *trends* to install renewables in 2020 to 2021 worldwide, had done as one hoped to see: Decline. More recent inflation from 2022/2023 hadn't yet shown up in these data; we'll see 2022 inflation in those data next. But looking back just at 2020 to 2021, at levelized costs of energy (LCOE) for new utility-scale solar, electricity *fell* 13% from 2020-2021 to $0.048/kWh. Onshore wind fell 15% y/over/y to $0.033 per kWh. Offshore wind, fell 13% year over year to $0.075/kWh. This is significant. Take say, Germany. It has *potential* to raise its offshore wind generating capacity to 81 GW. Notably like say 80 mid-sized current-gen nuclear reactors. Wind is intermittent, yes – yet to a Germany that faced electricity rationing fears 2022, that could be stupendous. 10x more power, than 7.8 GW its operating offshore wind had made in 1H of 2022. Put in perspective, 139 billion kWhs of clean energy was made by all of Germany's renewables 1H 2022, had met near 49% its total electricity demand! Its onshore wind energy had made 59 billion (Bn) kWhs; its solar plants 33 Bn kWhs; its biomass 24 Bn kWhs; its hydro Bn 9 kWhs, and its offshore wind made 12 Bn kWhs.

Yes, 2022 renewables costs rose hard in solar & wind. Still, it was far worse at fossils, where prices jumped inordinately. Renewables by comparison, up more moderately, handily beat fossils in unprecedented ways. Look at the average fuel-only costs for natural gas-generated electricity (no CO_2 Fees) mid-2022, it rose to $0.23/kWh. That's 23 cents per kilowatt hour wholesale ***for just the fuel alone***. Built gas plants in Europe were pricier to run - than was to build new onshore/offshore wind, or solar on free fuel. Gas fuel costs 2022 jumped to 540% pricier than 2020. Add carbon Fees like in Europe for 'once-cheap' so-called 'clean' (not) gas-fired power and it went >$27 cents per kilowatt hour! 4 to 6-fold more than solar & onshore wind 2022. No wonder renewables competing on an even-playing field were obvious choice. Thermals: coal, gas, nukes struggled too to stay cool, work in Summer 2022. That said big hydropower dams struggled as well, given droughts worldwide in 2022.

Over a dozen years, 2010 to 2022, LCOE figure had pretty much said it all. For electricity made from natural gas, costs had hit 23 cents per kilowatt hour for fuel-alone, 27 cents on carbon Fee in places like Europe. By comparison, best-case onshore wind was down near just 3 cents(!) thanks to 68% cost drop since 2010! Solar PV best cost down near 5 cents on declines of 88%!). Offshore wind best case at just 7 cents, on falls of 60%. Renewables enjoy their free fuel, plus get generally cheaper over time to boot. Was becoming No Contest.

As for piped (Russian) gas once EU's electricity path, suddenly it was a red letter of shame. Went from cheap & plentiful for industrial Germany – to unavailable, and a new 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 if LNG regasification vessels added fossil fuel infrastructure. On the other hand, Climate hawks wanted immediately to move off all that. Go directly to new, zero-carbon infrastructure exclusively on clean energy paths and green hydrogen. To keep on with any gas was seen by the latter as a mutual suicide pact.

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

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

So some rely on hope. Hoping, say, energy crises in the 2020s won't be as bad as 1970s. Yet, this decade's may be worse. The two 1970s crises were only about oil. Now, 2020s they're partly about oil – but vital natural gas too – even nuclear-fuel-cycle. All that demand pushing up prices for ugly coal too. All as CO_2 grows worse. Yes EVs / renewables may help keep year over year CO_2 rises less, 'smallish', near nil gains – yet that needs to drop hard, fast.

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

They included bad surprises not-covered in the media. Like methane concentrations in air that in 2022 inexplicably went far higher than expected or projected. If from anthropogenic causes, say leaky gas pipes, or sabotage, that's one thing. Or from agricultural practices, it too may be addressed. But methane is a very-potent greenhouse gas. Much more so, than is often-discussed CO_2. Should a then record 17 ppb methane increase grow to 1,900+ ppb due to 'natural, positive feedbacks', global heating effects we can't mitigate – then surprises could be truly frightening. That it's still being overlooked, mid-2020s, is of little comfort.

Opposing ideas battled over what's desirable. Whether based on science & CO_2 – or not. For those concerned over climate, 2020 & 2021 had first been about the US passing a huge early draft bill. That omnibus Build Back Better (BBB) draft bill had carrots – but also sticks critical to limiting fossil fuels. After it narrowly failed in 2021, then 1H 2022, it was all a narrower, smaller path. After that too failed, hopes instead were for big Executive Action. In words of one US Senator, was time for Executive 'beast mode' and Cost of Carbon Rule; Require Carbon Capture from All Major Emitters; Stricter Limits on co-Pollutants of Coal & Gas Plants; Emission Controls for Light/Heavy Vehicles; Put Emissions Front & Center in Procurement (like at USPS); Locate Methane Leaks & Enforce; Utilize DOJ for Climate Litigation, and more. Yet each & all those far-reached suggestions above, were far, far easier said than done.

Each was certain to be killed IRL, 'in real life' in 2022. Inflation rampant – opponents surely would call any of that Inflationary (although renewables *reduce* energy costs, so are deflationary). Plus, Europe badly wanted American LNG and so many in America were calling for a big ramp in exporting fossils. US Supreme Court had tamped down on EPA's ability to address carbon, too. Plus, any/all above would be bogged down in Courts. No doubt all the above too could be reversed in just one day by a new President on a mere stroke of a pen.

Thus 1 Senator's change was thus 'big', let Reconciliation Bill pass into law on 50 votes, well short of filibuster-proof 60 votes. Broke the logjam, let IRA happen. Yet not all may be done via reconciliation: some actions the Parliamentarian has ruled are non-revenue so needing a bipartisan 60 votes. Like streamlining permitting for oil, gas, grid. Here, a conservative party angry at that 1 Senator – had balked at giving another 'win' even if streamlining permits was in 'normal times' desired by that Party. And it eyed a majority 2024. Yet that IRA was a brief, up-catalyst to green stocks, for July gains for ECO, NEX. Then all drifted back joined by H2X & WNX too in a broad selloff latter 2022 over fears of inflation, higher rates, recession.

For even with IRA, issues abound vexing clean energy going forward. Untouched, much needed still to be done to swiftly ramp renewables & storage, streamline permits, more. In but one example, new offshore wind turbines are eye-openingly huge. Sensibly so, since wind power output doesn't just double if rotor diameter doubles – it can go up 4x in doubling wind speeds offshore, so going huge can give turbines 8x more power. All maths point to enormous scaled-up offshore turbines. Note too an extant ship that once could install a not very long-ago 'big' 1.5 MW turbine at sea, cannot now cope with skyscraper-tall blades seen in gigantic turbines already putting out 15 MW+. Soon maybe 18 MW at some 10+ times bigger than prior sizes.

Nowadays ships are purpose-built, giant wind turbine-installation vessels (WTIVs). But in the US it gets 'interesting' due to a longstanding Jones Act, that prevents foreign-owned, built or crewed vessels from operating between 2 US ports. Hence the big European WTIVs can't be simply brought over. IRA calls for rapid increases (huzzah!) in offshore wind capacity off the US; looks to 30 new GWs by 2030. As costs are eye-watering high to build new WTIVs, so first Jones-Act ready vessels weren't coming online until around 2024 at soonest. Hence, work-arounds in first years were needed. Like base European-WTIVs off Canada first, to help install huge turbines in seas off New England. Or US flagged barges transport turbines out to waiting WTIVs sent over from Europe, Asia, etc. IRA of 2022 created new issues as well. E.g., EV tax credits were just for US-built EVs; the battery minerals must be sourced, processed, refined in US or an ally nation, so only rather sparse credits were available at first. But if climate crisis/CO_2 is real foe, then such *carrots-only* US IRA that still incentivizes burning fossils (no sticks) - was No Answer at all. Bigger picture, sorely needed now 2020s, are huge investments in capacity across clean energy, including energy storage, grid, and climate tech.

It may be best to think of the huge scale now needed to 2050, in rough back-of-napkin figures. To focus Not on what 1 Senator was prepared to give – but rather of the CO_2 cuts needed on a global carbon budget according to the best available science. These figures are enormous – but that's true scale of this problem that's undeniable. *Very roughly, it's estimated that $100 Trillion total needs to be invested worldwide to decarbonize all activity in 3 decades to 2050*. Those are tremendous sums. But they can also create immense new gains/jobs – unlike *costs* of a Hothouse Earth, of sea levels rising to destroy State of Florida, New York City, so many other mega-cities sooner than yet realized. According to International Energy Agency (IEA), to get to net-zero (not even to true zero) emissions, humanity must invest over $4,000 billion/ per year: that's $4 Trillion/year worldwide. Annual over the next three decades to 2050.

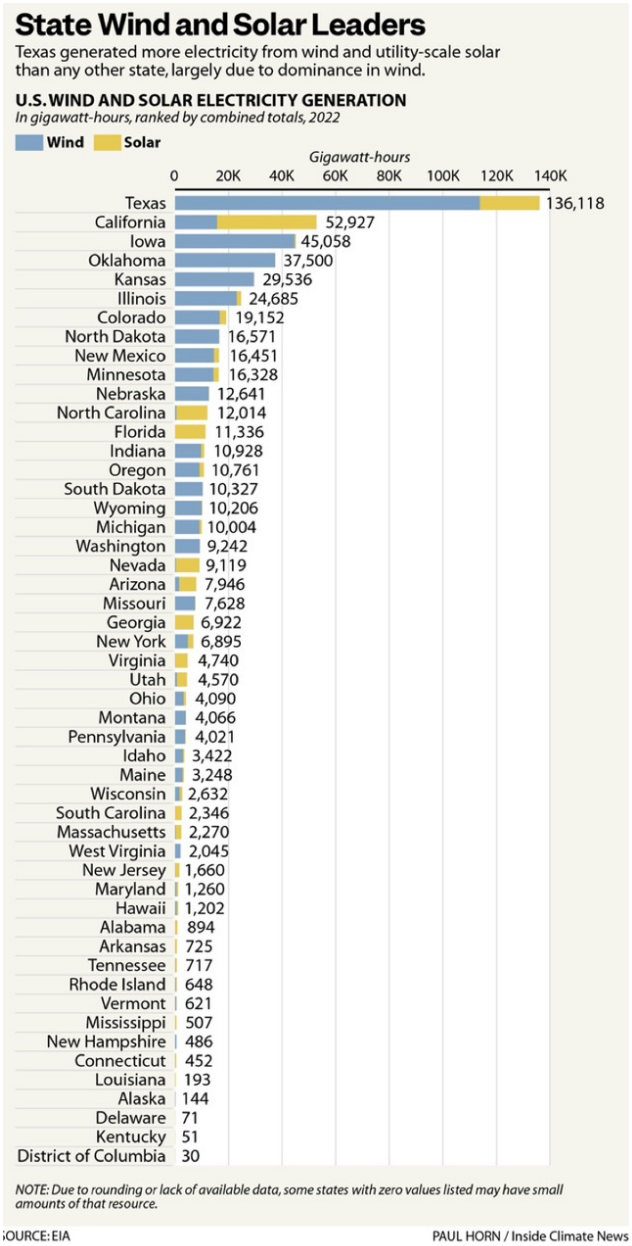
First good news: global investments had just hit $1,000 Bn ($1 Trillion) for 2022, a new record. A breakdown from 2021 showed renewables wind/solar investments had grown just modestly in a 5 years to $361 billion. What really took off, was electrifying transport: it leapt to $273 billion in 2021 up +77%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

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

On these metrics, an uncapped US $369 Billion 2022 IRA (even going >$1 Trillion with PTC/ITC lasting decades, discussed ahead) was just a start. Think of the IRA as one more public sector catalyst for more private sector spending on much bigger scales. For example, another place investing needs are great, is a more robust smarter grid. Interestingly, the antiquated US grid was so full-of-bottlenecks in 2021, it forced wholesale electricity prices to go negative not a little … but 200 million times. 2x the figure of five years prior (measured in 5-minute intervals over 7 US grids, 41,000 nodes). Was not so great as to crash regionally wholesale prices. But, meant so much wind & solar was held up, that pushed prices below zero; wind/solar was curtailed (shut), offtakers *paid* to take electricity. Quite notably grid issues now prevent more rapid-build out of new wind - also new solar – around the globe.

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

Folks may be excused for assuming California is #1 in renewables, when in fact its Texas. While Texas *political* leaders make much of their support for fossils (only) and their antipathy towards renewables – Texas business & local leaders, plus many land-owners now embrace renewables. Take a look at America's highest/lowest states for renewables wind/solar 2022:



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

A big 136,118 gigawatt-hours of the green power made in Texas was wind; yet its utility-scale solar (above) also is rising fast. Yet its Demand for electric power is so huge, the renewables still had only met 34% of Texas' electricity demand. Add in nuclear, and hydropower, and Texas led the nation by making a big 180,000 gigawatt-hours of zero-carbon electricity. All nice, but its coal & natural gas still are very big there. For how big renewables & nuclear are for the US, of America's total demand in 2022, the got ~40% of its electricity from zero-carbon sources: that was ~22% being met by renewables, and ~18% met by nuclear power.

What could grow wind & solar generation fast? A more modern grid infrastructure can make, use, share power better, with resilience. Means big changes, akin to building the Interstate Highways in 1950s. So far, instead it's been patchy repairs, few big upgrades, catch as catch can. Grid bottlenecks led to wholesale electricity prices going negative 2022 (to August 15th) a big 6.8% of the time – vs. 4.6% all 2021. Wind/solar had to be curtailed (shut) at times, or may have been worse. While fossil & nuclear interests criticize renewables for intermittency, as a defect if no wind or sun – they prefer Not to discuss when sun/wind flip-side are abundant. Then, firm coal/nukes - not nimble, unable to start/stop, must stay on as prices drop to zero – or even go negative! May 7, 2022, a big Texas coal plant saw prices briefly fall to -$8,977.46 or negative per megawatt/hr; *paying* wholesale users to take power! 'Firm' can be a liability, as renewables can & do make power at times very, very cheaply. So yes, some $2.5 Trillion in spending by private sector for the grid might happen and for many reasons.

By end of 2022, 31 huge grid outages had impacted 1+ million persons globally past 4 years. A Christmas 2022 freeze hit much of US. Odesa, Ukraine was hit by Russian drones. 1st Puerto Rico, then Florida was hit by Hurricane Ian 2022. 10 other outages affected at least 10 million! If uninterruptable power's mission-critical, power out >8 hours is more than li-ion batteries can bridge. So instead of storage, think fuel cells; running unlimited as long as fuel is supplied. Days, weeks, months. In 2022 that fuel was likely natural gas, CH_4. But ahead may be green H_2 to fuel cells. Even natural gas to fuel cells may be less costly, bit less-dirty, than a diesel genset. Diesel spews 161 lbs CO_2 per MMBtu, a gas turbine bad too @117 lbs, while fuel cell works via electrochemical reaction – not combusting, so more efficient & less polluting. Better is fuel cell, pollutant-free on green hydrogen H_2 – no SOx, nor NOx from burning. In this future, H_2 fuel may be made from wind or solar, plus water, simply using electrolyzers!

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

US blackouts near-term may lead to shouts from even conservatives, to modernize grid '*now*'! Conservative-leaning Iowa in 2022 got 60% of its power from wind, Kansas near 50%, Oklahoma close behind: yet their Senators have opposed renewables stimulus like in the IRA of 2022, though they increasingly benefit from wind. Conceivably a US Senator here or few House Members, may tear away from past 100% partisan GOP opposition to green. Maybe on weather extremes, or quakes from fracking, or unpalatability of Russian fossils. Many catalysts may bring elements back stricken from IRA, as sticks added to nudge CO_2 heavy plants to retire. Once-heretical ideas like carbon-tax, re-considered. Or $ Trillions wasted on fossil troubles, or climate disasters, or war/s fought again over oil & gas – could yet reframe US thinking.

We'll discuss ahead how 1 Senator impacted the IRA in 2022, got it defanged. Why breakdown gave 1 Senator inordinate power; far more than 1 vote suggests. Why a newer 50/51 Senate in 2023 (1 Senator went Independent in 2022) – matters more than one may think. In brief 1 Senator was concerned over spending, that the draft IRA mustn't be Inflationary, Americans were struggling. Note then that Larry Summers had correctly forecast the Covid stimulus as inflationary; thus he had the bona fides on spending and told the Senator this narrower IRA would instead be a bit *deflationary*. So did economists from U. of Chicago, Wharton.

Bill Gates emphasized it could help innovation and access to early capital. Bit like a national industrial policy, or picking winners. China after all had successfully nurtured early-on its own nascent battery industry. By 2022 it controlled strategic battery, rare Earths, other minerals plus processing, refining, production. Gates favored ideas like advanced gen (generation) new nuclear plants, liquid sodium, Natrium - vs riskier costly gen II; favored sequestration; green cement, more. To overcome a 'green premium', the IRA via Senator's 1 vote could help do that. When Senator & spouse dined with Gates, the 3 discussed how IRA could benefit West Virginia workers who'd lost jobs in coal mines, power plants. White House reps, manufacturers as well visited, pointed out how even defanged IRA could help this state so long wedded to coal. Two Cabinet members visited W. VA., praised a proposed new battery plant. Steel firms had ideas about solar manufacturing in state. All piled-on at this crunch time. AFL-CIO, United Mine Workers noted how IRA bill at last funds black lung health benefits, prevailing wages, building renewables near closed coal facilities. In the end, all of that + the Deficit Reduction = this 1 Senator gave a key Yes – to defanged, slimmed-down IRA carrots-only.

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

China was aiming remarkably for 1,200 GW of wind & solar capacity by 2030! Worldwide, offshore wind was set to grow at many nations. 1H 2022 investments rose year-over-year by 52%. From total global offshore installed wind in 2021 of 53 GW, it was expected to grow 10x to 2035. Combining wind/solar + with storage so firm, dispatchable, and available when needed. But China-alone, was putting all investments by the rest of the world to shame.

This also points to our 2 WilderHill Indexes launched in 2022: for Hydrogen Economy (H2X) - and for Wind Energy (WNX). These H2X & WNX Indexes are green, cognizant of European SFDR / BMR, and both meet article 9 'deep green' in Europe; they're very liquid with average daily trading value (ADTV) floor past 90 days of >$750k for existing, and >$1m for new components. Like NEX, these 2 also give each component a voice via being helpfully equal-weighted. Independent trackers are available for both H2X & WNX (that both meet article 9) in Europe. The NEX is on its way to meeting article 9, too. We'd first started indexing for deep green themes informally in Hydrogen & Fuel Cells, and for Batteries in late 1990s, so have a deep bench of experience here. The website for Hydrogen Economy is at https://h2xindex.com & for Wind Energy is at https://wnxindex.com For prior antecedents 1999-2007 for predecessor informal, Wilder-hill Hydrogen Fuel Cell Index see, http://h2fuelcells.org

A consequential 2022 ended with much changed. One option some hoped might shine – nuclear power (not in ECO nor in NEX) – was hard hit by a big wall of problems. One may have thought French current-generation nuclear could 'ride to rescue' in 2022 on war in Ukraine. That France's nuclear plant fleet and know-how, could grow output full tilt. Send extra electrons to Europe, sit pretty, unvexed by gas prices, or cessation of Russian piped natural gas.

Instead, France in 2022 was badly handicapped: ½ of its modern nuclear plants were stuck offline. Not long ago they'd been *the* poster child for top-shelf Western nuclear. Proud of her sovereign technological nuclear abilities, highest-percent nuclear in world, no mega-disasters of Chernobyl or Fukishima. But instead, France in 2022 was hit by massive forced power cuts. 12 of her 56 reactors were stuck offline, she saw a 27% year over year output drop to lowest power levels of 30 years. Taxpayer subsidized, yet very high electricity costs seemed to vex in perpetuity. Big power cuts in 2022 took La France to under 300 terawatt/hours. All with consequences for Europe, struggling itself to find enough fossils-created electric power.

Not yet well-known then, was France's nuclear plants had been acutely hit by unexpectedly bad corrosion issues, maintenance that needed time to sort. Only hopes of 30 GW back online 2023. Her focus on nuclear unhelpfully had held back renewables – which in 2022 only met 9% of demand (vs. 25% in UK). France looked to nationalize her debt-laden private champion of nuclear – then did so. With big problems rife too at a Hinkley Point C power station going up in Britain. Predictably far behind-schedule and far over-budget – yet it was the 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 nukes being built speedily, elsewhere? Aren't they going up fast, on budget, having learned from colossal mistakes like Hinkley? After all, nuclear-proponents talk often of lessons learned. Yes, but not in the West. Take America's attempt to do nuclear cheaply at modern Vogtle Plant in Georgia – 1st US fission in 3 decades. Begun 2009 on well-understood Westinghouse designs, costs to be a big $14 Billion, to be done 2017. But, instead, it drove Westinghouse bankrupt. By 2018 its costs were re-estimated $25 Billion. Then 2021, costs re-estimated at $28 Billion, its 2 reactors still not complete 2022; testing was begun in 2023 at $30 billion ! France's 'new' Flamanville plant begun 2007, decade behind schedule, incomplete, hundreds of workers redid welds in 2022, added Billions of € Euros. Likewise a modern Olkiluoto plant in Finland was due to open 2009; yet only began testing in 2022.

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

As stated 3 factors in equity declines 2021/22 were **Inflation in green themes as costs rather than dropping as usual - rose 30% year over year in *rises* not oft seen. **War, and so turmoil. ** Plus supply chain chaos: all renewables got tougher. But then, fossil fuels, plus nuclear costs rose too, more. Inflation tormented, as green energy so long used to price *Declines*, to cost *drops* – instead found No safe port. Green stocks got hammered all 2021 & then 2022, as costs surged then for everything: labor, capital, materials, shipping. Usually-falling wind & solar prices - rose. And thus green equities here fell – many down by over -50% in 2022.

Turmoil was by no means confined. In April 2022, Russia's Rosneft put up 37 million barrels of flagship Urals crude May delivery at 'fire-sale' (though high) prices, on fears Europe may halt buying: cheaper price if 100% pre-paid. Rosneft pivoted to China, India. A Western major pulled out of Sakhalin-1 mega-project; a trading firm abandoned its 10% stake in Vostok-1 mega-project. In 2022 Rosneft signed in prescient way a huge $80 billion, 10-year supply deal with big China counterpart CNPC. India's refiners signed on for heavy crude. Europe looked instead for alternate supplies for oil & critical diesel, natural gas, mindful of cold winters, hot summers. China halted re-selling or exports of gas given domestic needs. Some coal, some nuclear plants slated to close – kept up or restarted. Despite and here's looking at you, coal, oil, and natural gas - the climate crisis will be much worse than people yet recognize.

Destructive warfare wasn't just kinetic, and some attacks weren't covered in the media. Late February 2022 literally at start of invasion, an attack on satellite data took down remote monitoring of 5,800 wind turbines by Enercon GmbH. On March 31st big wind turbine maker Nordex was hit by cyberattack. In April a big ransomware group claimed responsibility for that; and 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 these were 'China-panels' so circumventing China tariffs, a 200% *retroactive* penalty grew possible - halting solar imports. Projects ground to 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 2022 proved lugubrious, and so solar panels in US grew scarce. Solar developers needed both clarity, and more panels, so in 2022 the US President gave a 2-year reprieve on tariffs. Skirted the issue. Re-opened the spigot on all Asia-sourced panels, whether Chinese or not. But it also somewhat just kicked the ball down the road only, in an unneeded own-goal.

Clarity was needed 2021 & 2022 on so many green-energy fronts. Would Congress extend US tax credits 10 years for wind, solar, stand-alone storage? Once 1 US Senator got a smaller IRA, a mountain valley pipeline try, more US gas to Europe. Answered some questions. Yet a fear was opposing conservatives might gain in 2022 elections – was 'then or never' for clean energy legislation. But needed too was renewable capacity growth, green incentives and a return to looser supply chains, better energy efficiency, EVs, carbon pricing. Plans arose 2022 for 5-fold increase in UK solar capacity from 14 GW - to 70 GW 2035. Germany began planning for solar to grow from 22 GW – to 215 GW by 2030. Europe, US, China, elsewhere pushing renewables. Sensibly so, as these are a great foil against dependency on fossils. Meanwhile, all renewables, and fossils too in 2022 with critical diesel, coal, oil, natural gas – and nuclear - saw pricing spike. Even rationing, flared of late. So clean energy went from a recent growth and margin expansion in 2019 & 2020 – to margin compression in 2021 & 2022.

Europe weaning itself off Russian fossils isn't easy – but begun with natural gas. Still, take German car making, so core to its economy. Germany has been exiting diesel – moving towards EVs that can be renewably-powered. But, what of its auto factories? Can they too, go beyond natural gas in vehicle *manufacturing?!* For a high heat needed say, in paint shops? How ready was it to shake addiction to cheap Russian natural gas, for heat, from 2023/2024/2025 …?

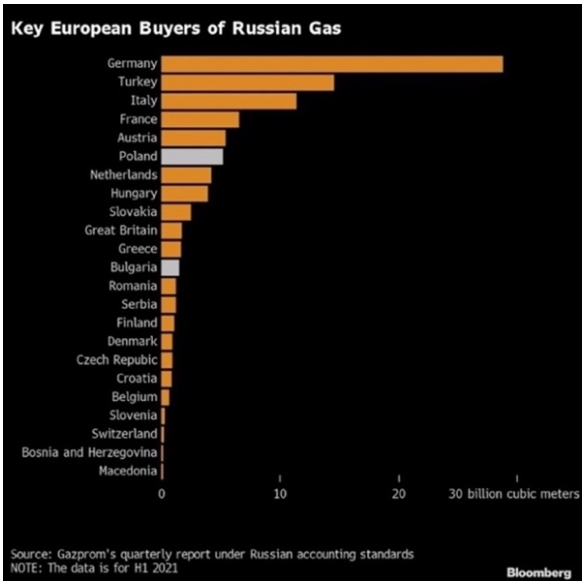
Shell-games like 'carbon offsets' or 'renewable energy certificates' have let firms pretend to use little natural gas. Claim say, trees upon slopes so steep that they can't be cut, 'reduced' fossil-use via carbon credits. Or that non-transparent extra European hydro certificates, could somehow incentivize renewables. But that was more virtue signaling. Once Russia's gas supply had first tapered off – then was shut, it fast exposed how dependent on non-renewable fossils gas & coal for both heat - and for electricity – the automobile industry actually was.

It was, by a lot. In 2021 over >½ of German 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 heating was by non-renewables. It did aim to go to cogeneration, to combined heat & power at a Wolfsburg 6.5 million square meters plant. Go from coal - to gas. But war in 2022 meant it stayed longer on awful, abundant coal. At BMW, 60% of energy was from fossils; mainly gas typical in industry. A Potemkin-Village, façade crowd-please-response was siting big renewables near a factory. But those only supplied overall some 1% of the electricity/energy eg 2021 at Volkswagen, less at Mercedes, BMW. An exception was a BMW I3 plant in Leipzig that got 20% of *electricity* (but not heat) from 4 nearby big-wind turbines. Meanwhile very cheapest-hydroelectric power was hit by drought in 2022, perhaps with irony due to those fossils. That drought stifled nearby industries too like in Sichuan China - where 30% of China's hydro was sited, hitting manufacturers there, aluminum smelters etc.

Again, with exceptions. Like the efficient Mercedes Sindelfingen plant 56 that got 30% of its *electricity* from solar. Still, those were the one-offs, nice for marketing – but not a norm. Plus, drought was killing hydropower. And what of needed, high-grade heat? 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 & 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 a high-grade *heat* at many hundreds of degrees Celsius like for making steel, cement, glass, aluminum, etc etc is much tougher.

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

The 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 fossils to decarbonize via green hydrogen, ammonia, methanol, takes in light of our climate crisis, too much time. Time-scales of decades, means a hothouse world very different from a habitable one. In short, green electricity & green *energy heat* are needed ***Now***. Given climate – plus suddenly from 2022 energy security crisis. Thus 1st half of 2020s, the 'solutions' were Not happening swiftly enough. Not one bit. And not very much needed, high-grade 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 bind at first as big buyers. A worry early 2022 was over natural gas rationing in Europe. Fast moves off of Russian oil, especially off gas was needed. Thus, Spring 2022 Europe first looked at a 210 billion euros (USD $221 billion) REPowerEU plan to up renewables (some) from 40%, to 45% in 2030. EU renewable energy generation targets rose to 1,236 GW. To cut on 6 years red tape for wind permits, 4 years for solar, new 'go to areas' for permits in 'just' 1 year. Aimed to grow EU solar capacity near 2x to 320 GW by 2025; then to 600 GW solar by 2030. New 113 billion euros for renewables, energy efficiency, hydrogen infrastructure, heating for industry. But - that still wasn't enough. Plus there was too much spending on fossils/gas infrastructure too - rather like seen in the US. So replacing in 2 to 3 years that Russian piped gas - with new LNG gas infrastructure, partly by bringing fossil gas in by ships – only not from Russia.

Despite such spending on, & attention to clean energy, seems counter-intuitive – yet did not - & does not equate to persistent equity gains for clean energy. Not in ECO, NEX, H2X, WNX. In one month, e.g., April 2022, ECO dropped hard by -22%. May, Year to Date (YTD) was down -40%. ECO swooned again June 2022 once more <100 on fast-rising headline inflation. To be fair ECO jumped some in July. A famous tech-heavy NASDAQ was also down -13% in April, then -30% YTD to June; from its own peak, 'Naz' was far off highs; S&P500, Dow down hard YTD in bear markets each. 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. As noted, ECO briefly jumped +22% in July, much more than major Indexes – it fell back to -50% at times in 2022.

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

Let's take a brief look specifically at ARKK, which has been a well-known, big-performing (active managed) fund that rose especially well in 2020. If one seeks a Fund of similar performance to ECO, including past 5 years to end of Feb. 2023, interestingly it's a pretty comparable chart. Their ARK Fund (ARKK) is younger, also innovation heavy; it began a decade *after* our ECO in mildly differing disruptive theme. Yet moves since have been roughly similar. ARKK began much later (ARKK is since 2014 – vs since 2004 for ECO & 2005 for independent tracker; our 1st Global clean energy NEX was born 2006 / tracker launched 2007). Both themes center on innovation; for these past 5 years to end of February 2023, clearly **ECO** (blue) and **ARKK** (red) had both jumped up about same time, in March of 2020 – then fell back.

But we can see ECO jumped higher & then went farther up, than ARKK - co-peaking Feb. 8, 2021. And while both painfully plummeted after, ECO ends far better here to mid-Q1 2023 up +72% - vs. ARKK to the same start of March 2023 at a not-so-good -7%, underwater:

Past 5 years to mid-Q1 2023: ECO higher at +72% (blue) vs. ARKK (red) down at -7%:

Source: finance.yahoo.com

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

Energy is unavoidably complex. Full of 'on the other hands.' Take renewables, in applied on the ground ways. Blackouts threatening worldwide 2023/2024/2025 etc: decrepit aging grids, war, fuels scarcity, fuel switching off Russian gas, weather extremes, wildfire, attacks, more. 'On the other hand', a positive milestone in 2022 was California on one windy day for a 1st time briefly got 100% of its power from renewables. A sample less-windy day, May 5, 2022 – eg 23,000 MW of demand - with 17,000 MW or 70% met by 3 renewables solar, wind, geothermal. Each may ramp potentially ahead, displacing that 17% from natural gas. On this sample day 70% of demand was met by solar, 23% wind, 4% just-still-emerging geothermal. Clearly, renewables arguably will need to grow much faster, still. With these figures, they're far behind where they need be on CO_2 & climate emergency. Supply chains in 2022 too were at sixes & sevens – bottlenecks galore. All as California was badly short some 1,800 MW much-needed electrical power – not enough to handle surely-coming hot Summers & cold Winters. Small wonder the life of its lone nuclear plant though costly, making 6% of State power, was extended 5 years 2022, so not a 2025 - but a 2030 Retirement. As shortages threaten, horrific Blackouts will too not just in this rich state, but in Europe, China, and globally too.

Clearly, bearish troubles had overshadowed all clean energy as 2022 opened. One worry at first was that *only* the bipartisan $1.2 Trillion for all infrastructure had passed in 2021. Little in it was relevant to clean energy – none to climate crisis. Compared to a BBB reconciliation draft, whose $3 Trillion, then smaller $2 Tn, then $1 Tn had focused on clean energy & climate - but had stumbled & failed 2021, it was thin gruel indeed. For example, to make an aged US electric grid net-zero, means very big capacity upgrades. Yet that Infrastructure law's text only gave grid facilitation meagre $ amounts. Grid resilience $11 billion, but power failures discussed ahead, vex now. These can potentially be crippling; $3 billion in grants was nowhere near up to task. A still 'small' $65 billion for all transmission can be quickly eaten by spending on transmission of fossils-made electricity, outside pressing need for decarbonization.

$66 billion was 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, discussed below. But $6 billion for batteries was nowhere enough 2022. Not when competing China already spent so many multiples of that last decade to now 'own' battery manufacturing. The US unfathomably nearly then 'gave up' in a global race for batteries. Tesla was 1 great US outlier in 2022 – but Asia, even Europe, were well ahead. Europe may install millions of EV chargers, to match 130 million EVs expected by 2035.

Globally 2021/2022 were strange for both its big new energy needs - & big equity declines. China, Europe, US - all saw much demand for solar, wind, batteries, EVs. Ahead maybe, hydrogen too. Yet interestingly, as renewables grew worldwide – risky high PE green stocks plummeted, dropping hard all 2021/22. Clean energy may show promise ahead this decade – yet this theme and so ECO Index - were down hard on inflation & supply chain shocks.

Consider one of world's biggest wind turbine suppliers end of 2021, Siemens Gamesa, a leading Western turbine maker. (In China too a domestic wind maker's profits declined 5.3% in 2021; revenues up just 3.3% as materials costs rose, supply chains broke). For Spanish/ German 'Siemens G.' its stock had declined -45% to end of 2021; market cap too plummeted by near half. October-December 2021 it saw revenues fall to €1.83 billion; year on year -20%. And expected revenues to fall further early 2022. It blamed vexed supply chains, worse than expected costs inflation. Pointed to volatility that "impacted some customers investment decisions", project delays. Dire straits, yet was not alone: competitor Vestas noted "supply chain instability caused by pandemic", "cost inflation within raw materials, in wind turbine components and energy costs." All were doubtless at issue in wind energy. Indeed, by end 2022, Vestas would post a Q3 loss of €147m – vs €116m profit in Q3 the year before; quarterly revenue was down 29% on the year to €3.91 billion, EBIT margin was minus 3.2%.

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

Perhaps partly was on 'Siemens G.' moving from high volumes to more profitable projects, departing markets. It suffered too from having been visibly an offshore wind leader: it was the one others gunned for. Vestas introduced its massive 15 MW offshore turbine hoping to take market share, so did GE with Haliade-X turbine. Vestas & GE hoped too to 'eat Siemen's lunch' as Siemens G. went from 60%-70% offshore wind share 2011, 'down' near 50% in 2021. Siemens G. reported 2022 a big EUR €377 loss on less revenues, negative margins, supply chain chaos. Then bigger EUR €884 million loss for 2022, as its fast-expanding in size turbines, had huge warranty costs, component failures. Only Servicing of turbines saw much growth.

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

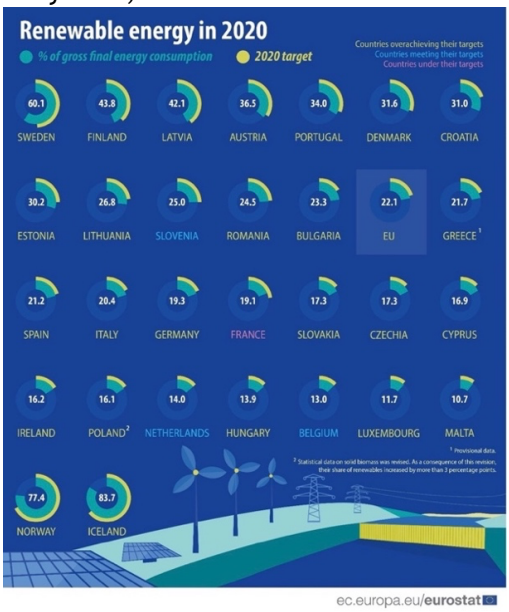
Siemens Gamesa expanded. Like in England, thanks to UK's wind vision. Now one rotation of its most huge blades could power an entire house for a day; coming yet bigger blades, could power a house 2 full days/per rotation! Wind's growth meant that by 2020, a new 25% of UK power came from wind over a year. And the UK wanted wind to account for more, over 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 green resource, with new energy storage, both wind/solar together could become firm dispatchable power. Green hydrogen, too, *might* potentially be seen as more viable idea - but only if wind/solar first get very cheap.

Yet as noted, wind's growth 2021/2022 didn't directly translate to equity gains. Parent, Siemens Energy AG in 2022 stepped in to buy last 32.9% stake of Siemens G. it didn't already own. Was a flailing, "deteriorating situation" to be "stopped as soon as possible". Ironically, wind power (and solar) were leading renewables early 2020s. Onshore wind grew moderately given constraints (China onshore wind grew by leaps & bounds despite high steel costs). Yet, Offshore wind really was taking off from scratch, unconstrained, starting to rocket. Orsted, for instance, grew its operating profit by 94% over Q1 2022, confirmed EBIDTA guidance 2022. Meanwhile, Solar too has enormous fantastic potential. Albeit but a tiny slice of overall power generation in 2022, far smaller than wind, look for that to change fast this and next decade. In places, solar & wind together will become the greatest 2 power sources, not just for clean renewables – but all electricity. Getting more affordable too than all else, maybe hastening energy transition. Since 2022's war in Europe hastens departure from (Russian) natural gas, from diesel, coal etc – that may accelerate renewables' growth across this decade.

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

Net result is that wind & solar were 2 big renewables start of decade, and rich Europe led. Europe's gross electricity consumption in 2020 met by renewables neared 1/4th, close to 25% of demand. 2020 figures below showed the 2 best were Norway & Iceland, at 77% and 84% respectively. Among the 27 EU states, the Nordics again led: Sweden at 60%, Finland 44%. Nearby Latvia, Austria, were 32%, 36%. But of course, there were EU laggards as well. Belgium then got only 13% from its renewables; The Netherlands then was just 14%. Both only barely reached targets (better since!), rather unusual vs. the rest of a more ambitious Europe.

So nearly all the EU 27 was *beating* targets. That bloc set its goals in 2009 and while included as 'renewable' - dubious municipal waste burning (Not classed as clean here at ECO), their main focus rightly was/and remains wind & solar. Mostly exceeding goals. Lovelies Sweden & Croatia did so by 11 percentage points. Poorer Bulgaria, by 7 percentage points. Poland (16%) had lagged in renewables but an altered definition let (dubious) biomass burning meet EU targets. A 'less green' lane of biomass burning was an exception; most goals were truer clean energy – primarily wind & solar. Russia's invasion/war in 2022 gave a horrible fillip, yes, to dirty coal, oil and diesel - but here's how EU had looked at start of decade in 2020:



Source: Eurostat.

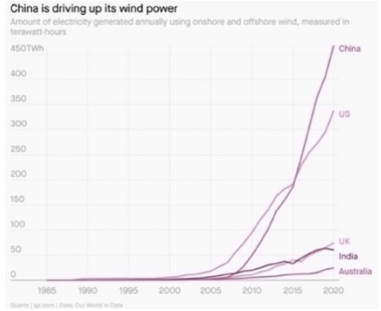
UK famously left a 27 member European Union in 2020, so isn't seen above. But, UK did 2020 source 42% of its energy from renewables thanks largely to a big wind push. Expect offshore wind to fast rise in UK & Europe. Yet curiously if renewables' costs in UK like elsewhere plummeted – why did UK average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

Meanwhile, US got only 19.8% of its energy from renewables in 2020, so lagged Europe's 22.1%. On war, 2022, Europe faster-upped its renewables commitments – ahead of a US. Of roughly 20% US renewables in 2020, 13% or 2/3 had been solar/wind; 7% or 1/3 big hydro. $105 billion did get invested in 2021 into renewables, EVs, batteries, etc – 37 GW solar & wind. Yet natural gas was generating twice that 20%, a key 2x, or 40% of power. Even as Europe pulled ahead. Big picture was neither Europe, nor US, made near enough clean power (India too was just 22%). Each must grow by 2x or even 3x faster, given decarbonization's goals. War did change much 2022; Europe started to grow its renewables, its EVs faster. European light duty EV sales at 19% of vehicles 2021, was double 8% world average. Near 1 of 6 cars sold in Europe (more in China) were soon EVs – growing fast. That vastly was beating a US at just 1 EV out of every 20 cars. For Europe where 1/3rd of oil, more gas in 2021 came from Russia, war in 2022 served to turbocharge green energy growth. Along at first with nightmarish rush to burn coal.

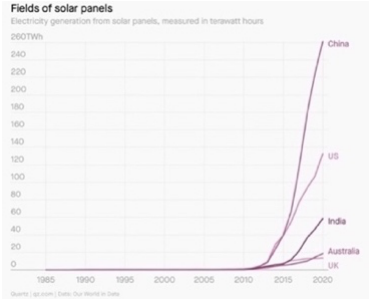
What of China? As arguably, the most important bloc for renewables? China in 2020 was a World Leader in its absolute energy generating capacity. Yet its 342 gigawatts (GW) green capacity meant (only) 14% of power was from renewables. 14% not far off figures for the US. Still, figures can deceive. China's energy demand is so enormous, ramping renewables just some is a damp squib. Yes, relative to Europe, or to US, its GWs growth far outstripped all, everywhere. In 2021 it aimed to install 1,200 GW new wind & solar by 2030. Unlike at times hollow promises of the West, China tends to meet goals laid out for itself. So 1,200+ GW can be envisioned. Yet a burning issue in 2021, was China still is utterly reliant on burning record-amounts of polluting coal. And then by the end of 2022 it was burning even more.

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

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



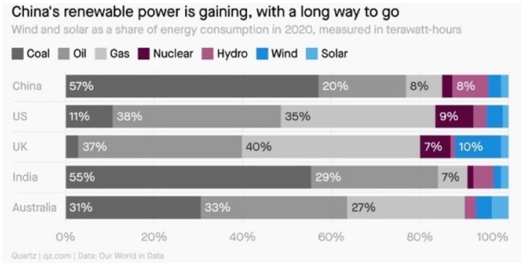
Source: Quartz / Our World in Data.



Source: Quartz / Our World in Data.

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

How 5 countries fared in 2020 is seen here as fossils in a dull charcoal, brown & gray dominate, left. At right, brighter blue & pink, solar, wind, hydro + nuclear have mild penetration, near 20% in 2020 - and growing. Leaving way too much room to improve, while Rome burns:



Source: Quartz / Our World in Data

Coal-loving Australia for instance at bottom here used coal for 60% of its electric generation in 2021. Even though renewables are a better bet; at a Badgingarra, Western Australia wind farm, capacity rate (how much time its operating) was 64% in 2022: competitive vs. coal that must shut for maintenance, buy fuel. Even current nuke fission touted by proponents as firm, saw dire straits 2022. France had to nationalize its nuke leader on its huge €350 Billion in liabilities & €19 Bn in pre-tax losses 2022, much unforeseen corrosion, rife poor welds at its Flamanville reactor – and cap power prices. Of its 6 latest-designs reactors built since 1999, 1 in France, 5 abroad – only 2 in China are working. All as Summer heat & drought threaten cooling and vex-nukes. Smaller modular reactors or 'SMRs' may aim to be cheaper, better ahead; but whether they'll deliver is highly questionable. Much preferable would be distributed 'SMR' of another kind, both cleaner & green: Small Modular Renewables.

World fossil linchpin China, at top still burns so much coal, absolute & relative ways, it ensures we humans release unprecedented CO_2. In 2021 China's coal production leapt to 4.07 billion tonnes/year for acute climate crisis, +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 release potent greenhouse gases like methane to air as well, freely, like to a sewer, treat it as meaningless. Despite flowery words by rich nations to the contrary. It all *makes* our climate emergency a foreseeable and maybe existential threat, right under our noses.

Even supposed climate leaders flailed 2022. In California a Commission overseeing utilities, favored big centralized utilities, over smaller rooftop solar. To a consternation of many – in December 2022 it *reversed* incentives for home rooftop PV, so that only solar+storage makes sense. An earlier draft NEM 3.0 even had a $8/kW solar tax, that would push solar payback from 6-9 years for solar – to 20+ years making No economic sense. It was dropped after uproar; but they imposed a 75% drop in economic value of solar-alone. Changed from retail rate, to 'actual avoided cost' – so compensation plunged from 30 cents /kWh, to just 7 cents. That has made solar-only (no battery) unaffordable or purely non-sensical to most people. Only solar coupled with batteries to generate in evenings – thus made sense – but is highly costly so unaffordable to a great many Californians. That, 2022, in verdant green California!

An expert in Net Energy Metering (NEM) called that original 2022 draft NEM 3.0, dystopian. Of 1st draft proposed decision (PD) 2022 to gut home solar, that expert pointed out while its backers claimed to want more battery storage, the PD would make home solar uneconomical. Without roof solar, fewer will install batteries in first place. Noted payback was not short 3-4 years (as PD claimed) – but near 7 years [born out by our own experience]. That installed PV doesn't cost low $2.38/watt proffered in PD, but is nearer $4/watt. Putting a huge cost on PV – *retroactively* – could kill distributed home solar. While storage too – will cost $$.

A pre-election outcry over 1st NEM 3.0 PD solar tax, seemed to kill that $10-$20/month 'grid participation' fee. Discriminatory anti-solar fixed charges paid only by homes with PV, were rare: seen at 2 of 172 investor-owned utilities nationwide, <3%. While 27 times in past various utilities had *proposed to* add charges for solar homes only, nearly all were withdrawn, or rejected outright. And none were imposed retroactively, like was being proposed here!

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

Utilities are accustomed to centralized, big thermal-plants - that they alone own/control. They may support big solar farms they own – but those haven't much lowered retail power costs yet, at still about 25 cents per kilowatt hour (kWh). By contrast, decentralized rooftop home solar like on California homes could instead fast cut retail costs one-half to two-thirds. In 2022 a (rich) customer say of one of California's 3 big investor-owned utilities could save ~50% by upgrading – go from buying utility-supplied electricity & driving a gas burning car – to instead have solar power roof & EV. 1st PD would quash that option, even in progressive California, even in 2022. Pushback was swift & vocal. Notably when California pushed that off to after the November Elections – it piled uncertainty atop 2022. Pushed down solar sector already hit by anti-circumvention further. Only costly solar+storage, might make sense.

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

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

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

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

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

That 2022 Plan anticipated 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. GWs can't happen soon enough. CAISO's draft Plan projected going from 7.8 GW California wind power, to 24 GW new wind across West 2040. In past a too long 8-10 years was needed for permits; green electrons are needed faster. So helpfully, regulatory bureaucracy is being cut of late. $30 Billion for transmission upgrades do-able. Like $11 Billion to improve substations & powerlines; $8 Billion to allow local off-takers to use offshore wind, $11 Billion to bring wind power in from out of state. Of course, $ Billions – and $2.5 Trillion over a decade: are huge sums. (As Senator Dirksen joked, 'A billion here and a billion there, pretty soon you're talking real money'). But in context of the vaster sums for oil & gas, these $$ for renewables are all relatable. Particularly when it means resilience for California's $3 Trillion economy. Were the state, a nation, it'd be 4th or 5th largest in the world. Ahead of India, the UK. And Blackouts whether due to heat/freezes/attacks must be avoided.

A biting issue 2022 was poor US grid resilience – power lost too frequently. 2021 saw 180 big power disruptions; 20 years earlier, it been fewer than 2 dozen. Not just unprecedented weather extremes at fault. The US grid is aging badly. 70% of transmission & distribution was far into 2nd half of 50-year lifespans, with 600,000 miles of key transmission lines, 5.5 million miles of local distribution. Back in 2010, big thermal coal, gas & nukes had made most US power; later on, natural gas became king when shale fracking made it cheap. Since then, renewables began to compete, and at times beat them all on price. But given an intermittency of renewables & need for storage, problems rife in all fossils and nukes, razor-thin power reserves – plus old grid and old power non-resilient, it will stay this way until vast new storage comes online. There's no easy answer. But certainly, with more abundant, cheap & clean renewables, both new storage & a better grid have simply got to be grown swiftly too.

Storage & grid take time to be built. So, what of 2 parts of this puzzle: current gas & gen II nuclear, near-term? Right now, California needs all its 25 GW of renewables – plus 50+ GW more green generation. 17 GW of utility scale solar should be added 'yesterday' - even utilities support it. More offshore wind fast. Were new gen IV/V nukes safe, affordable, no wastes now, that would be wonderful! But 2022 State's one gen II nuclear plant, life extended from 2025 – to 2030 had b een none of those things. California's grid ahead 2032, can well 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 died. Trillions of dollars, political capital went instead 1st to needed Covid emergency spending. Conservatives arguably had a point: $ Trillions in Covid spending early 2021 could prove inflationary. Progressives, arguably had a point that high gasoline prices at pump weren't due to US energy policy, nor to green energy (that's anyway deflationary) – for oil prices aren't set by whomever is in the Oval Office, but by markets worldwide. Unsurprisingly, the oil industry was refraining from swiftly ramping back up supply (as it had suffered huge losses in a last bust). So on that, and exigencies of war with gas used as a weapon – prices for oil/diesel, gas, & coal, all jumped.

In clean energy, spiking costs like materials in EV batteries may soon favor chemistries instead needing little, e.g. nickel – say iron/phosphate. Benefits include less fire risk then too as cells needn't be surrounded by liquids. And battery pack architecture can with new designs, contain far less outer cell structure. Going from say 40% of a pack being batteries, to drop the modules and doubling that. As packs grow cheaper, last longer and go much farther.

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

Something a bit like that might happen in US as well. A big US >$4 Trillion Build Back Better Bill had died 2021 – only a small IRA passed 2022. Further, newer Bills in 2020s are certain – but may have more fossils and nukes in them too. Acknowledging facts on the ground, new elections may end razor thin Senate majority – a small House advantage. Or not! But in the US, like elsewhere, there's surely 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 oft economically a best-option; even in some red-states once reluctant to embrace it. Wind, solar, perhaps green hydrogen in future - stored say, under salt domes. Geothermal at times by fossil firms. More wind in a US Midwest – soon much offshore too.

There's a wide consensus coal should be eliminated both on its costs, and health burdens – it should be 100% retired. Yet, we burn ever more. Meanwhile the world called for much more gas & LNG in 2022 to replace Russian gas. Progressives understandably find wretched any more natural gas or current-2nd generation nuclear fission. But in compromises, conservatives may get high-carbon fuel & nukes – and may accept the clean energy they've heartily opposed. It's a question of how swiftly huge new renewables plus storage, can be brought online, cheaply and right now, in these early 2020s - *Before* latter part of this decade.

To win some goals, progressives may swallow hard for all the above 'energy independence' with fossils and nukes. America won't really be energy-independent – each barrel of oil in global supply isn't identifiable as barrel as a, b, c etc. But, if it gets support for renewables, those compromises may be required. Oil firms want e.g. subsidized, so-called 'carbon sequestration' (isn't really reducing GHGs) – and other dirty paths. On the other hand, tremendous key downside to this dismal politics, which we prefer to avoid, is 'IRL' – ongoing use of fossils already Dooms Us All from an objective, science & climate-perspective.

It's easy thinking above of politics, to forget about how CO_2/climate actually has THE final say. Politics ignores that, although science indicates this may revisit us many-fold. Work is happening in future-gazing science, getting ever-more right models that help better see what may be ahead. Clouds, especially, have long bedeviled forecasts. Just how clouds, water vapor ahead may contribute to heating – or not – with other greenhouse gases (GHGs) is vital. Potentially, clouds *may* mean Earth gets much hotter still. Or, reflective clouds might mean we're on a bit less of a blazing cauldron, than what the models so far have predicted.

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

Past brute models were somewhat right - even if at times, they've *understated* heating since. A look at 17 basic models 1970 to 2007 showed pretty good overlap with what later was seen. Still clouds' complexity vexes. Older models had expected if CO_2 levels doubled from start of industrial era – from earlier roughly 270 ppm to 550 ppm where we're fast now headed with CO_2 already over 420+ ppm, we all may be baking say early next century between 2.7 degrees F - and 8 degrees F (1.5 C - 4.5 degrees C). CESM2 implies an unbearable 9.5 degrees F (5.3 degrees C) baking may be possible! Result of doubling+ CO_2 partly due to water vapor/clouds. Near 1/3rd higher temperatures, than prior models implied, so getting accurate modeling was no small interest 2022. 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, estimating what temperatures may be like ahead. (Maybe it's back to Pliocene, then Miocene for us)! Either way 'mere' transitory heating we may feel 1st century or two at 550 ppm, can pale to a far hotter equilibrium later unfolding over a few millennia. With rising seas discussed ahead.

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

Let's shift gears from climate - to finance & equities, for a bit of helpful news. One is there's much better breadth of late across potential candidates in clean energy stocks. Far more public companies working in clean energy, climate/tech solutions. Markets better advancing global new energy innovation. Firms here, by market capitalization in 2020s, now oft much larger than turn of millennium ~25 ago, even 10 years ago. In an applied side-note related to Indexing here, market consultation in 2022 and Announcement Jan. 2023 resulted in a few changes to NEX Guidelines. NEX average daily traded value (ADTV) floor became USD $1 million/day past 90 days for adds, USD $750k extant components. 4 screens for NEX/H2X/WNX are Global Standards Screening (GSS), Controversy Score, ESG Risk Ratings (ESG RR), & various Product Involvement (PI) fields; companies missing GSS, Controversy Score, ESG RR or all PI fields, would be removed from the eligible universe. More is on the Indexes website.

Returning to stocks more broadly, perhaps reasons 2021 then 2022 were rough for equities, one was many investment banks already in late 2021 were predicting few profits for all 2022. Earnings targets for big S&P500 firms were 'lower-highs & lower-lows'. Take a newish S&P500 name, Tesla: it had a huge market cap, among S&P's biggest when it entered that 500 (funny enough, maybe late on hesitancy over reputational risk) yet it 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 an S&P in 2022, foresaw only 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 dismal pessimism importantly weren't transitory either; instead, they saw persisting headwinds that could be sticky all that next 2022 year.

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

Back in 2019, there'd been sound reasons for optimism on earnings & growth in 2020. S&P500 profits then had just hit a record. Government stimulus was about to flow due to Covid. Profits just jumped +25% to new records. Still, operating margins hit a plateau. By late 2021, there wasn't such great room for big 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 had ended. When S&P dropped a total -40% over 3-years in the dot.com decline, it would then take another 13 years, until that S&P again reached its prior levels.

Another headwind at start of 2022, had been rising interest rates that can kill equity themes. Not long-ago, investors had gotten near Zero % from 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%. Fell in Covid emergency to eyebrow-raising *negative -1%*. As PEs shot up, from more common 21 – to a very high 27, CAPE went from a normal 20s – to a (yikes!) 40. On rate hikes, return to mean will be bearish for stocks, especially across quantitative tightening. All had been fundamental points in 2022.

If a threat in 2023 wasn't of 'Unprecedented' inflation (since that had been awful in 1981) – then maybe it was of high inflation taking root, growing hard to kill. Inflation is part a state of mind, part psychological. If expectations take root, get persistent, hard to knock down, combined rising rates with stagnant or sluggish economy (stagflation, slugflation), then Fed Rates tool grows wickedly un-useful in a recession. No central bank wishes to hike rates going into recession, economy cooling. Equity-risk premiums in holding onto stocks (vs safer bonds) - makes equities a decidedly less happy place. As interest rates rise, money is no longer free. Higher rates are something a younger generation doesn't viscerally remember. For over a decade to 2022, no G7 central bank had put rates above 2.5%. But, way back in 1990, they'd all then been above 5%! Broadly then, rising rates over 2021 & 2022 were probably not a great time for risky, volatile, high PE growth themes here in green technology.

It's impossible to successfully time markets. To see far in anticipation, the low entry point. Compelling forces pushed down all 2022 as *Inflation was much worse than a Fed had initially recognized; *Rising Interest Rates hammered growth themes future income; *Capital Shifted to Value and thus *Re-Pricing Risk, with *War in Europe, tensions in China/Taiwan, and an *End of Liquidity & easy money. All that sent ECO plummeting 2021 & 2022. In a theme as volatile, dependent on future earnings, it was a poisonous setting with repeated lows.

Made worse 2022 by factors specific to clean energy. As noted, 1 US Senator *Declared late 2021 a huge BBB bill's, billions for clean energy & climate, Dead. Did so again, early July 2022 – then changed mind late in July for a smaller IRA of 2022. That however, isn't an end of it. Yet to be seen, perhaps ahead, might be looser EV credits, bigger $$ sums maybe resurrected from 2023 and onwards, more an 'all-in, all the above' US energy policy – or perhaps *Not*.

Changing topics, lightening the mood for fun, coincidences occur *looking back in time, only*. For example, ECO had hit a high Dec. 26th 2007 of 297 (297.05 close) – just coincidentally it next hit a big peak Feb. 10, 2021 near-ish at 287 (286.89 intraday). Or, rose a near-perfect/ neat 200%, or 3X over 2020 (from 71.47 on Jan. 2nd – to 214.06 close on Dec 31st). Or, passive ECO plummeted by a strangely non-imprecise ½ to nadir low in 2021, from 286.89 intraday peak Feb 9th – to 142.39 intraday low Dec. 29, 2021. Fell again, a near-perfect -50% from peak close 1st day of 2022 – to its nadir 2nd from last day of 2022. Or, prior to rising hard in 2020, it fell earlier by a near-neat -50% from 92.53 close Feb. 20 – down to 47.37 close March 18th. After, rose big 6-fold from that 2020 nadir - to Feb. 2021 top. Again each -50% was by chance, looking *back* at rich data. 2 oddly not-imprecise, consecutive declines near a 'perfect' -50%. Or, in Q1 2022, hit a near 100 bottom 4 times (103): 28 Jan.; 24 Feb; 28 April, 2 May.

Just spotting coincidences in a data-rich past: it's meaningless looking forward. Does though, point to how volatile ECO is, falling -50% even in the up years! Take non-calendar 12 months, say, end Q1 2021 – to end Q1 2022. Meaningless, as a non-calendar period, it moved roughly 200-100 from peak April 1, 2021 at its 205.65 close - followed by 2 lows Jan. 27th & Feb 23rd both at 107 close (102 intraday). Come to think of it, funny how those 2 lows, were both again not far off neat -50% drop from 205 - to 102! War sparked a brief +40% rally on better clean solutions Q1 2022, before falling back Q2-Q4 to near 80. But, to so cherry-pick these data, especially infra-year is NOT predictive. Only bit of fun given so much data, especially if non-calendar – for as Mark Twain humorously put it, "Lies, Damn Lies, and Statistics". Just playing with ample past data is a mere parlor trick, no real help when looking forward.

One mustn't read much into it, other than to confirm a great volatility, oft down! Jan. 2022 alone, passive ECO fell a nearly neat -30% in a blow-out month; not predictive, it's ephemeral. Maybe bit of attention to 'enter on dips – sell on rips'! Just for giggles, let's for conjecture (as this was 1st written Jan. 2022) say *if* 2022's high remains a 152.8730 on Jan. 3rd first day close (154.4136 intraday Jan 4th) - which indeed played out as year high by end of 2022 - then a hypothetical calendar year low at ½ down - still just playing, would be a 76.4365 nadir low close at some time in 2022. Any realistic nadir possible of course – yet all maths were - are, it's very, very unlikely to be this figure! 70s were seen not long ago, may go lower – on war, inflation, recession. But at a neat, -50% figure? No. So, was interesting to see where a 2022 nadir would/did - fall. Not surprising was *not* exact 76.4365! Just was spotting coincidences, in ample data. Interestingly though, Dec. 28, 2022, ECO did hit its 2022 closing low of 76.0202 – not far off a 'perfect' 50% nadir of 76.4365; near an even 76! Yet broader tech markets were rather similarly down here as well. Lastly having now fallen so far, going forward a -50% down no longer applies. For ECO past data, see, https://www.nyse.com/quote/index/ECO

Recent Quarters

If the WilderHill Indexes with purer-plays can/do jump fast/er, hard/er – flip-side is surely, certainly they plummet hard/er in down periods. Q1 2023 embodied this. Competing 'not-so-clean' cap-weight other-themes did relatively 'better' (down less) than ECO in 2021/22. Yes, in January 2023, ECO jumped hard/er after 2021/2022. Like as 1 CPI Report on 1 day late 2022 showed maybe cooling inflation ahead, ECO jumped +10.1% that 1 day, on a hint of bullishness if/when interest rates stop rising. That jump was much larger here in purer ECO than in most all other younger themes for clean energy – we're the original Index here. But… February/March ECO fell back hard/er to end Q1 at 84 on global bank fears. Billions unrealized gains may be exposed mark to market; so riskier volatile ECO dropped hard/er than others given smaller pure plays. Most of its (low-interest rates) history, clean energy enjoyed cheap debt, immense demand, great liquidity. In 2023 that great demand stayed – but it confronted high rates, and capital that's dear. Plus lately, natural gas was off -50% Year to date:

Q1 2023: Jan to end of March for ECO & NEX trackers - plus vs other competing themes; ECO/NEX up most despite plummeting in latter Q1 - while Natural Gas was down -50%:

Source: finance.yahoo.com

Components performances in 1st month January are easily seen given equal-weighting:

ECO Index® Q1 2023: started the year at 80 and ended 1st month January about 100, up +25%. Components in ECO well up Year to Date (YtD) for January included in EV charging (+56%), in lithium (+55%), electric aircraft (+55%), another in EV charging (+54%) and advanced batteries (+50%). Components in ECO well Down YtD in that 1st month included another in electric aircraft (-39%), advanced batteries (-36%), another EV charging (-20%), solar inverters (-16%), and iron flow battery. The Ups> were up greater than <Downs. February next fell back, but YtD Ups still out-performed those down, YtD. In ECO & all 4 themes, fears over Inflation so interest rates dominated. 2-year Treasury Yields went over >5% March: is difficult for risky equities to compete with guaranteed 5% returns. March tough too for ECO, Q1 ends at 84.

Global Clean Energy NEX Q1 2023 components well up Jan. 1st month YtD included an EV maker (71%), electric aircraft (55%), EV charging (54%), batteries (50%), power electronics (+41%). NEX components much down YtD January included wind (-22%), solar (-16%), another solar (-10%), global renewables (-8%), and global renewables (-8%). By end of that first month, the NEX Index was up YtD +13%. Ups again were greater than Downs. Then, Feb. & March were tough for NEX – yet closed Q1 as more positive than ECO so outperformed here, at 310.

Hydrogen Economy (H2X) Q1 2023 started at 64 and ended January at about 73. Components in H2X well up YtD in that 1st month included an EV truck maker in H2 fuel cells (+45%), power electronics in fuel cells (41%), fuel cells (+37%), up for an EV bus that's done work in H_2 fuel cells and H_2 fuel cells maker. Components in H2X most down Year to Date (YtD) that 1st month included wind to green H_2 (-25%), renewables to H_2 (-8%), biofuels to H_2 (-8%), ammonia to transport H_2 (-6%), and again biofuels to H_2 (-8%); Q1 ended at 68, marginally just up.

Wind Energy (WNX) Q1 2023 started at 82, and ended that 1st month at about 88. Components in WNX well up Year to Date (YtD) for that 1st month included in electronics for turbines (+41%), wind firm in S. Korea (+30%), carbon fiber for wind blades (+28%), minerals used in turbines (+25%). Components in WNX well down YtD that 1st month included wind to green H_2 (-25%), global wind (-8%), Canada-wind (-7%), Japan-wind (-5%), and a wind leader that shifted long ago out of fossils – to a big pure play for wind (-4%); Q1 ended at 85, slightly up.

In sum while green themes jumped in a first month 2023 by 15% - 25%, that was on a narrative – or more, hopes really that inflation may soon slow. Fed could then pivot from raising key interest rates (its only tool) - to welcome soft landing. But, in February & March, talk shifted. Went from No or soft landing – as employment was strong – to Fed raising rates 'til things break – which latter Q1and early Q2 was happening. Bank crises. Maybe a recession. Spikes in unemployment. A debt bomb. Big rate hikes halting inflation, but at what cost. All 4 green themes thus plummeted in February/March of Q1. To be sure was a Q1 of great volatility.

One cause for recent volatility: was war. Big equity valuation changes, whether downside - or up – oft are associated with Surprise. Many surprises lately, but key here was War. Energy used then as a weapon. Fossil/food prices spiked, as shooting went beyond Crimea & Donbass and all hell broke loose. First weeks of war, 2022, ECO jumped +40%, from an intraday Q1 low of 101.64 on Feb. 24th at invasion's cusp – to 141.82 on March 30. That, was maybe on many re-assessments done around the world over need for a speedier transition to clean found here. And need for better energy security: 13 European nations 2022 had relied on Russia for >1/3rd their oil. And yet ECO soon after fell back to <90 May 2022, dropping as clean growth was stymied by supply chains chaos, inflation. Yet arguably, that invasion shouldn't have been such a surprise, if one were watching very closely early-2022. There were small hints.

For global intelligence assets watching in a run-up to war, there'd been a few warning signs. To wit 1-2 months prior to invasion, Russia had moved 3 of its LNG ships to geopolitically vital, stranded Kalingrad Oblast on Baltic Sea. Natural gas piped from Belarus had to go via Lithuania to reach Kalingrad, kept Russia potentially from shutting gas to Lithuania. So re-positioning its 3 ships unusually to Kalingrad, gave Russia an option to *possibly* sever gas. Could provide Kalingrad too with 4 or 5 weeks more gas. A military-vital Kalingrad Oblast lets Russia alter NATO's power, in its own backyard. So it was notable Gazprom sent 2 LNG ships Energy Integrity & Velikiy Novgorod – & 3rd Marshal Vasilevskiy regasser Jan 2022. Before, the former had carried LNG from Russia's Far North, to Asia. To re-position the Integrity, that ship had weirdly gone a very long distance, Cameroon to Kalingrad. It had been carrying Cameroonian gas prior to China (only 2 of 58 shipments were to Europe region) - so was all unusual. Having moved 3 LNG ships meant if conflict began, and fast went past Ukraine - then Russia using energy/gas as a weapon, might keep strategic Kalingrad outpost at 4x the size of Manhattan and militarily significant, energized for extra weeks. (Perhaps Russia had at first envisioned a quicker run through Ukraine, & Kyiv falling speedily… later June 2022 Russia's leader mused that Peter the Great had once 'took back' their 'Russian land' from Sweden – and he gave a shout out to Narva on the current Estonian side. Today's nation of Estonia & most of Latvia had once been captured by Peter the Great, in the Northern War from 1700 to 1721).

It all seemed early in 2022 invasion of Ukraine might in fact happen – contrary to what many incorrectly felt was to be an impossibility. Russia first denied planning to invade Ukraine. Germany's Navy Chief seemed to take Russia at its word, and stated Crimea was forever lost and that Russia only wanted respect, nothing more. Regardless, invasion began in Spring 2022 and it seemed from the start that Ukraine was put then in a very precarious spot.

But that narrative mid-2022 got flipped on its head, as post-invasion, nations like Lithuania stopped buying Russian gas. Vilnius used floating 'regas' vessels in order to import LNG from Qatar, from Norway, US, replacing Russia's gas. Germany needed 90 billion cubic meters/year – and aimed to go >90% storage in 2022: it was accomplished. Floating re-gassers became all the rage. Was a chess game, & due to LNG, Russia no longer held all the power. Lithuania could even ban trains carrying sanctioned goods across it, from Russia to Kalingrad.

Soon Russia relocated to Kalingrad 3 advanced MiG-31E warplanes with its Kinzhal (Dagger) hypersonic missiles. Smack in NATO between Lithuania & Poland; 1 Kinzhal earlier in war had obliterated Ivano-Frankivsk Ukraine weapons depot. In pathbreaking real change, Germany at last began to cut its overreliance on Russian gas. Once, both Russia & Germany had promised Nord II was a commercial project only – no political leverage. But war and then gas cuts, had put paid to the idea! Germany started plans to bring forward 15 years its aim of 100% renewables, to 2035. Started planning 20+ GW/year solar capacity latter decade. Onshore wind 10 GW/year. Offshore wind capacity, from scratch, to hit 30 GW 2030; then 70 GW by 2045. Germany's Greens 2022 could swallow LNG terminals - if they meant hitting new 100% renewables sooner. Plans had been to shut nuclear, zero-out coal; but on no Russian gas something fast was nedded to fill gaps as renewables got built. Fast-filling storage was one; LNG terminals (to after be for green H2) until renewables fully take over, another. Still, gas storage may get past Winters/Summers. But what happens at few-reserves left, next high demand re-approaching!? Amidst all that, ECO had fallen over 2022 to the low 80s.

That set a stage from which clean energy/ECO briefly jump Q3 2022. In Real-Life, 'IRL', oil & gas had just before jumped hard, like nothing in recent memory. Oh my, what a reversal from what we'd seen in fossil fuels last decade! But especially with a new IRA law, and ECO down in 80s, clean energy briefly jumped. Spiked noticeably. Setting a stage were declines due to a long-ailing, and then-a-failing draft $4 billion+ BBB bill: its repeated failures had owed in part to a staccato NO from 1 U.S. Senator. That pushed clean energy equities Down in 2021 & 2022. Helped compress the spring, knock down equity prices to just before Q1 2023.

How is it clean solar/wind had stayed cheap-ish, moderate price increases – while broader energy prices overall had spiked??! As noted overall energy prices tend to reflect the 1 fuel that's most crucial – the one most key to grid stability. Rather like how income tax rates can reflect the very highest marginal rate on the very highest dollar earned. Natural gas was still key, it had made all the difference, so as its prices spiked – energy costs did too. Even US electricity from burning coal rose +22% in sympathy 2021. Such energy spikes will recur ahead. Even if renewables (still a minority of power supplied) rise in cost a bit - hold steady, or decline - as seen ahead. In sum fossil prices *rose* hard in 2021 & in 2022 – but only after long, very deep lows. Then fell 2023 rather predictably, given longstanding boom/bust cycles.

Past is Prologue: 2021 spikes were only *after* fossils had plunged in 2020. Only *after* US coal production had hit 50-year lows, 151 mines were closed or idled. Only *after* oil had hit historic lows 2020 on Demand Collapse. Much of oil industry needs it at least in $60s, so oil down then at 'just' $50s in 2020 had punished shale producers, $40 oil was misery for producers. Equities are inherently forward-looking, so oil 2020 hadn't been attractive for investment. Only after big supply cuts, some output shut + renewed demand discussed ahead - did oil rise back to around $70s-$110s/barrel on supply curtailments. At any rate, after that, high-again oil & gas prices may yet 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 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 on global demand for coal, prices too jumped by +25% in 2021 partly on overseas demand and on gas crunch spike. US domestic coal economics are dismal, so miners look to where it's being burned, and Asia (even Europe) had 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 greenwashing by fossil interests. Much hyped 'blue hydrogen' – though methane leaks can make H_2 (hydrogen) from fossil gas near as bad as burning gas directly. Russia's war too bodes ill for blue H2 in Europe. Yet, scarily electricity from gas will likely be big in US, & China 2030. Given climate crisis, that's a huge worry, as is burning coal. Rich Europe *may* by 2030 have reduced 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; it walloped prior monthly record. In a new record global coal grew +9% and more coal was used 2022, as gas costs rocketed. Even in rich EU coal made more electricity – it grew in 2022 over a year before. Western Europe/Germany *may* go well over 50% of electricity from renewables by 2030. But, scarily, that 2 of the world's 3 big blocs may still rely on non-renewables (perhaps coal too!) end of this decade, looms large. As does sneaky Hydrogen leaking: 10% leaks from this GHG will obviate its advantages.

Another issue discussed ahead, was a possibility of forced labor perhaps 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, panel makers & others must carefully vet and address all supply chains. Tracing complex supply-chains takes time & effort. By late 2022, many Gigawatts of solar PV from China passed – and some was withheld from entering US due to this WRO issue. It has started to be addressed by WROs and we are watching carefully.

Broader change is afoot. Some helpful. Maybe spiff electric aircraft to help electrify all, challenging fast past hegemony of fossil fuels for efficient short range air transport. Cleaner power for ships, planes. Batteries made less-cost, low-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 has attempted to ramp domestic US production of lithium for EVs, and rare earths. But given CO_2 levels already 2022 were over 420+ ppm and growing fast, there's no realistic possibility to hold global heating to <2.0 C. Let alone to <1.5 degrees C. Hence climate emergencies, crises, do seem to forbiddingly loom soon ahead.

Action is necessary – and has been nowhere fast enough. With some irony Russia's war on Ukraine, its cutting gas, European rationing fears, little diesel/heating fuel, may accelerate action. Maybe to 'Marshall Plan'-like levels of action. Faster wind and solar, grid, storage, maybe green hydrogen. Yet shorter term, more LNG & gas is a vexed compromise, one even Germany's Greens had to grimly accept. Due to ongoing fossil fuels use, most acutely this has been / and continues to be, simply a huge climate opportunity lost.

Year 2021 was wracked by record heat, drought, storms, and floods. Yet in just a few decades, or even sooner, people may look back at 2021 with all its miserable heat, floods, cold, hurricanes, rapidly disappearing sea ice, and start of fast-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 made clear too, that 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 in 2021, then worse still 2022. On climate we're losing badly. Facts so far are no cause for optimism. Not for this decade, nor even this century.

2021 did flesh out debate over big proposed US climate spending. Outlines of Gordian knot were well-known: 2 legislative bills were in play. One was a classic, 'smaller' Infrastructure Bill supported by some conservatives, so Bipartisan. However, it would do *nothing* for climate solutions. Less-costly of these 2, yet still was $1.2 Trillion(!) and had clear 'pay-fors' as 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 or $550 Billion was climate/clean energy and needed No votes from conservative party: it could pass but ONLY if voted-for-unanimously by liberal party. At first was a $3.5 Trillion wish-list of liberal aims, and climate-heavy. Early text 2021 had Grants (carrots) for utilities to green - and those that didn't, would pay Fees (sticks). There were many big $$ green tax credits too. As for incentives, utilities *growing* clean energy 4%/year in early BBB draft 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* cleaned 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 key 1 oft described moderate Senator from a fossils-state couldn't support BBB reconciliation bill as conceived. Both on substance, saying 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, 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 much 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 a 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 deficit-spending like by conservatives to cut taxes. They'd noted blood & treasure spent on wars without benefit. They feared their own party's moderates were too concerned over pay-fors, not enough on climate – so might go for a small $1.2 Trillion bipartisan bill only. Moderates won a vote deadline on this smaller bill, so there was brewing tension late Q3 to agree on BBB bill too. Liberals aimed for $3.5 Trillion top line dollar figure – not wanting a lesser $1.5 - $2 Trillion hinted at by that coal state Senator, who resisted naming a final $ figure. US Debt default also grew possible – so shutdown. End of Q3 2021 it grew self-evident any BBB figure would be well under $3.5 Trillion, so there was choc-a-bloc uncertainty. All got pushed into Q4 - when a deal *might* happen near Christmas - or it might then all fall apart. If BBB died, there'd perhaps be still a narrow lane to resurrect parts for a smaller clean energy & tax credits bill in more piecemeal fashion in 2022.

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

Meanwhile, conservatives had no-doubt enjoyed the moderate's call to pause on BBB. They also could threaten to Not raise US debt ceiling, 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, a Committee Chair had helped sculpt bipartisan bill, so desired it. And goodies could make much possible (recall Bob Byrd?) bringing moderates off the fence. But, could a $1.5T reconciliation, BBB, *also* happen? Or, smaller bill only? Might internal dissension liberal side sink both bills/all!?? Progressive members were arguably wise to try to hold to all or nothing – as was 'nothing' for climate in that roads and bridges Bill. Yet infra-party dissension could kill both. All came to a juncture just before a G-20 meeting, and then a global COP26 Climate Conference in Scotland.

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

Had that $3.5 Trillion compromise progressives wanted won out, analysis showed 7.7 million US jobs might have been created as clean energy grows US economy $1 Trillion to 2031. Jobs in electric grid, solar, wind, EVs, charging, better efficiency, smart buildings heated or cooled by air source heat pumps etc. That could mean good, green jobs. As discussed ahead, going big earlier-on, at 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, sooner.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

That US Senator had repeatedly declared a big $2 Trillion+ BBB 'Dead'. Not surprisingly as that Senator long criticized its size, scope, direction; especially social spends not energy/ climate from start. But it wasn't, really "dead". Not omnibus; a smaller more targeted Bill was possible. Thus, like in 'Princess Bride' movie, hopes lingered it wasn't 'all dead' – just was 'mostly dead'. A slimmed bill *could* get to 'Yes'. In the movie, Inigo Montoya hoped to return Buttercup's True Love, back to life. Miracle Max told him 'mostly dead' is slightly alive – here a slimmed down bill, better than 'all dead'. And in Washington DC, the joking was the 1 Senator might allow something – but helping all fossil fuels too: thus it was no longer BBB – but rather 'Build Back Manchin.' Then, late in July 2022, the Senator 'surprised' all.

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

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

Consider what's possible there, high end. In theory, if all China's areas that can easily have solar, had it, in 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 China's then total 7.5 PW/hrs of Electricity Demand (2x then-Total demand all energy with heat). By 2060, as solar efficiencies improve, its solar potential might rise +50% more to 150 PW/hr, when China plans net-zero emissions. ½ its potential solar-areas were already capable of PV being cheaper there, 2020, than coal. 80% of its solar areas can be cheaper than coal in 2022. As solar improves more, by 2030, solar could be cheaper than coal - across all China!

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

By 2060 solar + storage could make 7.2 petawatt-hours, meet 1/2 China's electricity demand - by just sun. Complimented by huge wind, geothermal etc; those could meet all needs – alongside maybe later nuclear fusion, that might be so better than fission!. Yet put aside the unknowable nuclear/fusion – think instead of challenges in ramping proven renewables. Especially in its raw materials that pinch the most. Battery designs if needing say, cobalt, may hoover up 36% of world known cobalt reserves – if older battery designs. On new, better batteries that don't need any cobalt, discussed ahead, all gets easier. Even lithium needs might then be 'only' 8% of global reserves. Hence green, alternative technologies are crucial – and myriad ideas beginning to blossom that require fewer of costlier raw materials.

Materials availability, tech maturity, costs, efficiency, all impact choices. Look back a few years, it may have been propitious to have 'gone into Photons' then – gone into solar/'P' (like China did) for it gained sharply after. Later, 2020-2022 surging inflation meant commodities like oil & gas did relatively well. Look ahead, another P, here 'Protons', risky energy storage & energy conversion, along with electrons in H_2, fuel cells etc *maybe* possibly bit propitious one day ahead too. But, it was unknowable in 2023, given their huge volatility. What's certain, is 'protons' theme early 2020s *is hugely risky*. Likely much more so than then-surer-solar.

Solar already was steeply cutting costs. Modern manufacturing got ever cheaper, like it did with semi chips. Energy conversion/protons, are a different matter. Vexed by uncertainties, many breakthroughs are still needed for protons (energy conversion) - unlike photons, PV costs sharply going down. Unlike too electrons; battery-making say, where persistent, steady cost reductions of 6-8%/year were forecast & so helpful. Instead, protons early 2020s say in fuel cells, green hydrogen, ammonia, methanol, were far more of vexed wild card.

A wilder step in 2023 was a *potential for* nuclear fusion. Put aside attention to electrons & protons in H_2, in fuel cells, in PV, in batteries, electricity. Instead, a focus there is neutrons: fuse 2 isotopes of hydrogen; deuterium (^2H in seawater with 2 Neutrons) - with tritium (^3H with 3 neutrons bred by lithium) – and this creates 2 neutrons helium (^4HE). Critically it leaves a third neutron unused; that, on Mr. Einstein's famous $E=MC^2$ is extra mass, could convert to immense kinetic energy, 17.59 MeV as mass disappears. Immense energy, No wastes! But, practical issues like overcoming Coulomb barrier net positive ways, and inertial confinement at temps & pressures mimicking a star's core, mean it's latter half of century at soonest - before significant applied fusion might be on grid. It was presented at first, as energy-positive – but in fact 100x that ignition power used by lasers – so was far from it!! Next century it *may be* a new addition, but climate + energy security require renewables now: 2020s-2030s.

As for this *work* of growing clean energy now, input material costs in 2022 had soared. Supply chains stretched, inflation was far stickier than 'transitory', initially curiously laid out by Fed. Steeply rising input costs are very thorny for clean energy. Went from efficient 'just in time delivery', to instead 'what if' worry. Take solar. If US, Europe, Japan, are to wrest back the manufacturing leadership that had shifted to China in 2010s (we well recall 20 years ago as Japan, US, Europe had dominated PV making, and China was near zero) – then big changes are needed, fast. Confinement needed. Not of $^2H/^3H$ DT fusion ignition – but of price rises like 2021, when Europe wholesale solar prices inflated +19%, back to prices of 2018. True, was still -33% below back in 2016. But, panel prices 2021 were up 50% euro cents per kW, from in 2020. Polysilicon prices, had spiked up 4x, from 2020 to 2021. Rose again in 2022. If the US is to grow its solar from meeting a meager 3% of its demand in 2021 - to meeting over 50% in under 30 years by 2050, hurdles to expansion loom large. Think then of materials. Polysilicon is discussed ahead. But there's other key materials in manufacturing for solar.

To fast ramp solar PV, start with its costlier thornier inputs. Take silver: pricey in making PV panels, ripe for change as conductor in PV. How better to reduce, better, replace dear silver with plentiful copper. Panels 2021 had devoured 20% of global industrial silver supply. Inflationary times, silver can be 15% total costs of a solar cell. *May* be worse on slugflation (sluggish growth + inflation) or stagflation that's arguably been here! So, to grow solar even more swiftly, think then of displacing that all silver, since it's such 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. So 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 here ahead in place of silver, is to be seen. But it's clear, many other and diverse sorts of greener changes lay ahead.

Take buses, likely to see change. A typical dirty, smelly diesel school bus 2021 cost $150,000. A quiet, electric school bus, by contrast 2021 had cost dearer $350,000. So only 1,000 buses, as pilot projects or on grants were electric in national fleet 480,000 school buses. Think then of a passed 'small' bipartisan infrastructure bill: of $5 Billion, half for electric, half for low-emission (CNG) buses. That could mean, schools maybe buying perhaps thousands of electric buses ahead. Driving costs down too, for future EV buses with vehicle to grid 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. Understandably, given high upfront purchase costs. Yet low-maintenance electric school buses *may* be afoot. Moreover, with greater battery storage, fleets of EV buses could be excellent backup to grid. Made cheaper by mass production. Used some days maybe Vehicle to Grid (V2G) selling back power, earning schools' money, or in emergency community backup power. $7 Billion for EV chargers. $ for hydrogen demonstration buses (electric too in a way) passed back in 2021 in the Infrastructure Bill, meant they'll improve faster as well.

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

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

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

It's been suggested gas export tightening in 2021 by Russia on spot markets was to help it win a needed OK for its Nord Stream 2 pipeline to Germany. Or to prepare for coming gas stifling to Europe 2022. Europeans for their part needed much uncontracted, cheap, spot Russian gas. Alternatives were few; get more gas from say, Norway – 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 in 2023 or 2024. If sparse breezes are making less wind power, nukes are down for maintenance, emissions tighten coal – and Germany aggressively targets clean renewables by 2030 – it can get very tight.

Indeed, sparse breezes early 2021 did hurt Europe's wind, as nukes were down for repairs, hydro hit by drought. All that combined, meant late 2021, unhappy records were set. Europe's natural gas benchmark spiked up +300%. Gas futures in a key Netherlands basket rose past equivalent of $150/barrel for oil. Very early 2022, gas rose higher, past an equivalent of $500/oil barrel(!). This all made Europe's natural gas prices start of 2022, dearest fossil fuel by far. Ireland's electricity costs late 2021 jumped 10x in a 7-hour period on gas shortages. Gas was so tight late 2021 in Spain & Portugal, electricity hit $165/MWh, worst since 2002. UK electricity prices briefly rose 2x, or 7x a year prior; next day UK power $395/MWh. UK imported 7.5% of its power from France; an undersea cable loss knocked out 2 GWs power from France. With good breezes like 2022, UK can produce at times most of its power from wind, cheaply! Yet with few breezes, a big UK wind 24 GW faceplate capacity - can fall to 1 GW. Europe's natural gas once was so cheap – so Russian. But early 2022 that Russian gas suddenly became a new question-mark; might even Nord I cease flowing? If so, might mean replacing piped 150 billion cubic meters (bcm) - with LNG delivered by ships from Qatar, Algeria, US etc starting in 2022. Might it mean 15 bcm of new US LNG, with more of Europe using coal, nuclear? Aiming to replace a huge piped 50 bcm, with LNG infrastructure.

Past simmering European fears about over-relying on Russian gas were waved on how bloody cheap it was; thus, it became 40% of Europe's gas, more for Germany. Until that blew up in peoples' faces. Literally. To win approval for Nord Stream 2, or soften targets was maybe behind Russia's cuts; or to divide Europe, or prepare for war. Paradigms shifted fast on fears Russia could invade Ukraine – faster when it did so. All as China, Japan, S. Korean buying LNG pushed prices >$15/per million BTUs. US gas rose too, for all is interconnected, from $2 mm/BTUs - to well over >$5 – prices unheard of in a US shale-fracking era. European Market Winter gas demand competes vs JKM (Japan-Korea Market) – and geopolitical urgency meant Europe had to and did fill gas storage fast. That + mild 2022 helped. But all became scary on ripened reality of wat. Europe's storage reached >95% in Fall 2022; but could that refill again for Hot Summers 2023 & this decade; maybe cold winters too 2024, 2025 etc.

2022 had thrust Europe's debilitating, long 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, gas storage vexed too – as clean hadn't yet grown big enough. In particular as Europe was trying to wean itself off coal, reduce current-gen nukes (though persisted on war, allowing heat as renewables grew) – now wind & solar early 2020s were at an awkward stage. Growing yes, but not yet near-big-enough yet to be Hero. In 2020, renewables had met only some 20% of European electricity demand, not enough to overcome gas' failures this decade… yet.

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

For US solar, a deployment target had been to hit 45% electricity from solar, by 2045. From a scientific standpoint that wasn't only possible, it was *required* given climate carbon budget. Yet such a ramp would be unprecedented. The US 2014 had got under <1% of its electric power from solar. By 2021, was nearer 3%, as 15 gigawatts (GW) was deployed that year. To ramp from there, fast enough to reach 45%, would mean the US must double its solar each year. 30 GW more installed in US in each year 2022 to 2025. Rising 4-fold/year over that in 2020. On to a freshened 60 GW new installed solar each and every year, from 2025 through 2030.

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

After big ECO gains in 2019 up 58%, then in 2020 up +203%, it was perhaps 'unsurprising' to see the falls 2021 & 2022. From then-peaky Feb. 2021, it was unknown of course if clean energy so ECO might fall in harsh backslash shaped "\" down for a year, two or more? Or perhaps an "L" sharply down then sideways. Or given January's rise, an inverted "V" as ^ right leg goes down much further than bit of increase on left. For 2021 & 2022 *might* well go on suffering headwinds on: *Simple Regression to Mean; *If a big $4 Trillion, or $5 Tn+ BBB were cut; or *China on unforeseen exigencies pushes coal burning past 2025; or if *Europe suddenly faces Russian gas issues, or…?? then refrains from hoped-for aggressive moves away from gas, oil coal all early 2020s. All this, despite strong global hopeful words on climate.

3 added worries too were: *Green stocks had hit 'too-high' P/E multiples 2021 and 2022; thus *Inflation/Quantitative Tightening; and *War. Perhaps a Feb. 2021 peaky high was then soft *ceiling?* BBB maybe succor, if one felt a big BBB could pass, as $3 or $4 Tn *might* better justify rich Price targets ("P" in P/Es). But all 2021 was maybe fated as an interregnum, a pause between Q1 2021 hopes - & clarity next year on BBB's fate and "E" Earnings. Plus, maybe fast rising rates as the Fed had let things run too hot – could mean years of tightening. Thus, tech stocks shifted to lower valuations, poorer expectations, falls 2021/2022. On discounted future values. Capital, unsurprisingly, went reflexively 2021 & 2022 from growth - to value - so not towards clean energy! Markets may in future get re-accustomed ahead to see higher, yet historically typical, non-zero Fed rates like in past. But that was not yet so in 2022.

Valuations above 25x EBITDA (Earnings Before Interest, Taxes etc) might be seen again. In risky green themes, few dividends, little positive "E" for earnings – all swung bearish hard. In global NEX, like ECO, components fell hard as one might well expect macro-picture. A big, long classic sell-off soon followed Feb.'s 2021 peak. Maybe much due; NEX/ECO had already spiked upwards 4-fold/& by 6-fold from Q1 2020 to Q1 2021 – after big gains 2019 too.

Recall how within Q1 2020 ECO earlier had fallen -50%; so plummet again by the same, neat -50% in 2021 wasn't so surprising. ECO went from 287 closing high (286.89 intraday) Feb. 2021, down almost exactly ½ to a 142.39 low for 2021(!). Given 2020's gains, 142 was a level seen not long ago: ECO was in 140s as recently as Nov. 2020; it fell near 80 in Dec. 2022. Or, say if NEX goes down say by half; it was 315 as recent as Sept. 2020. Much bigger drops in both themes can well be envisioned. After all ECO in 2020 saw a -50% fall 90 to 45, down -50%; then rebounded. Was notable to see similar-sized, neat, -50% fall again in 2021 *coincidentally*, curiously a 2nd neat -50% decline to 2021 nadir. Then a near -50% fall to near 80 (intraday) as year 2022 nadir. Further falls could be envisioned, but a -50% decline no longer applies.

In sum, 2021 & 2022 were interregnum, rough patch rife of uncertainty. They'd come well off of a peak as the theme had spiked on high hopes after Presidential win, plus surprise 2 seats gain by POTUS' (blue) Party. Fueled by hopes of huge $4+ Tn BBB passing. Started out weighted down by high P/Es – not more usual 14 or 15. Steepened inflation, fear, uncertainty over if anything like BBB could pass 2021/2022 – then BBB failed. For an air pocket 'twixt 2020 election hopes – and tougher clarity. Frankly some more skepticism was always needed, like how truly (un)likely was huge spending 2020-2022; only a small IRA passed. But then, the House going just barely red from 2023, Senate staying blue with 51 seats was important. On a Senate majority, no power sharing agreement necessary. Just a handful of red House votes needed for maybe a $ Trillion+ for clean energy. Without doubt, passive ECO/NEX/H2X/WNX may fall more ahead; ECO just under 80 end of 2022 was understandable. If P/Es are a useful metric - & P/Es early 2021 were 'too steep' - then gains maybe yes from 2023's lower levels. Yet odds of green energy again soon justifying very steep P/Es can be pretty daunting.

Much happening early 2020s in clean energy. Some hopeful; a US President aimed to cut CO_2 emissions by 50%-52% by 2030 (in theory doable). Other things, not-hopeful: the renewables' actual growth since that pledge not enough for a 50% CO_2 cut – though 2022 IRA gets us closer. Solar & wind are capable of it – but on current trends, we will Not hit 50%-52% CO_2 & GHG reductions – 'til later. Broadly on 2 factors: 1) Renewables not growing fast enough to displace coal, oil, gas. And conversely 2) inertia in global coal is not yet letting up. With war especially, fossils were left burning - Not shut-down anywhere near quickly enough early 2020s.

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 by 100x over! They could be generating 6,700 Petawatt/hours (PWh) clean electricity (1 Petawatt/hour = 1 million Megawatt/hours, or 1 megawatt for 1 million hours). Despite vast opportunity, the world in 2019 was only capturing 0.7 PWh solar power, 1.4 PWh of wind. Though winds & sunlight scaled up could meet *all our global power needs*. Forever.

It has been no surprise they're expanding! Solar grew +39%/per year last decade: roughly doubled capacity every 2 years. Wind grew 17%/year onshore; offshore wind boom can raise wind's rate of growth much higher ahead latter 2020s. Clean energy's potential, especially thanks to its free clean fuel, is eye-opening. Sub-Sahara Africa might generate 1,000 times its current energy demands from renewables alone. Australia, Chile, Morocco, could generate 100 times their current energy demands. Even voracious China, US, Europe, India can generate more than all their electricity needs from clean renewables alone.

US offshore wind's GWs ahead start from 'zero', so will likely see big gains late this decade. But for 50%-52% cuts in CO_2 to avoid crisis – falls short. That ought Not dissuade. New energy *can* deliver abundant, affordable change. Electric cars *may* go from a poor 2% of US car sales 2021, to 50%+ in this decade; even as China & Europe are doing far better. In Norway new pure-battery EVs had hit 74% of sales(!) 2021, 11,274 units; EVs/plug ins there totaled 95% of all new car sales! If Norway presages, then auto makers who bank on just 50% gasser lineups in 2030, are gambling with BK (bankruptcy). China, seeing this was 15% electrics 2021, rising fast to soon be EV dominant. Global EV sales in 2021 already far outshadowed puny US figures. China had sold 1.1 million EVs early 2021, Europe sold 1 million – both far better than a US. Europe led the US too in clean power generation by wind/solar - & in EVs too. Meanwhile China rising very, very fast from near nil, is beating all ahead. All this while the US lags.

In Western Europe, coal-use 2019 was falling fast – until war in 2022 revived dirtiest coal! So too natural gas may be cut - but not quite yet! Instead, gas shortages made Europe's energy prices jump. Gas, portrayed as a 'transition fuel' may become a last pariah fossil; as socially unacceptable one day, as coal or cigarettes now. Europe's Climate Law may mean a border tax on CO_2-laden products. There's keen need to *heat* homes, buildings, industry, no fast-green-fix early 2020s. Replace gas boilers with heat pumps costly – but can happen faster than expected. Renewable natural gas (RNG) blended with green hydrogen (H_2) to say 15%, a ways-away. As is running ships & aircraft on green H_2, or ammonia (toxic, so carefully) or methanol – if greener ahead. Maybe: transport hydrogen as benzyltoluene for H_2 released more efficiently from possibly, big Liquid Organic Hydrogen Carriers (LOHC) at lower temps. All that's greener, is vital – but it's only one-side of the climate coin. Other side, has got to be big new moves especially by China, to cut coal/CO_2/methane/GHGs. Clean energy gains for naught if coal & GHGs don't drop to near nothing. Yet huge populations in China, India, Africa, have economic & energy development ahead that may be driven by coal.

So, coal's declines in 2019 in rich Europe/US – regrettably was an outlier. It reversed, got worse in 2022 even as in China, India, Japan, even rich Europe, coal saw terrifying growth. China early 2020s is growing its renewable power + EVs: great! – yet also expanding thermal and 'met' coal too at least to 2025. Notably China in first half of 2020, added 11 Gigawatts (GW) more coal, with another maybe >50 GW of coal to come. Of all the world's coal power added in 2020, China had made up 90% of that. Late 2022 saw even speeding up of coal-use, including by India, given that spiking costs for natural gas had been tough for everyone.

Not only nations, at issue: 33 of the world's 60 largest Banks grew fossil funding in 2020. As any & all hopes to decarbonize the world in 2020s are thus blown apart by coal alone. In 2021 world carbon emissions had spiked 1.5 billion tons, mostly on coal. 2022 was worse. Instead of a big coal drawdown needed, according to best science to decarbonize – plus big cuts in methane too – the fossils instead were expanding globally in early 2020s. Sure, there are happy words. A 'US commitment' to cut emissions 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 played; a UN baseline was 1990 – not 2005 when emissions were higher. So, pledging say '50% cuts from 2005' is then more like a 43% reduction. Worse, the US in say 2021 (pre IRA) was on track for real cuts only 12% below 2005 levels by 2030 – not close to 43%. Games played too, like counting '*not*-cutting' down trees, or seeing oceans as 'carbon sinks', or reducing emissions by 'offsets' in a mockery of reductions. Some words may inspire, others mislead. Air traffic & shipping are kept out of emissions tallies(!), methane too, so the facts are far worse. Aircraft, ships, methane; each with big climate impacts, ought not to be pretended away because they've just gosh, just too hard to reduce.

There's Huge Gaps between *promises* to 2030, the 'blah, blah, blah' - vs. reality of science. These data show *growing* CO_2 & GHG emissions worldwide 2022/2023/2024 led by coal. With no great global actions yet to cut. So, a high GHGs plateau, CO_2 concentrations & its PPMs elevated above 400 ppm for a very long time. Meanwhile, cuts just pledged around the world, fail spectacularly. They are themselves 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 the 75 commitments would only reduce global emissions by 1% from 2010 levels to 2030. So even if NDC targets by many countries are met, there'll still be unprecedented historic emissions driving climate change. That's to say nothing (as we do) of the uncounted methane threat that may force rapid heating too.

An IRA of 2022 helps reduce CO_2 some from a US, one of the worst offenders. And the Paris Agreement won curious fanfare, supposedly holding heat to 2 degrees C (3.6 degrees F), or (impossible) 1.5 C or 2.7 degrees F of rises. Yet assuming science is to be believed, global CO_2 emissions need to be cut and right now in *this decade and far more* enormously: by some half to 2030. Yet actions worldwide point to a plateau – first of coal (then lower), with gas and oil peaks in the 2030s. Nowhere close to required reductions, and Paris arguably already out of date. Far more bold actions, by all 3 emitters, China, US, Europe, are essential. Whilst war 2022 accelerated some helpful changes – it also took our eyes off CO_2 and GHGs. So, to be clear-eyed, recent fanfare over a 1.5 C or even 2.0 C target wasn't deserved. Not when Paris lacks mechanisms to enforce needed cuts to achieve it. Not when there's no real Plan to meet a 1.5 C target this decade. Not as leaders talk as if mostly meaningless Agreements will head off likely(?!) catastrophe. Against needed cuts in this decade – vs. actual lack of global action – further 'net zero' greenhouse gas targets to 2050 aren't worth discussing.

We can squint, for little bits of hope. In 2020, superior economics of renewables meant 80% of new generating projects worldwide were in clean energy. Makes dollars, & cents/sense. That led to a 10.3% rise in carbon-free electricity generation, globally. Also, was nice to see 91% of new renewables were wind & solar. Wind at 58 gigawatts (GW) 2019, doubled 2020 to 111 GW. As a percent of total global electricity production, sustainable energy grew by 2 percentage points – so went from 34.6% clean power generation total 2019 – to 36.6% in 2020. *Yet that was far from 100%, let alone 50%*. Numbers & science show we're near a climate precipice, perhaps irreversible changes. As CO_2 got worse of course in 2020, 2021, 2022.

Overall the world's electricity production pie is growing; yet a thing is, coal is growing too. Coal vexes from its mining, to its waste disposal, yet more's being built with financing. Thus, even as renewables' share of electricity grows overall, total greenhouse gas emissions have continued growing as well. Worthy of note is Not been a single year, yet, of *falling* global coal capacity… ever! Says nothing of wider coal use in high heat industrial processes like making steel, aluminum, cement. Nor coal's big expansion in war 2022. Nor huge embedded CO_2 in products exported like from Xinjiang, China - to the US, Europe, and worldwide.

Greenwashing abounds. Ill-defined ideas 'net zero' or 'climate neutral' are bandied about. Emissions 'offsets' as a shell game, disingenuously is counting trees, forests, oceans as natural uptake. Coupled with distant targets like 2050, words get meaningless. 'Carbon neutral' is proclaimed – yet Not the Same as zero-carbon. True zero-carbon – stands apart from net-zero. So, words are important. They can inspire – or forestall stronger actions. What's clearly most needed, is to *decarbonize now,* in tandem with cutting all greenhouse gases: so less methane, black carbon, hydrofluorcarbons etc. The latter, less-noted, GHG super-pollutants are more climate-forcing than is CO_2. Shorter-lived they are potent at trapping heat - so nearer-term drive global heating in this century. Or these could be smart fixes – if ended-right-now.

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

Instead, we hear words to dissemble. Much of that as Greta says, is just: 'blah, blah, blah' like to 'end coal' (later). It follows that no nations yet merits praise. 'Twixt words & action, the void is huge. Gains so far have been necessary, but not sufficient. In short, action to move away from CO_2/GHGs – means enlisting new capital to decarbonize worldwide. Arguably, market forces much shape energy – and markets matter deeply. Policy too. Once, markets & policies together made coal, King Coal. Later they made Oil, near-exclusive in transport uses. Later still, markets/policy made abundant natural gas so common last century, it would dominate both in making electric power - and across industrial & home heating.

Lately, market forces have helped renewables somewhat. But according to the best science, this transition isn't happening nearly fast enough. A shift from coal – to hydrocarbon oil & gas – had taken half-a-century. We don't have half-a-century now, on what the science tells us. And this transition isn't just to flop new energy – atop lingering old fuels. Instead, it's flipping over to new energy only; solar, wind, storage, maybe green hydrogen. Policy can hasten that, especially as clean is cheaper, better and is always healthier. Yes, as we saw 2022, energy can be a cudgel in wartime that slows renewables - expands coal. Or, can be better - capital markets & policy matter. Helping shape our future. Time & pace of change now, 2020s are of the essence. It's simple. Listening to what science, and seas in fast decline are shouting – matters like never before. We'll turn next to energy Indexes & to financial markets.

Stepping back, let's look at ECO/NEX back first in 2020. Given the 2 Indexes/ETFs stood out as top performers that year worldwide with ECO in particular 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 the down years – these 2 volatile Indexes will drop harder/faster than most!

One big factor: perhaps our long use of *decarbonization* as an organizing principle stood out. Another may be: *Market Inefficiencies: our Indexes hold smaller & mid-caps not as known to mainstream analysts; fewer analysts in cutting-edge innovations like in electric cars, Li-ion, green hydrogen, fuel cells, solar etc – may add sizable pricing inefficiencies. Fewer analysts then in zero-CO_2 (and those that are, do excellent work!) on a flood of new attention & price discovery 'animal spirits' in tow, brings scope for gains. A 3rd factor may be all-too human: *Disbelief! Difference of Opinion Is What Makes a Market; deep skepticism, even shorting - vs +12,000% gains in an equity impactful. 4th is many 'ESG' baskets are steeped in greenwash; for example, they still may have natural gas! Our's with true clean focus is instead very unique & has been consistent for 18+ years; that it's come into favor maybe is good fortune.

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

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

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

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

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

The Good: Reasons for Equities Rise in 2020

For bit for fun, let's call factors behind big 2020 change, or that 'delta': the Good, Bad, and the Ugly. Good, ***Huge Reductions in costs** of clean energy, solar going towards **least-cost electricity* in much of the world; wind too. Solar/wind could become the *cheapest electric power in history!* Unimaginable to many, just a decade ago. Many models had long foreseen dirty coal, or gas instead, as definitively THE very lowest-cost power across 2020s!

A good driver too 2020 was ***unprecedented commitments*** by 3 economic blocs, China, Europe, US. In 2020, China made statements on decarbonizing overlooked 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, fleshed out post-2021 when a seminal 14th 5 Year Plan was released to much anticipation. Possibly China could aim for 'solar superpower'.

Had it meant all greenhouse gases? Methane/CH_4, HFCs too = climate neutral - or just, CO_2? How much disagreeably, dismal 'carbon capture & storage' (CCS) plays a role? Is CO_2 just temporarily stored? Monoculture reforesting? May 'carbon intensity' allow increasing gas use – and be regarded as an improvement?! Might CO_2 be seen sadly as 'per unit of GDP growth'? The latter could/would all distort the true numbers around 'carbon-neutral'.

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

Models by Tsinghua University showed how China can hit net-zero CO_2 by 2050, all greenhouse gases by 2060. Requires big fast declines soon, in coal power - and heat – plummeting from >70% – to <5%. To instead cut coal only post-2025 means then very sharply cutting after 2030. Far better would have been aggressively Decarbonizing now: this would've been preferred to many worldwide. China, instead, may linger with coal, and ramp its nuclear up from 'just' 46 plants for 50 GW 2021 – to far more nukes at end of decade = yet that equals higher odds of devastating radioactive accidents ahead. Regardless, China's new energy spends may well top $15 Trillion. Or, far greater: recent estimates are global $100 Trillion to $120 Trillion must be invested on green energy + climate tech. So, it may be 2x, 3x that. Most ambitious efforts the world has seen. Maybe 10+fold increases in solar, wind. Maybe 10x-100x PV manufacturing capacity. Tremendous ramps in storage. New energy technologies, like green hydrogen for zero-CO_2 heat for steel and cement. Colossal challenges all needing heroic actions, now.

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

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

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

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

Or look to wealthy Western Europe, to European Climate Law. It had laid out 'carbon neutral' by a distant 2050, but could yet get 55% or better there *this decade* by 2030. Little-discussed in US - yet seminal – is that it was given more teeth following war in 2022. Perhaps a 2030 target to be more than 60 GW offshore wind, 5-fold increase from 2020; then to 300 GW or more by 2050. Greater now, since Russia's invasion. Plus, needed to start now – not later. Meanwhile, China's green growth fastest in the world in areas to which it commits.

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

There's ample coverage of what might have happened in US 2021/2022. Bigger legislation was close to creation, far more green incentives, jobs. But one party lacked 51 Senate seats in 2021/2022, to pass that. From 2023, however, if a handful of House Republicans can be had - then there may be a chance for even a small carbon tax, a National Renewables Standard. For US to start out-competing, akin to China in green energy installations. What might have been, may be: lower-cost solar, wind, better grid; more swiftly an-electrified US. More still, like has begun in other nations: manufacturing for new batteries, EVs, wind, solar, green H_2. Products with little embedded CO_2. An uncapped IRA may lead to $1.9 Tr given $$ in private investments. And $ Trillions *may* come ahead, if a handful of House Votes can be found.

Some 'Bad' Factors maybe for Equity Gains in 2020

Perhaps there were a few 'bad' factors behind 2020's equity gains. Bad, in a sense, to some, they didn't warrant such exuberance; Hydrogen (H_2) & fuel cells come to mind. Not that they can't, possibly, sooner than expected - be vital. More that they didn't justify hype, 'til breakthroughs occur. But these are passive Indexes – not active managed – so not trying to predict rises or falls, winners or losers. And H2 fuel cells did outperform in 2020 - plus is very specific to new H2X Index. Browner H_2 is burdened by sparse CO_2 avoided, low efficiencies. But, H_2 may grow increasingly relevant. If still just made from drilled 'rock gas', natural gas inextricably fossil, its not a worthy solution. That 'blue' H_2 made of fossils & sequestration, could only pass a very low bar as it is so polluting. True, big Oil embraces a chimera of blue H_2 – but that 'blue' may only compete with green H_2 in this decade, before green H_2 scales up big. And neither blue H_2 with 'sequestration', nor uglier brown/grey/black H_2 made even from coal - are created cleanly, green, in truly renewable and scalable ways.

Best is a green hydrogen renewably, cleanly made. As by solar, wind, other ways ahead. Early on, 2020 Spain hoped for €9 billion spending on green H_2 ahead. France, €2 billion green H_2. Germany looked at €9 billion by 2030. A Catapult plan for 25 GW green H_2 at <€2 per kilogram. Saudi Arabia was considering 4 GW from solar & wind; UAE looking too. Different, is capturing potent greenhouse gas (GHG) methane (CH_4) from landfills, dairies, etc, maybe as 'renewable natural gas' (though that may prolong rock gas). Or a step further, as 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, 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 now touts H_2. Maybe too 'green ammonia' (H_2+Nitrogen=NH_3) or liquid organic hydrogen carrier (LOHC) easier to handle than H_2, made e.g. by offshore wind. (Blue ammonia undesirable). Visuals of wind or solar making green H_2 – or 'green-ish' ammonia NH_3, or LOHC - may be painted.

Cost, is the rub. Affinity of H_2 to react & combine, means much solar/wind power is required for electrolysis to split water. And green H_2 has been too costly vs. H_2 steam reformed gas – even brown too costly in its own right. An inflection can be if: 1) solar/wind costs fall; and 2) green H_2 goes to <$2/kg by 2030 or under <$1/kg. Profoundly then, H2 is no longer out 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 next to well <$2/kg is targeted, far cheaper <$1 may arrive in innovative new ways.

But, all that was a dream start of 2020s. Green H_2 cost x-times too much, everywhere, seldom seen anywhere. Just 42 hydrogen stations in California in 2020 – vs. 22,000 electric outlets for charging. Worse, the inefficiencies. 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 renewables, holy grail of abundant firm power & heat. Nearer term, green H_2 may displace rock gas – but only to <15% content to not embrittle steel. Renewable natural gas may be a drop in fuel. Uncapped methane captured, upgraded to a renewable natural gas, *truly* sequestered C in stable form. Still, renewable natural gas is just going on defense vs. climate risk. Not great, a tiny help near term. In sum hope for H_2 partly why clean jumped 2020 as equities are forward-looking. But case for green H_2 was far hazier early 2020s - than it was for solar, wind, electric cars. That said, green H_2, before only barely conceivable, *may be* plausible ahead - *if* renewables bring us very cheap power.

The Ugly: some unpretty factors perhaps in gains in 2020

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

Issues too its adherents don't raise. What if that CO_2 leaks in a few centuries?? At Lake Nyos, Africa, a CO_2 'burp' killed a thousand people. Far better, would be a stable, truer CO_2 storage or mineralization mechanisms that are inert, safe, permanent. And solar is cheaper than coal now, anyway, so coal+CCS is no answer! Costs to capture CO_2+pump it underground renders that coal 4x too costly!! It's why we see 'clean coal' (ha ha ha) in ads only - not for real.

To be compelling, DAC must *Remove that CO_2 from air & seas *Permanently, and 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, seek to dim our planet's air or dump CO_2 massively in oceans without knowing effects??!). That of course should be rejected. Yet even such hydra-headed monster is overshadowed by immediacy of the climate crisis. In 2020s, global heating is fundamentally fast altering our once-cool planet. This last specter concentrates the mind: how now to better and swiftly, sensibly, avoid more CO_2 in the first place.

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

Closing gaps from past energy 'wrongs' – can help propel clean equities upwards. A few years ago, conventional wisdom held EVs, solar & wind power were all costly toys at best, always slated for a kids' table. Regarded as unserious. Thus, rather than 'listening to the sea' or thinking holistically – electric cars were dismissed as ever-slow and silly golf carts, forever vexed by hills. Their range terminally thought of as under <100 miles so always a sad joke.

How wrong! Proving old beliefs wrong, sleek electric cars have been/are getting vastly better. They were fated to do so! Foreseeing this favours the bold. Closing gaps between state "A" (old inaccurate beliefs) – and "B" (truths) – can be disruptive, innovative, useful. Clearly, it can make delta/change in equity valuations – maybe 'alpha' too in financial terms. Foreseeing these gaps even if just a bit before others do, may potentially be vital.

It's also non-linear. Think of big falls back in 2008/2009 as green themes crashed; again in 2021/2022; they certainly can/will do so ahead. In slumps profit margins here go non-existent, down for years. There's often a non-Euclidian, curved, non-flat geometry. Like disjointedly compressed margins, not straight lines. Solar's margins in time did becalm; we're learning to make solar the *least-cost electricity in history!* Learned cost-reductions leading to virtuous circles. Electric cars got better in most every way. Think by contrast, of heat engines; unfathomably still all around us, spark plugs explode fuel, push pistons to power cars, trucks. Coal makes electricity also by heat difference. Nuclear too = world's costliest boiled water. Delta in that hot - vs. cool. It's difference of state, temperatures "A" vs "B". But that difference found in heat engines, is also brutally inefficient - unlike nature herself.

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

This last maybe so significant, it could stand out *sui generis*, global crisis. Potentially, climate risk may devastate whole societies, humanity. Possibly it's an existential threat, one not yet understood. On tipping points, feedbacks: permafrost melts, methane bursts, clathrates that can't be unwound. No matter how hard we humans may beg, bargain with, or badger nature. On most topics, scientists will counsel calm. Soothingly they'll remind us that things really aren't nearly or 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. One day may hit us, not in a spirit of bravely looking at solutions. Not as boldly advancing our better natures. Instead, maybe we hastily try to save what might be saved: remember Summers lasting only 3 months? Winters? Cool nights? A century out, who'll recall living coral reefs? Sandy beaches? Healthy seas? How to cherish what we bequeath. Especially as sustainable, no regrets paths can make us healthier, happier, richer, safer, more secure. Instead of costly spiraling blood & treasure, new diseases, pandemics, despair. Better may be *Listening to the sea*, embracing a wisdom of *Prevention Rather than Cure*.

NEX/ECO/H2X/WNX help capture & track, sustainable paths. Decarbonize, electrify all, low and better-yet, zero-carbon fuels, energy efficiency including in heating & cooling, circular industry. Ideas just emerging of particular ecological advantage in Index themes. Consider for instance, what was seen in 14 most volatile, upside constituents in NEX early 2021. Themes the most up over a past 52-weeks to early 2021, hence the 14 biggest gainers then.

NEX back in Jan. 2021 was near highs, so we'd avoided looking right at a peak time. Instead, here's figures from March 2021 as NEX components in green innovative equities globally had begun steep falls. These % figures moderated a bit by looking on March 3rd amidst a then -25% YTD plummet. Nonetheless like ECO's story, where we'd also noted big gains up +1,000% from lows 52 weeks in 2020 to March 2021 – here an NEX worldwide is showing what's most up. In these instances of richer gains globally, 14 NEX components with biggest deltas to March 2021. Those showing gains of at least +600% up from their 52-week lows early 2020 were:

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

So, 2020 saw big gains in EVs, fuel cells, wind, solar – followed little surprise, by big 'normal' falls 2021 & 2022. In 2022 ECO went down just below 80; NEX down below 300; they could drop both much farther yet! In future even as climate bills again rise/die, stocks crash, rates change, pandemics, war, blackouts etc etc - these 4 risky themes can plummet, swiftly so. While other 'not normal' far outliers may happen too, like terrorism, even US Debt default, Sun CMEs, or EMPs, etc. All these risky, volatile once-high-fliers could then be badly hit.

What was special 2020 about these gainers? For sure they're remarkably diverse. Some were in energy innovation scalable for 'on offense' against climate crisis, like solar & wind. Names upstream in solar included in poly & ingots, wafers, panel manufacturing. Downstream we saw inverters, PV sales, installation. There was 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 was 'defense' too, on climate. Smaller steps, extant infrastructure. Capturing methane – otherwise indifferently released to air like to sewer. 'Renewable natural gas' far from ideal, may just turning methane to CO_2 – combusted as a less potent greenhouse gas like in rock gas. Or just for lower CO_2 - or a near-negative-CO_2 sustainable aviation fuel, gasoline, diesel.

Past equity gains like 2020, *in no way* foreshadow gains ahead - as was seen in 2021 declines. Indeed, big rises may auger sharp/er falls. Regression to mean, nothing 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 once-magic fossil jobs - mean what's bad for fading coal, oil or gas - is bad for humanity. Wiser, would be to set out for stable climate asap. Towards broad sunlit uplands we'd once enjoyed, carbon back down under <300 ppm. This choice is seminal.

30 years ago, paths forward weren't so clear. Solar seemed viable, but could it be cheap? Horizontal or vertical axis wind turbines in red in tooth & claw competition? Electric vehicles maybe possible if better batteries, but *when* might that happen? Green H_2 *ever* economically viable? Same for fuel cells? All were obvious questions – no obvious answers. Barely imaginable then, yet getting possible now: electric jets, green H_2, energy carrier ammonia, methanol MH_3OH for ships, ultra-deep geothermal; scale DAC sequestration as carbon mineralized rock. So much yet to see in this decade. All debatable, inherently now unknowable. We recall this is rather like was late in last century/millennium, which was only some 30 years ago.

To passively pool diverse clean energy *possibilities* in a single Index basket, made great sense then – & arguably still does. Victors, unknowable, which of these competing technologies may win the day. Mitigating individual stock risk via a basket, was compelling then: it is just as, or 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 themes, more ahead. Which equities, all very risky – will Fail – which Survive. Perhaps thrive. This vexed matter bedevils, and helps to make passive Indexing like here, arguably rather compelling.

Volatility, though, is a differing beast. We say on great confidence, oil prices will move very sizably ahead. Fossils may be in long-decline - yet events happen: lack of supply or storage; accidents, attacks on grid/infrastructure, drought, floods, hot days, bitter cold snaps, even solar weather's CMEs, EMPs – may be big price changes. To not weatherize against extremes = Unpredictability that's predictable, in a sense. Drought too, stalks both fossils and nukes as all need cooling water to work. Or, stratospheric heat in a changing climate may occur say one-month; a weaker Jet Stream next month lets super cold arctic air South, freezing temps. Or a slowing ocean Gulf Stream, ironically, may mean dramatically cooler Europe on altered weather patterns. In past, the stability of both key Streams: the Gulf + the Jet, was crucial. Yet now, on less temperature contrast 'twixt the Poles vs. Equator, may mean wind droughts. Fossils, may be in a longer-term decline – yet we'll certainly see huge volatility here.

Foreshadowing disaster hit Texas 2021, as a freeze took down its main electric grid. That big blackout also showcased battles going on in messaging. What will it take to build a reliable grid ahead? More gas & nukes? And/or - more renewables and storage? Natural gas long has dominated there – yet lately it is finding itself on its back heels. Case in point was amidst that crisis, an argument was hastily put out even during blackout that it was due to clean energy - and to Texas' own wind turbines freezing up! Whether promoted by uninformed, or instead politically motivated opponents – that false tale was widely circulated especially on certain media outlets. A photo image was spread of a helicopter with vat hovering above frozen wind turbine – claiming that this was a current Texas photo of flailing attempts to drop chemicals and unfreeze, unstick turbines. They claimed it proof wind was the ***main, and only cause*** of the terrible grid outages, during a freezing Winter week of February 2021 in Texas.

Was that really so? Let's start with that frozen wind turbine photo being shown by many. In fact, it was an old 2013 photo from a Swiss helicopter company from testing hot water off a boiler truck (no chemicals) in Sweden – on a turbine lacking usual de-icing features. That compelling photo shown at a 2015 conference – here made a powerful but fictional 2021 false narrative. The meme was shared widely by publicist, website, & others: it was memorable. But clearly untrue. And it stoked misinformation and was seized on by wind's opponents as 'proof' of wind's failures. The truth then, in Texas was very different - but facts 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 on 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 2021 forecasted models. (Wind soon spools up enormously in early Spring months).

Relative small underperformance vs expectations was for wind, narrower than was for coal. Latter was off larger, 5 GW from where '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 *unplanned* capacity outage was due to natural gas. 22% was wind. 18% was coal. Plus, the nuke losses. Thus, each source of electricity was hit. Truth is wind's shortages were much smaller (nearly least) of all the disruptions in that crisis freeze over 3 vexing days.

The key shortfall was of 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 divert oil from the 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.

More normally, gas producers might sell product at around $2.50 per million British Thermal Units (BTUs). Contractually obligated to supply gas which they couldn't provide, instead some had to buy (to provide elsewhere) at ridiculous prices like $200/BTU. On Exchanges where gas prices hadn't gone up to $200, they'd added a digit. Nearby, in wealthy Dallas, the price of natural gas 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 an ever-ample feedstock gas. And expected wholesale power rates of around $24 per megawatt-hour. But because gas was unavailable on freezing temperatures, and 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/MWh! Reminiscent of crazy gas pricing seen again in Europe in 2022, on war in Ukraine. But in Texas, power producers needing gas to make electricity, competed with gas producers needing it to meet contracted obligations for available unfrozen supplies. All got hurt. That gas trading expert well described how differences in trading normally are in just 1 penny amounts. Instead, they were dealing then with gaps of $50+ 'deltas' in gas prices.

In retrospect, to understand how to do better, lessons should be drawn. Lesson #1 is *more* natural gas would Not have solved anything. 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 of preferring light regulatory touch in electricity supply, natural gas is less burdened. But, this arguably was a matter of public safety. Plus, more unregulated power markets like this one, as it turned out, perhaps surprisingly were not always the cheapest.

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

More *storage* too, suggested, yet of *natural gas*. In Texas' crisis, *gas Storage* was a Hero. It didn't freeze like gas *production*. Another idea, *winterize key power plants; a multi-billion-dollar nuclear plant gone down on pump freezing, was cheap to prevent in first place, a no-brainer. Ensure *critical infrastructure gets power in crisis. Hard to protect against: drought. Big thermal coal, gas, nuke plants: they may *have to* shut on low water – not only hydropower big dams. In Texas, Arizona, the West, drought stalks – broken by atmospheric river floods.

If feels like playing at edges of a teetering system bound for scrap ahead, you're probably right. What it shows, too, is what really went wrong in a 2021 Texas crisis. It wasn't smaller loss of wind! Wind turbines can readily be winterized; it adds 10% to turbine costs but is done round the world. Wind energy works in Arctic, in US Upper Midwest, in places far colder than Texas; in fact, wind prefers colder, heavier breezes. (Natural gas too prefers cool days, but no claims to the contrary were 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 fossils as 'reliable energy'. Even though its 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 no power! We don't realize how dependent we are on electricity 'til it's gone'. Only by shedding 7,500 MW of demand (effectively turned off ~1 in every 8 homes in State), were they able to take a first emergency step. That was twice a 2011 emergency shedding that 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.

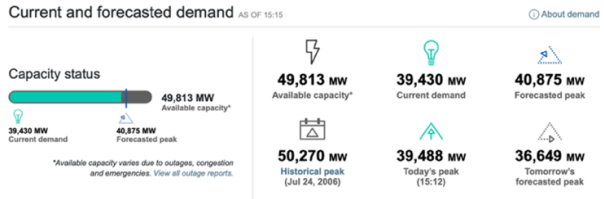
It boils down to: How ready are we for a changing climate? Honestly, not at all. A key oil pipeline from Texas to US East Coast, if shut – can paralyze Southeastern US. Glance at a weather app like Ventusky, and it shows swirling arctic polar vortexes in every Winter. Bitter arctic air drops at times in Winters near population centers yet remains just North of the US, like in Europe, Asia. We're saved by historic Jet Stream wind patterns. Yet these change. A sudden stratospheric warming high in atmosphere can weaken this 'fence' protecting us. It doesn't take much to envision Jet Stream shifting, wavering, weakening: bitter arctic cold descends further south. While may not sound at all harsh to the ear, consequences would be. Flooding, yet longer droughts too from air that's arid, warmer, so holding more moisture for occasional big bomb cyclones increasingly imperiling big thermal power plants & dams. Terms like 'Climate Change', 'Global Warming', may be too benign for what may become, Calamity. Better might be 'Climate Crisis', or 'Global Heating', even 'Global Weirding' if decades, or centuries on a blazing Planet. Perhaps uninhabitable equator, yet temps not too far apart at 'Hot Poles'. Getting there may not even come slowly, or incrementally. Maybe not linear; not pleasant, no 'desirable' warming along the way with gradual gentle changes only.

A slowing Gulf Stream *could* paradoxically mean centuries+ of bitter change – colder or hotter. Look westward - or eastward from Northern Europe - away from a North Atlantic warmed by Gulf Stream - and it's quickly frozen. Should this Gulf heat train fail, changes will be immense. Science is unsure if its to be a Frozen Europe? Or Baked one? But most impossible, is centuries of no changes at all! It's a difference engine yet again, both in stocks (finance) – and in driving natural world – that we've talked much about. A Gulf Stream failing as fresh waters dilute salinity – and/or as a melting Antarctic alters the overturning currents worldwide – and we all lose. Solutions may present myriad ways, but here: *More renewables, storage, EVs & better grid, in short Clean Energy* - is where all our attention now ought be turning.

Despite all many benefits renewables clearly offer – so many politicians oppose them still. Funny, how despite anti-renewables rhetoric from some Texas politicians – a year and a half later Summer 2022, they were ironically saved thanks to fast-growing renewables. Amid record Texas heat 75 GWs(!) of demand, wind+solar generated 27+ GWs, to meet near 40% of demand! Plus kept electricity prices cheaper than gas & coal power. Over 2021 growing zero-carbon power in Texas (with nuclear) made 38% - nearly a 42% then made from gas.

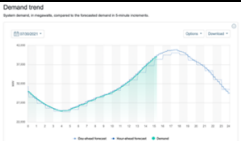
Yet grids in Texas – like so many places are exposed. In July of 2022 Texas teetered on edge of record Demand, 80 GW total. Should there be one-day insufficient generation, or kinetic attack on grid hardware, or a cyberattack on software, it confounds keeping grid stable just above critical 59.3 hertz. If its grid goes full down big-time, a 'black start' may be needed – whether can be done fast is unknown. As we look forward everything: more green energy, more storage, better transmission are all needed to decentralize grid. We fundamentally need a better more modern, more stable and resilient grid, using much more renewables, fast.

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



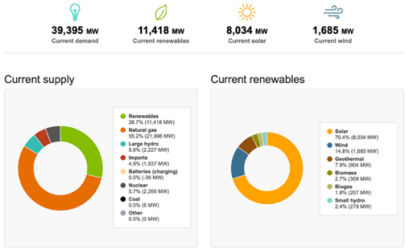
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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



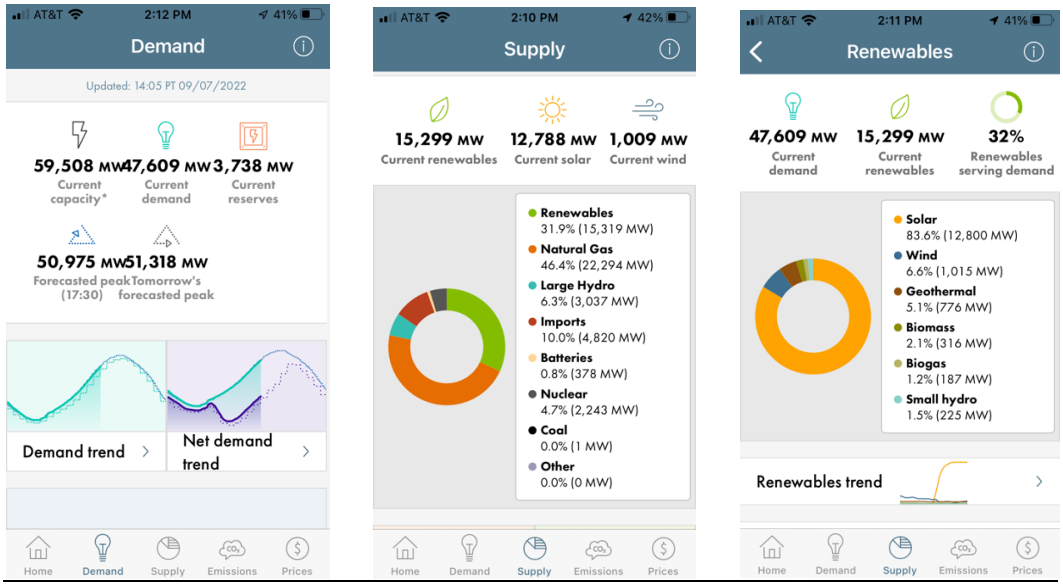
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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



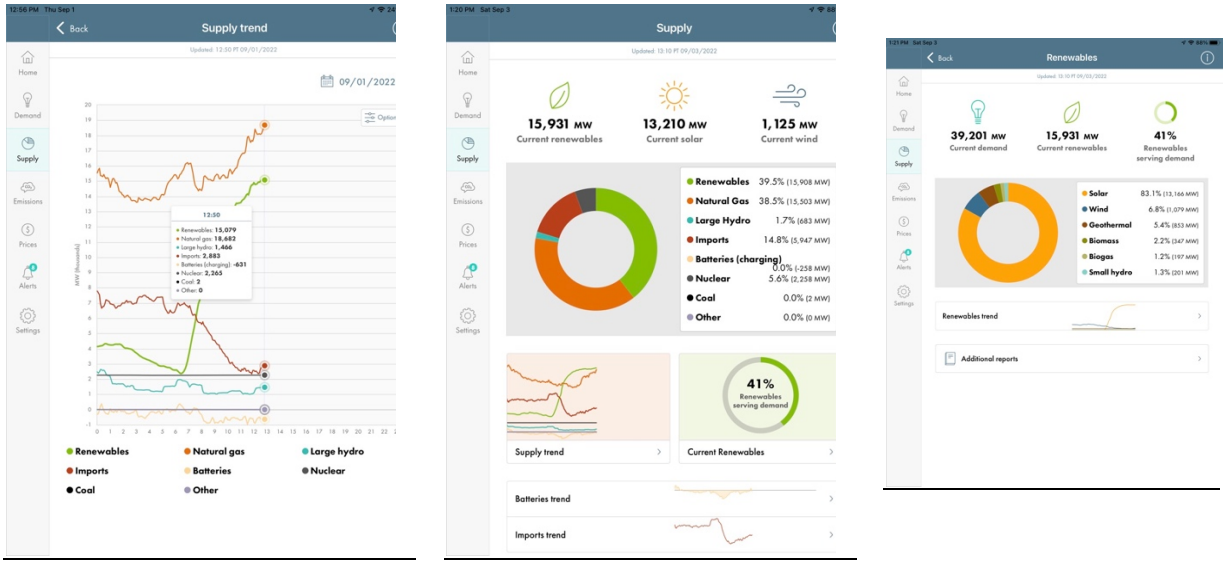
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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



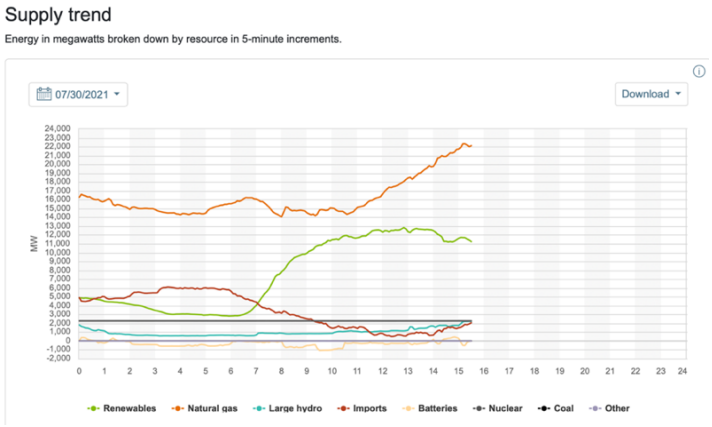
Source: CAISO.com Today's Outlook - On Sept. 7, 2022 at approximately 2 p.m.

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



Source: CAISO.com Today's Outlook -

Put it together, one saw a pretty expected hot summer day 2022 (above) flirted with disaster. Renewables served just 41% of California Demand. Far too low in a changing climate. Yet good news is renewables are eminently scalable. Grow solar by a doable 5-fold, quickly, so solar (above) that had made 13 GW (13,166 MW) – becomes, instead, solar making 65 GW. True demand expands too – so grow firm Geothermal many, many fold. Wind Energy is oft strongest at night, so grow it 5x. Global 94 GW of wind added 2021 had brought world wind capacity to 837 GW; in California new offshore wind should grow many-fold, much more than just 6 GW, fast. Couple with green storage for nights/windless days to meet all California demand. All this with modern grid, import from desert sun & Midwest wind. Ponder how supply arc in green, daily, ends each day in an eminently expectable solar 'issue': the Sun setting!



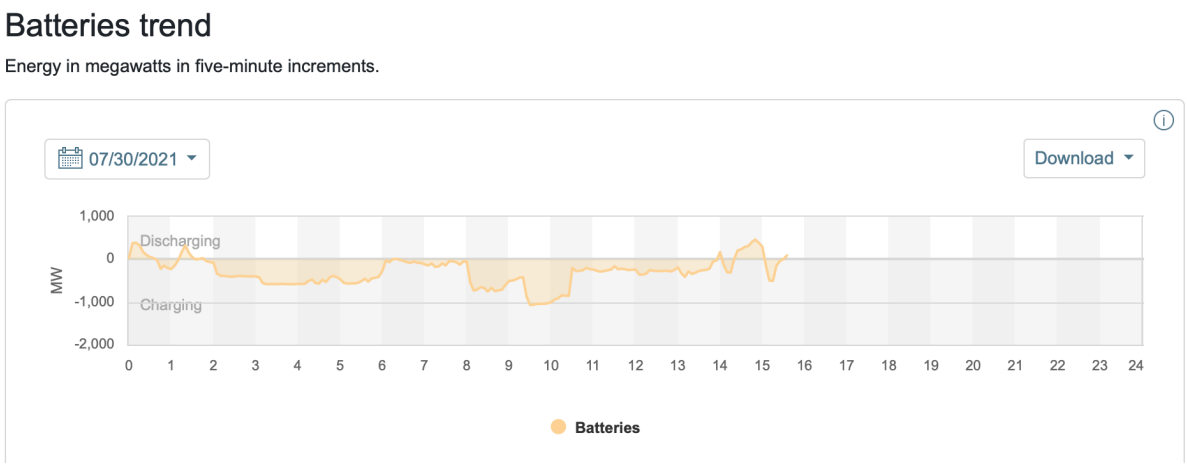
Source: CAISO.com Today's Outlook – On July 30, 2021 at approximately 3:30 p.m.

We must expect this, solar's huge renewables contribution here, green, is about to drop hard as the sun begins to drop. Of course, that's eminently forecastable! So, 11 GW of solar at 3 pm helped to meet 40 GW demand; but will fall soon very hard 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 'lost' the GWs from solar in an arcing, soon to plummet line above.

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

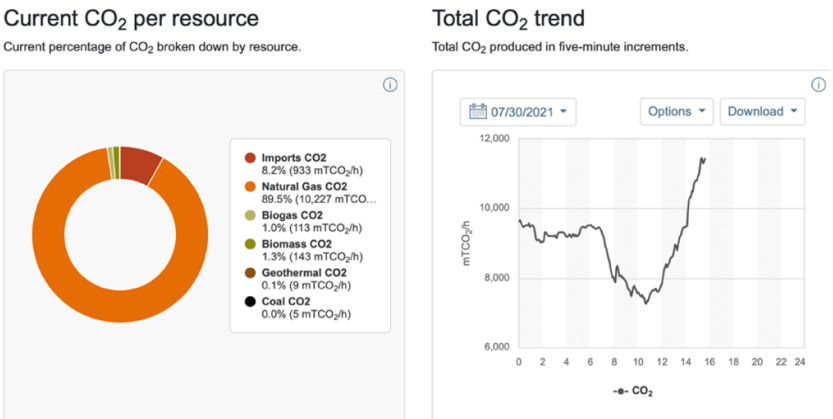
Fast-scaling renewables is the favourable path. But not perfect. Drought in changing climate with flooding is hard on big hydro. New wind patterns tough for wind energy. But distributed generation, like new infill solar on roofs – doesn't show up in the attractive figures above for Utility-scale renewables. This Report's been written for 20+ years in a building with 2 solar systems for power, 3 electric cars (no gasoline/petrol needed at all). Solar powers our cooling - and heating – with 2 heat pump/mini-split AC systems. Electricity from solar; hot water from large passive solar tank on roof. All this with a battery backup – linked to solar PV. So when local blackouts do occur, or say, gasoline prices may spike, we're left blissfully unawares. Repeat this millions of times over, especially given for 20+ years it has Saved us $$$!

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



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

A wickedly Insufficient storage early 2020's meant we'll go on suffering ongoing dependence on fossils. From more natural gas 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 not quite as awful as coal CO_2 per MWh, but its methane leaks do badly vex Earth. And we *know* while its *measured* CO_2 is a big issue – the unmeasured methane leaks have made it a climate killer given methane is a potent GHG.



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

Insufficient Electricity Supply is Given, hottest days in wealthy Texas, California, and much of Europe. On drought even in a once-hydroelectric-rich, Sichuan, China. A game of catch as catch can, blackouts threatening, pollution left to go up wildly hot days. That's No solution! It's been left to hope, was seen Hot days 2021 & 2022 as California's Governor had to give Emergency Proclamation to shed load – up generating capacity. Shed 3 GW power to industrial customers, who'd thus lost power but who were paid handsomely. Dirtier backup generators used freely. Ships were allowed to burn very dirtiest fuels in port, rather than to use far cleaner shore electricity. All scary, near blackouts, threatens lives, and Ugh.

California grid means that in a Flex Alert, CO_2 Emissions will spike to get Supplies as high as possible, now over >50 GWs. Gas peakers run flat-out 100% no maintenance, imports needed from out of State. Demand in a very foreseeable Heat Wave like in 2020, 2022 etc had outstripped State capacity. Given efficiency strides already made, look to green supply, and storage. Yes, California is ever-adding (yay!) more electric vehicles – those can charge at night, leveling out demand (and not the threat some might worry about). But in fewer and fewer years to 2030, that 1 lone (2nd gen fission) nuclear plant making 2.3 GW will then close; that will mean a big 5% loss of firm generating capacity. Blackouts surely ever-looming.

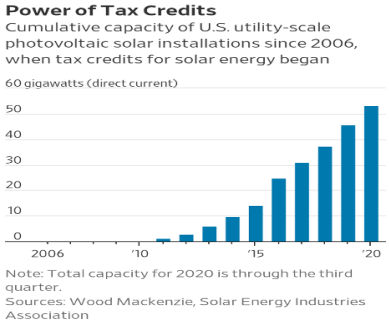
The State is breaking out band-aids. Importing electrons from power elsewhere in the West, even in times of regionwide need. Imported power that's generated by dirty sources – coal, gas, or costly 2nd gen nuclear hit by cooling issues, all suffering more so than renewables from heat waves. Drought with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

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

Used to be, proponents of US natural gas pointed to it as energy transition saviour for America. But what they hadn't figured, was gas crisis in distant Europe – that sent prices up worldwide. For prices are set globally. True, fracking in America helps to prevent spiking gas prices, as does filling US gas storage. Still… Take say, Sept. 2022: US natural gas already had more than doubled that year – and that hit utilities very hard. US electricity nationally Fall 2022, had averaged near 15 cents/kWh, up 7.5% over year earlier. CPI for electricity costs was up a big 16% over a year prior; largest spike since 1981. Some regions, much worse. In parts of US like New England, residential electricity went from 10.67 cents – on up to 22.57 cents/kWh. Due to gas rises that utility's wholesale costs tripled from 2020, to $130 per megawatt-hour. As Winter is coming, renewables = less costly! Recall again Bidding cleared prices in the UK in £GBP/MWh 2022: offshore wind just 37.35 pounds; onshore wind 42.47; solar 45.99. How better!! On war in 2022, weaponized gas was an Achilles Heal, worldwide. But a take-away, is it doesn't need to be this way. Not reliance on gas, nor on China for key minerals.

That 1 Senator who'd shaped the IRA in 2022, had firm thoughts on sourcing & processing of vital minerals in the US, building green industries at home. Energy storage, now so vital – was a theme China especially, but now even oft-lugubrious Europe far led on. That Senator wanted a new, more pro-US trajectory: mining & processing here; the IRA to reflect that. It gave a 30% tax credit for stand-alone energy storage (needed before to be coupled to solar, so 2021 fully 93% of storage was tied to solar). Developers could benefit from extra 10% ITC if 40%+ components were made in US. Another 10% if in areas once heavily in coal, oil, gas. All that was foreseen in previous draft bills. Will take years, but with newer 2022 IRA incentives, key minerals should begin to be sourced from in the US. Biggest US EV makers may be expected to build this decade, new US plants for processing lithium (even if mined elsewhere).

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



Sources: Wood McKenzie & SEIA

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

Just one upstream example is tax policy may help bring about moderately green 'lower-CO_2' lithium for batteries, that's cheaper to boot. Where naturally hot lithium brine occurs, geothermal power from hot brine may make lithium hydroxide, without water waste. Freed from intensive evaporative ponds, needing no sulfur. Co-locate battery/EV makers – like poly plants+solar PV makers - decarbonizing as one organizing principle; that can build lower-costs and efficiency. Ever better is a circular economy with new zero-CO_2 solutions.

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

A useful non-Correlation of our 4 Indexes - versus Fossil Energy

ECO/NEX plus now H2X/WNX themes - show good *Non*-Correlation vs fossil energy. What an example of diversification! There's been robust differences: sometimes, e.g. clean alone gained. Or sometimes, clean fell hard - as dirty fossils were up like in 2021/2022! Yes, all themes are *energy* – yet clean marches to distinctly different drummer vs. coal, oil, gas. Take say a 2020 vantagepoint and look back from there: an interesting thing had happened. Dirty energy few years to 2020, was THE worst performing sector of S&P500 in 4 of the prior 6 years; it was down -30% in 2020 - as clean energy roared. (In S&P500, 'energy' mainly was still fossil fuels). In sharp turnaround, fossils jumped 2021, some 2022, after long doldrums. Still, past years were remarkable for all diverse energy, so look a bit more closely.

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

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

Drilling deeper let's consider oil & gas behemoth Exxon. In 2020 the Dow Jones announced it was dropping Exxon from its leading ~30-stocks Dow basket. Why? Apple was splitting 4-1, and a price-weighted Dow Average needed component/s to better keep up with other baskets. (Dow had sizably lagged in performance then). New representation was chosen - but not from fossils. Instead, they added in 2020, 3 tech-heavy names. Dow Industrials dropped Exxon that in various incarnations was in since 1928; once a long-serving Dow component, no more. Only Chevron in oil, stayed. (That was due to a prior decade perhaps when dirty energy had fallen – yet it would rise big 2021/2022; indeed, energy became bigger slice of S&P500 after 9 of its 11 sectors fell, and energy gained +14.3% in e.g., Sept 2021; in retrospect then Dow maybe should have kept in 2 fossil fuel names – which really later jumped up 2021 and 2022).

Make-up of financial baskets, matters. Battles quietly going on, 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 of any 'discernable trends' in how retirement funds were invested in energy (FAB 2018-1). There'd been sizable outflows out of fossils – and into new sustainable energy themes. It's been reported that fossil 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, even explicitly pointed to green themes as important. Still, it's useful to recall how a stealthy attack at top, recently occurred (and failed) against clean energy 2018-2020. And after in 2023 in Congress (vetoed).

Real-world Returns for clean energy in a 2018-2020 period, at Up hundreds of percent were hardly 'non-pecuniary'! In that time, clean was up +300% (ECO)! - while traditional Indexes were up more modest +85% (Nasdaq), +40% (S&P500), +25% (Dow). And fossils, oil & natural gas were then *Down* some -60% - though they'd soon spike hard up 2021 & 2022. Interestingly fossils & clean energy both non-correlated vs broader Indexes last decade. Thus maybe it was No surprise to see billions of dollars flowing to ESG, breaking records. ESG assets in 2020 up more than 2x vs. 2019, to $246 billion early 2021. Q1 2021 inflows $55 billion, vs. $41 billion in Q1 2020. Assets in ETFs/ETPs topped $6 Trillion for a first-time 2021. As ESG in particular may grow, it will surely be 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 State-level 2022, when Texas moved to divest from funds 'boycotting' oil – even those with clean or new energy in their name (like NEX)!

ESG is quite different – vs. our focus instead on Clean Energy Transition, though they're often conflated. In sum if the proposed Federal rules 2018-2020, then attacks in States like Texas, then from US Congress in 2023, had sought to prevent a look at CO_2 & at climate, deeming it 'non-pecuniary', then that's a bit curious given these quite glaring Performance facts:
In 2018-2020 Clean/Climate theme (at top) – Left Traditional Fossil Fuels far behind:

Source: finance.yahoo.com

From March 2020 to March 2021, ECO had ranged from 46 to 286, rising 6-fold. Global NEX had ranged 150 to 630, up 4-fold. As was said of clean equity's gains in 2020 by one 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 expiring subsidies – installing 72 GW of wind 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, it briefly proposed writing-off some sums. In response a big wind developer's stock fell -30% over 4 days, soon rebounding once that proposal was dropped. Point is regardless of for sure ongoing volatility, decarbonization has begun to figure, though in early 2020s decade, supply chains and war vexed globally.

In a 2021 & a 2022 smitten by diseases, wildfires, temperature extremes, blackouts, we increasingly saw mounting evidence the global economy is a wholly owned subsidiary of the environment. Yet, to notice the fact of climate crisis, doesn't mean smooth sailing ahead; no nation has yet risen to the occasion. And for host of reasons, volatile ECO, NEX, H2X, WNX will fall at times, *very hard!* Take batteries & metals production – where China clearly is still 'eating our lunch'… well, not just beating the US, but all would-be competitors, worldwide. Europe is lately ramping. Yet a real question is, whether battery & minerals production in the US and elsewhere can ramp fast, to begin to truly compete from 2020s. So uncertain.

One big problem has been that the US lags badly in producing lithium, nickel, etc for batteries. Producing rare earth minerals too, that in fact aren't very rare, yet are needed in motors, turbines & strategic uses. As Sen. Manchin observed 2021, "We don't produce any of the rare earth minerals, or very, very, very little of any rare earth minerals that it takes to make a battery. We depend on other sources of the world … that we seem to want to be out of sight, out of mind, and we just say, 'Well, we have an electric vehicle." Or nickel, for instance in batteries, electric cars, grid. Yet in 2022 it spiked briefly on a short squeeze from $20k - to $100k/ton. The 2022 IRA seeks to address it, but doubtful a US can move fast enough.

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

By 2030, so in less than 10 years, China is smartly on track to 140 big battery factories! Europe looks to have 17 big factories. On projected US electric vehicle demand, should be instead 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 in 2021. Construction having started 2023. Here again the IRA of 2022 is aiming for better.

All underlined need to act pre-2025 to *Cut CO_2 emissions - where the world failed badly. US is clearly far behind China, even behind more committed Europe. If the US has an expected 200+ electric & hybrid car models 2024, it should be producing far more needed, rare earths minerals for motors. Rare earths that 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). While 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 of rare earths are awesome; they make possible unmatched blue-sky advances. Like batteries that need lithium, or even basic iron, so too do clean energy's myriad applied technologies especially need too rare earths to work their magic.

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

Sens. Manchin, Capito, Murkowski had in past bills to get rare earths in coal wastes of which they've got rather a lot. So wasn't a surprise to see echoes in 2022 IRA. Studies have also shown greenhouse gas methane at Appalachia's old coal mine regions. Places unemployment is high, like in coal country, arguably special attention should be given to jobs in minerals, and to cleanup. Legislation prior to IRA also considered incentives for domestic US solar & semiconductor manufacturing, a proposed LIFT America Act for domestic battery-making incentives, support for US critical supply chains. Still given how far ahead China is already and how fast Europe is moving too, it's questionable if US can move fast enough in producing the needed minerals, rare earths, batteries and EVs without a huge push. IRA is just a start. And sadly, US will still be dependent nearer-term on importing these strategic materials. Often means buying from a more ambitious (and at many times goals-conflicted) China.

Subsidies too for fossils are unlikely to change-soon. Were 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, benefits from lost royalties in deep-water drilling. There's Master Limited Partnerships for fossils. While G20 has advocated eliminate ALL dirty energy subsidies, and their removal could cut CO_2 emissions 0.5 to 2.0 gigatons, like removing to 2030 all annual emissions from Japan, that's unlikely soon. One initial Covid relief bill initially had $8 billion in tax breaks for 77 fossil firms. More $$ was given to fossils following outbreak of war Spring 2022, in order to hasten exports. Cutting those fossil subsidies would be stridently resisted, and has always been a non-starter in both the House & Senate.

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

Yet the IEA has criticized too rich nations for so much cumulative emissions. For puny Pledges nowhere close to what's needed for a 2 degrees goal. Calling them out stating "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, it notes vague pledges by corporations are combined often with very distant target dates.

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

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

We'll discuss it ahead, but a point is, oil's crash in 2020 *was a crisis* for it. Until oil's rebound 2021, with production mainly restored. By contrast, green themes solar/wind - can & do move very differently. Clean energy's future, thankfully differs too. Key drivers differ for green energy, amid consolidation. For instance, in 2020, 1 US solar maker sold its operations & management arm to another O&M. A big integrated solar name split in 2. Vertical-integration was once seen as positive: before it had made panels, and had installed & serviced them too. Split by a spin, newly specialized, the parent refocused downstream on selling PV/storage in North America. That's a big market with thin margins: the storage arm allows it premium branding and can get bigger. It's in-country work that can't be outsourced nor done overseas by cheap commodity competitors elsewhere. While there was rising solar power 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 2020 had brought 2 US solar installers together as 1 behemoth. Post-2022 the latter *may* see robust valuations, more comparable to seen in another standalone solar name less dependent on Net Present Value, NPV. As all seek lower-cost access to needed capital, unclogging of PV supply chains, lowering inflation.

Upstream, that spinoff premium PV maker 2021 had 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, at least cost') as module pricing was down ~80%, in 2012-2020. Module capacity rose, then it was hit. Downstream, efficient premium, back contact panels may help hurdle razor thin margins. In 2021 module prices were near $0.20/watt on price inflation - spikes *may* subside. It will be interesting to see how performances of these 2 solar 'cousins' unfolds. In 2022 their mutual exclusivity softened, one a 'new' premium solar product maker – and the other now separately focused on PV solar sales & installs.

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

Moving on let's consider a past 5 years. Here, fossil fuels stand out for a long decline - then rocketed back up 2021/2022. Until a few years ago, an ECO picture past 5-years in-the-2010s, was often *down*. Breaking that end of 2019, ECO (alone) 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 then up +300% as green jumped. While fossil themes were down -30% to -70%. By 2022 as dirty shot up, clean was going 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, 'All energy far down', following it clean changed in 2020 - by a lot. Clean was up 6-fold in that 1st year of this decade, in 2020. Then, clean plunged from February 2021, as fossils enthusiastically instead jumped. Despite those gains in dirty, for Past 5 years to 2021 or 2022 - dirty was only back near nil, still far below clean.

Past 5 Years

In this 5-years Chart to mid Q1 2023 below, clean ECO/NEX have now departed a 2014-2016 down period. In 2 Up years 2019/2020, clean had gained absolute ways – plus big wins relative to major Indexes too. With ECO briefly up +400% it left major broad Indexes 'in the dust'. But then, came Down years 2021 & 2022 with big falls. That said, ECO still finishes the most up. This past 5 years shows ECO tracker is strongest of all up +73%; the global NEX is near tied for 2nd at near +53%. Only major Index 'bogey', the NASDAQ just pips out NEX at up +57%; the Dow is up some +34%. Normally, up over +50% in 5 years is bit of a 'Win', so absolutely, here especially the NASDAQ did well. Just relative to clean themes ECO/NEX, did Dow and S&P500 flail somewhat – just one barely able to nudge out NEX. And ECO up most. Farthest down at bottom, are 2 big fossil oil & gas themes, both far underwater at negative -31% & -58%(!).

ECO/NEX trackers vs. fossil fuels & major Indexes, Past 5 years from March 2018 - to start of March 2023. Once a past 5 years was tough for All energy; now it's Differentiated – with Clean ECO/NEX at top and moving very differently vs. fossil fuel Indexes:

Source: finance.yahoo.com

Clean energy certainly plunges at times. ECO/NEX/H2X/WNX more so than less-clean big-cap caps. For sure when broad markets are declining – one may see ECO, NEX, H2X, WNX with purer play, risky volatile components – fall harder, more so than competitors too. Like 2022 when threats re: nuclear weapons not heard in decades had put world on edge; all very strong headwinds for volatile small caps here. Plus, after tremendous gains 2019 & 2020, drops over 2021 & 2022 were not so surprising. On the other hand, jumps/gains in our themes may at times quite outpace other Indexes. Consider in August 2020: Dow gained +7% for its 7th best Aug since 1984; S&P500 was up +7%, its 8th best Aug since 1986. Meanwhile same month ECO was up +20%, NEX up +15% (not their greatest monthly gains that year: Nov/ and then Dec. 2020 saw larger ECO/NEX gains). Or say, with a single CPI Inflation Report suggesting maybe cooling on Nov. 10, 2022, ECO Index jumped a big +10.1%: so more than major Indexes (or others in this space) – but ECO swiftly afterwards fell back yet again in 2022.

Next page, is past 10 years rolling. Until 2020 the clean story last 10 years was a relative 'dog' (our apologies to all dogs). What changed? From a strict charting sense, 2020 was far up – then 2021/2022 far down. After steep declines long ago early 2010s. Then a recent green plunge; to include any bit of that, bends performance downwards. In sum clean energy at times relatively outperforms vs. dirty – and clearly does so here! Still, any plunge warrants attention. Thus, next is a rolling chart for the past 10 years, 2013 - to early 2023. In a change of view too, in place of far broader NASDAQ for comparison – here instead is an excellent, passive, solar-only theme – as well as Dow; and natural gas and oil far, far at bottom.

Here interestingly, for the past 10 years now an excellent passive solar-only theme is far at top: it's up some +375%(!!). And passive *Global* NEX tracker is still well up here 2nd highest at about +127%. ECO after suffering all 2021 & 2022 has dipped considerably over 2021/2022. So passive ECO after being past years far ahead, here has quite fallen after 2021-2022 to come in at below the Dow, at +93%. Still, for any energy theme, this Trounces all fossil fuels!

Hardest to see here for being so very far down, underwater, doing rather absurdly badly past 10 years - are oil in purple – and natural gas in pink. They are Far Down around -75% & -89%! Of course, they'd jumped in 2021 and 2022. But, put that in context here of past 10 years, and it did not much make up for arduous, prolonged declines they'd suffered for a decade! So this period leaves behind a Great Recession that thunderously dropped all 2008-2012. That put in bottoms at many tech stories; much non-energy went up after. But not so energy, which got hit harder, stayed down longer. Especially seen in dirty energy themes: they fell terribly. So much energy had gone on falling across all the 2010s, no immediate rebounding up.

<u>Rolling Past 10 Years from March 2013 to start of March, 2023:</u>

Source: yahoofinance.com

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

Notably, clean energy had done 'best' in 2020. Solar-alone, & clean new energy innovation NEX were the most positive of the 5 themes then last 10 years, up near +400% and near +200%. These clean themes were relatively strong – versus fossils! Even vs. major Indexes. That was a tale of 2 cities, Past 10 Years: there were first Big Declines in Dirty energy – vs Clean that was Up varied degrees. Until of course 2021/2022 reversal: for brief gains in oil & gas - as clean then plummeted. And anyway those gains for clean could all evaporate tomorrow! As time rolls on, good times or tough times for green Indexes *may* begin telling a new story. Depending on how each is defined. As shown next, just how a theme like NEX captures global new energy, How the theme's defined, is no backroom matter; it's very consequential.

NEX: the Global Clean Energy NEX – vs. a narrower and not-as-clean theme:

Consider next key differences between Global NEX with trackers in the US & Europe – vs. a differing, younger, other global 'cleanish' energy Index also with trackers in US & Europe. That other, global Index has several characteristics setting it well apart from NEX. One had long been that this other Index was maybe a fine choice if wanted a very concentrated basket, made of big caps only. Narrower with little to no energy storage, no electric vehicles, no green H_2 etc: because that other basket was so highly concentrated, so skewed, plus not-as-clean - it differed much from NEX that's instead clean with diverse solar, wind, EVs, energy storage, hydrogen, decarbonization etc etc. There's also several more contrasts too.

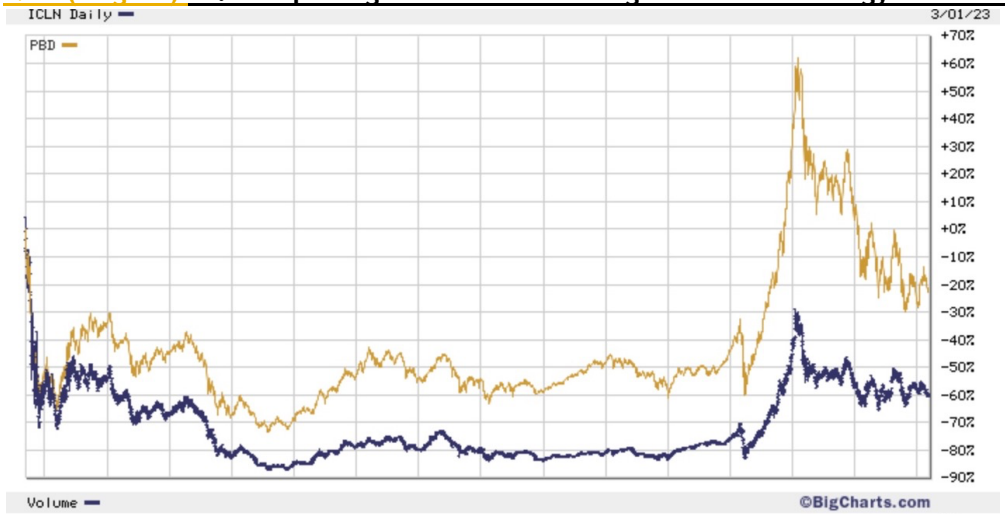
For example, the clean NEX has zero-carbon ratings far better and so more deeply green – than that other 'only-cleanish' Index. NEX is also steeped in diverse new energy innovation – so it's unlike old GICS (Global Industry Classification System) 1999 nomenclature that put the other global basket very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

Yet consider too that their most key divergence has been: Performance. Briefer periods, NEX vs. other Index trade leadership back & forth a bit. Shorter-horizons, one Index might lag the other sizable ways. Briefer time frames have often been a wash, no clear leader. For example, over 2021 & 2022 that other 'not so clean' theme had out-performed. But longer periods, a key fact stands out: **Global NEX (seen here in gold)** has well Outperformed that other Index both for a global clean energy **theme (seen here bottom, in bold).** This is for lengthy periods: say, since their inception, or from a time when all were falling from 2008/2009.

Here's a Chart below for global clean energy as captured by both Indexes via live trackers, for some 15 years, Sept. 2008 - to Q1 (March 1st) 2023. It's interesting to see how divergent their performances are for 2 Indexes/tracker funds. *In sum the **global NEX tracker (gold)** clearly has had far, far better longer-term performance in global clean energy:*

The NEX (in gold) as first Global Clean Energy theme and **-20%** here does far better – vs a separate, **other Index** for global clean energy theme **at -60%** (Sept. 2008 – mid-Q1 2023).

NEX (in gold) vs. competing and not-as-clean global clean energy theme - since 2008:



Source: Bigcharts.com

As seen above, clean NEX has far Outperformed, by some +40% better. NEX goes up much stronger in rising periods; while NEX drops much harder in downturns. 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 is:

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

Nothing wrong with that other *per se*. *For example, that other Index did much better in down years like 2021 and 2022*. Also, it's a good contrast – purer vs. less pure global energy Index themes! For other differences as between global NEX – vs. other global energy basket, the NEX launched/went live first, 2006 – before that other Index. Seen say, early 2021 the NEX had 125 components. The other global basket then instead & for years since its inception, had then only 30 components to 2021. Just 30 didn't allow it true clean energy scope at all. So, wasn't possible for it to capture stories across EVs, green hydrogen, storage etc etc.

Weighting styles, matter greatly too. Other basket used market cap weight, modified by 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 trade leadership back & forth – but longer periods, NEX has done very significantly better. Equal weight NEX, eg early 2021 had a much greater 125 names with far wider reach. And helpfully, its equal weighting lets more & smaller names be heard: each has a voice. With No Overweighting at Top. Given such a huge performance gap long periods, it seems equal weighting may allow the passive NEX (& tracker) to better capture more - especially small & mid cap inherently clean purer plays. *Please note though that: neither approach is 'right': they're simply 2 differing methodologies*. 2 varied ways for global clean stories to be captured. The other, concentrated, 'cleanish', allows in dirty names, is biased towards big – while NEX is notably always clean, more equal, and wider-ranging.

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

After a useful public consultation early 2021, that other Index made numerous understandable changes for Q2 2021 & going forward. From fixed 30 only components, it added at first big 52 more – and 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 is growing ahead. Such could allow too for that other Index to better reflect evolving story over time.

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

Mid-2021, that other global Index could & did hold non-clean names. For just 3 examples were 1) that other Index added big 5% weight 2021 a utility getting only 8% of its earnings from renewables: fracked natural gas with near-enough pipeline to go New York to Paris and back: can't be either clean nor sustainable for decades at soonest. 2) They added another dirty energy name too that also can't be in NEX, it's heavily natural gas and long nuclear too; so not eligible for NEX that's for global *clean* energy. And 3) that other Index added 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 much gas(!) just weighted a bit less. And kept an unfortunate Carbon 'Intensity' score metric. That faulty metric can allow for inclusion of dirtiest fossil fuels, by a distorted false numeracy. *Clearly fossil fuels don't belong inside any ESG basket*. *Nor* should they be in a genuine global *Clean Energy* theme. So, that Index though fixing some distortions, arguably made changes post-2021 too that allowed itself to become even dirtier. It did so again 2022 with more gas and nuclear names – becoming arguably only sort of, kind of, global 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: 1) it's dismaying to see big oil & gas names - in any ESG fund. Especially 2) in global clean energy Indexes or funds. Beyond this, Europe SFDR/BMR aims to help rectify that. And for NEX/H2X/WNX, a floor $1m average daily trading value (ADTV)/$750k continuing components, looks at ESG severe risk ratings, and carbon. In sum NEX/ECO & new H2X/WNX all much greener, avoid that 'greenwashing' pitfall.

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

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

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

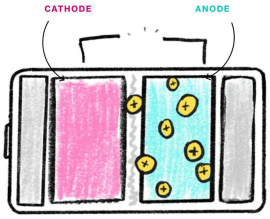
So great uncertainties abound, giving rise to volatility, tremendous risk. Myriad sub-themes *may* see advances: some incremental, some may be non-incremental, perhaps disruptive. Advanced green energy storage & batteries plainly merit focus 2020s, areas ECO & NEX have had exposure to since 2004. New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

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

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

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

a) 4 basic battery parts:



Source: Bloomberg Businessweek

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

Source: Bloomberg Businessweek

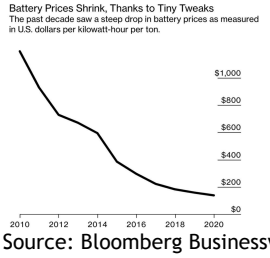
c) NMC as seen in a Nio:

Source: Bloomberg Businessweek

d) Tesla 3 has used NCA:

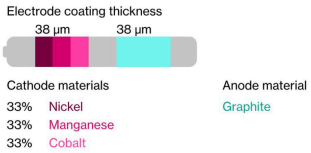
Source: Bloomberg Businessweek

Battery prices are falling hard:



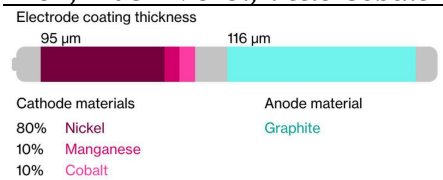
Source: Bloomberg Businessweek

NMC Composition back in 2012:



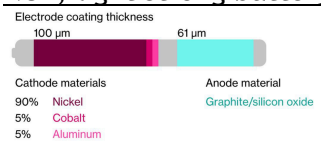
Source: Bloomberg Businessweek

Then, much Nickel, little Cobalt = thicker:



Source: Bloomberg Businessweek

NCA, light strong battery, no manganese:

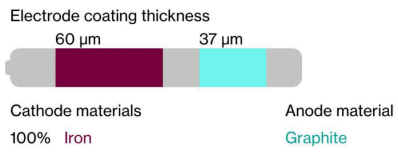


Source: Bloomberg Businessweek

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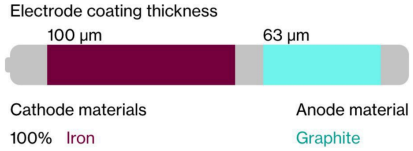
f) Modern LFP, a bit less-energy dense:

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, that most 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 heavier carbon, oxygen atoms, 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 terminal iron core, no further energy can be released by fusion – for it takes energy. More energy required than released, thus it may go supernova. That 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, then that iron is again easily found.

So iron is, quite literally, everywhere! We see it in Mars' red-tint of 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 point re: Charts. An issue with **rolling** Charts past 5, 10 years, ahead, is they *may* show very different returns in the future for ECO, NEX, H2X, WNX. As charts leave big falls 2008-2012, tough energy times too 2014, & 2021/2022, so big drops removed, ECO/NEX/H2X/WNX *may* show great relative gains. For that reason, a view is needed too with great ECO declines like in 2008, 2021/2022 etc preserved: hence Chart below. From fixed, not rolling 2008, it looks onwards (to Nov. 10, 2022). Long-running ECO+tracker could have begun 2005, yet the other trackers didn't commence until later – 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 plummets in 2008, 2021, 2022 etc are highlighted, 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 in mid-2010s, is brightly preserved below forever.

Note at the start, Everything in this Chart is Down, Negative, so underwater! Starting from at bottom, fossils oil & gas are Farthest Down here some -90% and more(!). 'Above' them/down but less is that excellent solar-only theme here off -70%. Active managed alternative energy fund is off -60%. 'Above' yet still well down, up steeply at times with big falls is ECO at -58%. Clearly 'highest'/least down energy theme is the global NEX though down -30%. Broader major Indexes (Dow is removed, not seen here for clarity) all did *far* 'better' – though differ sizably – as energy is but a sliver there. Generally speaking volatile ECO/NEX/H2X/WNX may really rise in climbing markets. Clearly, they can also *plummet* in declining markets:

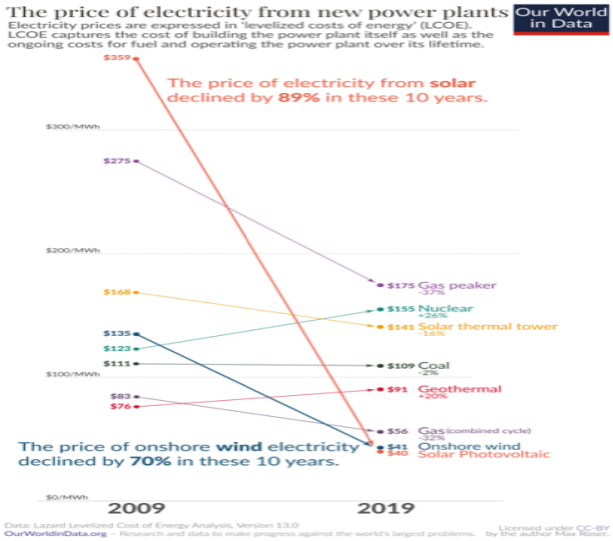
<u>Roughly Last 15+ Years starting from a Fixed June 1, 2008 to mid-Q4 2022:</u>

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:



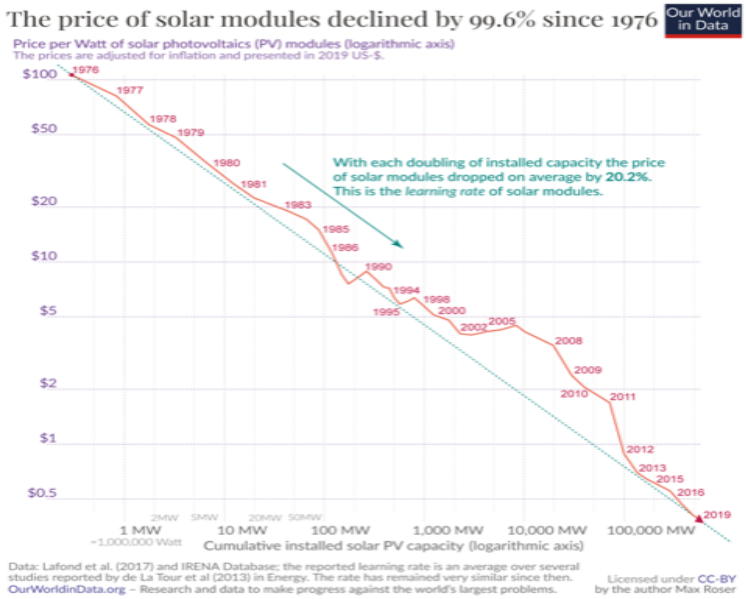
Source: Roser, Why Did Renewables Become So Cheap So Fast? Our World in Data (Dec. 2020).

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

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

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

This (not so great) return was No straight climb. As noted in MoneyWeek in 2021, it had peaked in 1999 earlier at 6,930. Later it passed that 2016, next in 2018 at 7,877. But in Jan. 2021 at 6,400, it stood out as only +11% higher than where it had been some 15 years prior. In March 2022 it was at 7,500, up a mere +3% from where it was 5 years prior. It hit 8,000, in Feb 2023. But a stronger growth rate was seen 1984 to 2005 when it had had a much better return compound average growth +12.5% (real terms +8.5%). The 2005 through 2020 annual growth rate had been much slower, at only 2% better than an inflation that then was at +4.7%.

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

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

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

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

There's been some names related to health/biotechnology like AstraZeneca. Some in tech like Aveva, Rightmove in web-based real property. But last 15 years, or obviously in 5 years to 2021, the FTSE 100 returns clearly lagged behind Wall Street/ US broad Index baskets like S&P500, Dow, or Nasdaq 100. And an FTSE 100 was absolutely crushed last 5 years to 2021, by two themes of our own for 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 is enterprise software, Next plc clothing retail; but much entered top 100 by mergers & acquisitions – not a good long-term ramp for growth. A more innovation-heavy Nasdaq 100, Nasdaq Composite - or S&P500 are different. As seen in MoneyWeek, an S&P had 19 technology stocks in 2005 – when the FTSE 100 had but 1. In 2020, more tech names did join a FTSE 100. Still, by contrast, US Indexes are reflecting considerably more in tech. A mid cap/smaller caps FTSE 250 did enjoy more momentum in 2021 with innovative-equities, than FTSE 100.

In a chart below, clearly bottom performer in 5 years thru end 2021 is FTSE 100, light blue. It was up relatively little in the 5 years period to end of December 2021, a very puny +5%. The better-up mid-cap FTSE 250 in purple did do better +21%. But tech-rich S&P500 in pink doubled here, +102%. And **NEX tracker in blue** was up about +140%; Tech innovation **Nasdaq, in orange** was most up +165%. To be sure innovation themes are always very risky: at times they'll drop very hard. More Conservative, may = less risky. Yet recent periods, energy & tech outperformed. So much so, one must be wary of a bubble – and recall that the NEX – like risky 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 recent years – or, big/conservative can do better in down years. In FTSE 100, big older energy firms in 2021 were 9% of it, plus mining/materials 13% - for a hefty 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 an 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 27 Nov. 2021, "The London Stock Exchange (LSE) increasingly looks like a care home for old-economy companies, rather than a cradle for new-economy ones. Less than 2% of the FTSE 100's value is accounted for by tech firms, compared with 40% of the S&P500's." Tastes change; Britain's Statistics Office mid-2022 removed coal, and with Covid, men's suits too from its basket for consumer price index, putting in antibacterial wipes, and sport bras. In sum, an Index's rules, construction, & its goals, definitions too, vitally shape a theme. They matter. Next, let's look at a few possibilities for clean energy ahead in the 2020s in a world fast changing.

Recent Changes – and perhaps possibilities ahead:

Bills proposed early in the 2020s were just a start: there'll be much more such legislation in this decade. What happens soon *may be* historic for clean energy. *Just possibly* impactful for decades. Consider our future: young voters rightly demand a more sustainable, equitable, zero-carbon future - than us 'oldies' contemplated. Though some or most bills will 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 investing at big cap oil & gas firms: it showed of the 7 Big Oil firms committing to net-zero emissions 2040 to 2050 - fully 6 were based in Europe. Of these top 7 all from 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%).

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

Following huge 2020 supply cuts, on increasing demand, prices rebounded: oil/gas/coal leapt up 2021/2022. But look back, further, and Big Oil stock valuations mostly Declined in a prior, past 5 years. That's important. Perhaps the 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, a last 5 years to Q3 2022. With big Oil's Gains in 2021 & 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, had 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, in Geothermal. Maybe lithium-rich hot brine for cleaner power – & 'lower-carbon lithium'. Maybe ultra-deep new drilling to produce geothermal power – anyplace on earth!

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

Data from Bloomberg New Energy Finance (BNEF, our long-time prior NEX partner) - and US NREL in 2021 showed how badly America lagged Europe & China in offshore wind. All can use big turbines – GE's Haliade 12 MWs, Siemens 14 MWs, Vestas 15 MWs, 18 MW China CSSE turbines developed in 2023 - to consider a key Wind obstacle in US has been: Permitting. (Like in Grid, Solar etc). All America 2021 had but 2 tiny offshore wind farms. One a 30 MW site so like just 2 big turbines! That figure ought to be huge; is growing a bit – but still too slowly. Breaking down the US wind Pipeline, there's 1st a Project Planning stage (developer or Agency initiates site control), then Site Control (lease/contract), Permits (plan + offtake agreement), then Approval (regulatory OK), Financial Close (sponsor investment), lastly Construction (build), Operations. Doesn't include myriad lawsuits along the way. Nor political opposition, sparse infrastructure to offtake power that all halts offshore wind before it begins. Perhaps little wonder then, that wind power's been so absurdly 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 was hardly visible at 30 MW, a tiny 12 MW in final approval – as 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 has been bit of progress finally starting in US.

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 too slowly, although 2020s are ramping. Confoundingly, all but 2 of 11 US States in wind pipeline back 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 needs submerged cabling. That said BNEF raised estimated offshore wind projections by +70% from 11 GW by 2030 estimated in 2018 – to 19 GW estimated by 2030 as was projected in 2019. It's been growing since.

Big changes may lay ahead in offshore wind relevant to Index themes, WNX, ECO, NEX, H2X. In the US - and world. For scope of potential changes, consider how puny offshore wind was recently. Then, imagine what *may* come by late this decade – escalating fast near 2030 and just after. Up until 2019, global cumulative offshore wind capacity had only reached 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 just one year, 2019.

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

More granular, it gets interesting from 2024, when 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 on America's East/Gulf Coast; the 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: Asia – US - & Europe - may come to be about 1/3rd of floating pipeline. A 25 MW test called Float Atlantic in Europe went operational in 2020 and proved potential. Very early days yet. And Asia's leadership in floating wind isn't just China only, nor just Japan, too. It may be also South Korea (1.7 GWs), with Taiwan (1 GW) in pipeline. Also UK, France, and Spain have proposed much for Europe, each has had operating floating test units.

A startling change may be 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 shallow draft they might be built dockside, towed out without heavy lift install vessels. That design has made up 89% of substructures where a choice was made. And note for fixed wind towers on the seabed, with huge 12-16 MW wind turbines, the number of vessels able to install nacelle mass >500 tons hub height >100 meters & rotor diameter 200 meters(!) is vanishingly small. So highly specialized vessels (WTIVs) for installing offshore wind must be built, for monopiles on seafloor, jackup depths over 50 meters. New US vessels too given America's Jones Act. Port infrastructure must be built from scratch, as well, to grow both fixed & floating wind.

Most crucial in wind is pricing. Like solar, it was falling to 2020, 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 by 2021, from 18 cents/kWh to near 9 cents. US offshore wind was 9 cents 2020; Mayflower Wind off Massachusetts one of world's better-priced ocean wind projects was 6.9 cents. And US tax changes could make it better. Floating wind may possibly fall farther, ahead, post big inflation spike of 2021/2022.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Lashing lately new batteries to AC motors for electric cars, is but 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 on solar. Not far apart from land used by coal, oil & gas infrastructure; dirty energies use 126,000 sq km. If solar grows super-low cost, 'over-size' solar may compensate for costs of storage. Oversizing solar – as fuel's free – may mean No penalty like over-sizing a nuke, coal or gas plant. Moreover, solar may in time be shared widely by grid, or green H_2. Ever say, over-size a nuclear plant? 'Fuggetabouddit'!! That nuke plant would be so costly, so inflexible, vexed by wastes needed to be stored for centuries/millennia, that it is a cul-de-sac of an idea. Makes no sense at all with current 'old' 2nd generation nuclear fission.

Intriguingly it's clear that solar/wind *will* get very-cheap. And since electricity must be used immediately as generated – we've avoided oversizing or costly 'curtailment'; wasted 'extra' wind power cost UK consumers GBP 806 million (USD 1Bn, EUR 942m) in 2020/2021; 82% of it was 'excess' wind in Scotland. But long-duration storage or say green H_2 may avoid overcapacity on sunniest/windy days. Preventing brown electrons with downsides. If clean abundant renewable electricity is already at very low-cost, then H_2 & fuel cells ('fool sells') once so staggeringly foolish only a few years ago, *might* just begin to make sense.

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

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

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

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

New rebuttable presumption language 'guilty until proven innocent' was passed into US law 2021 in a UFLPA (Uyghur Forced Labor Prevention Act) – but with a long lead time to prove Absence of forced labor. Allowing say traceability protocols, or moving to source materials all outside Uyghur region. In a less-thorny transparency matter, the US 2022 named companies non-compliant with a 2020 Holding Foreign Companies Accountable Act (HFCCA); they could face US delisting from 2024 – if their auditors aren't subject to inspection by the US Public Company Accounting Oversight Board (PCAOB), https://www.sec.gov/hfcaa The US brought on-site inspectors to China in 2022 for on the ground inspections & investigations on whether mainland China/Hong Kong firms provide requested, timely, unredacted documentation to PCAOB via its CSRC. Discussions aimed for China/US Agreement in 2023 to resolve this topic and avert delistings in 2024, https://crsreports.congress.gov/product/pdf/IF/IF12212

In conclusion, a burden is on Xinjiang-based materials: solar, wind, quartz, textiles etc to prove Absence of forced labor. Plus, companies may be removed – others not added to themes - on a possibility of forced labor; indications can lead to removal. It is an unnecessary risk, one to be watched closely, with moral implications. Xinjiang products now have positive burden to prove No Forced Labor in supply chains; some firms may opt to relocate away from that coal-powered region. Traceability services, 3rd party Independent Audit Verifications may arise – in 2022, GWs of solar PV were kept from entering US on UFLPA. Europe is looking into this as well. Separately China Auditors are subject to inspection – or may lose access to US capital markets under HFCAA, https://www.sec.gov/hfcaa In sum forced labor mustn't ever seep into supply chains, anywhere. Looking ahead one coming issue is transparency; also ending-*coal-use* in manufacturing, decarbonization in upstream manufacturing everywhere. Green circular manufacturing has begun of late, as seen for instance in the Nordics.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

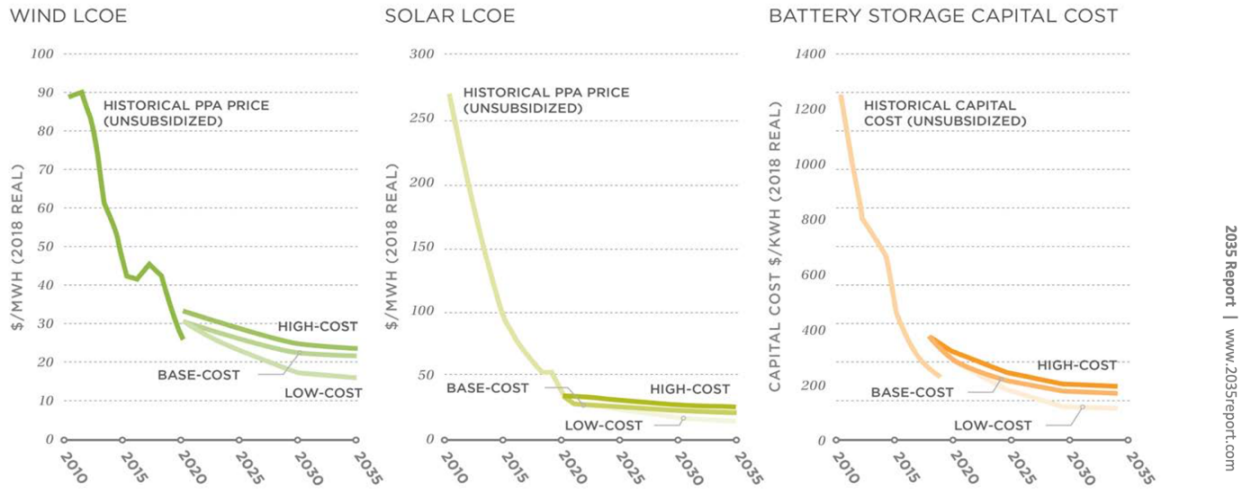
US energy generation growth had gone big before; natural gas grew by 65 GW in 2002. Now what's needed, changed: *energy storage* is 3rd leg triad to solve intermittency of renewables. Key new storage deployment needs to grow by 25% each year. Starting from a measly 523 megawatts storage in 2019, it should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

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

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

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

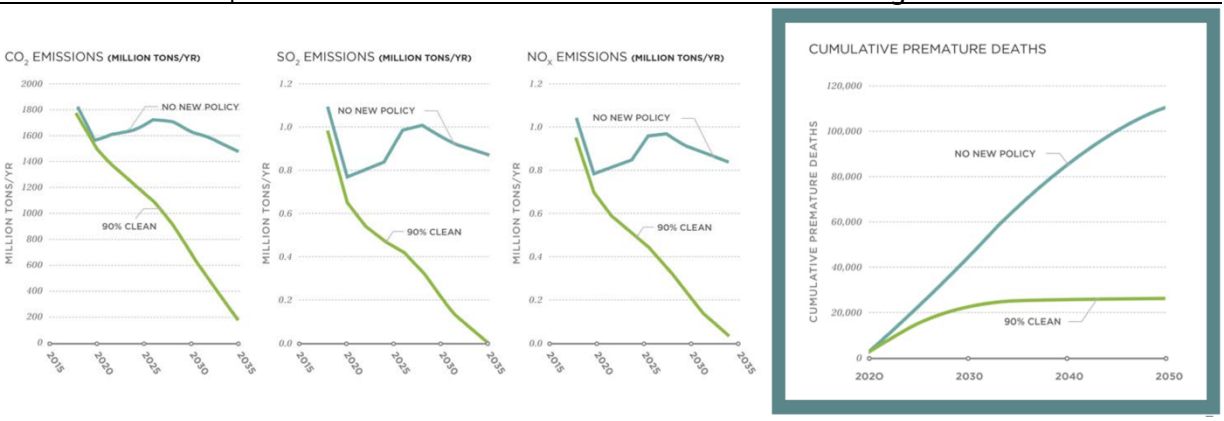
<u>Dramatic Declines in Costs Have Arrived 2020 Far Sooner than Expected:</u>



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 (NO_X) & Sulfur Dioxides (SO_X) emissions by 96% and 99% respectively. This clean Plan separately also saves over $1 Trillion in health and environmental costs!

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!

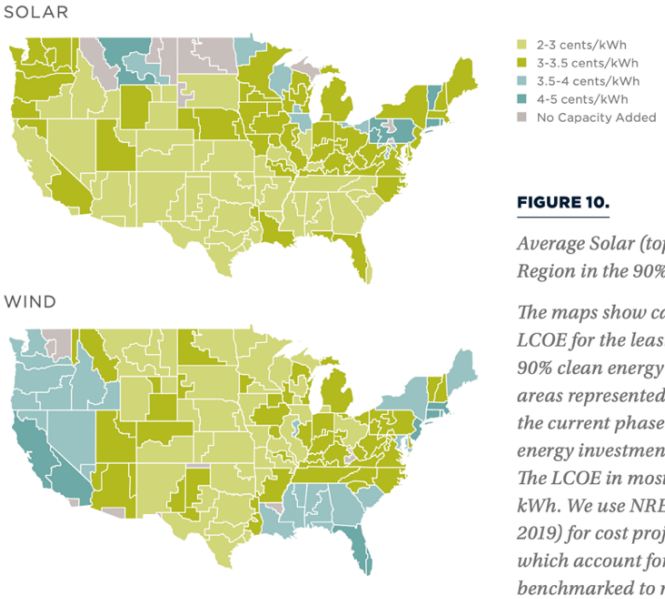


FIGURE 10.

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.

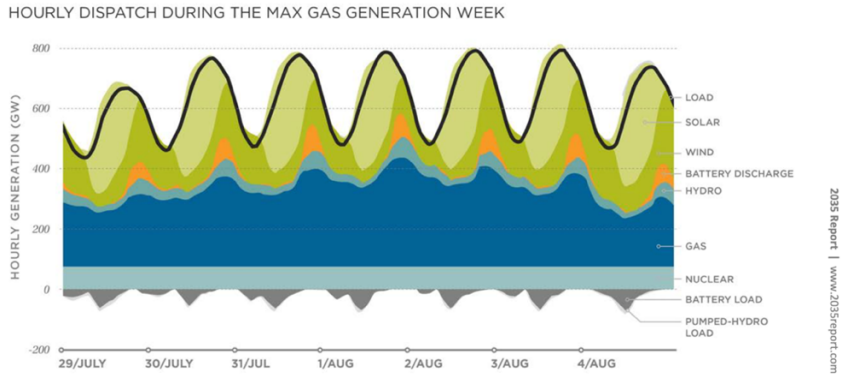
Over 7 weather years modeled, in normal conditions, wind, solar, battery storage generally, regularly provided 70% of annual generation; hydropower & nuclear provide 20%. But when there's very low generation by renewables solar/wind – and/or unusually very high demand, existing natural gas plants, hydro,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

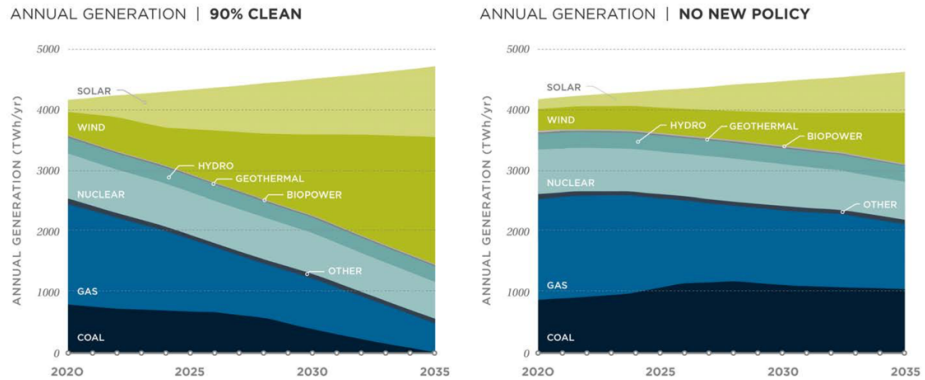
A Worst-Case Generation Period for Renewables: Still Moving Off of Fossil Fuels/Nuclear:



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, yet akin to COVID stimulus rounds, with enormous positive lasting benefits. (Add efficiency improvements ahead too, like barium sulfate painted-bright white rooftops, to better lower demand).

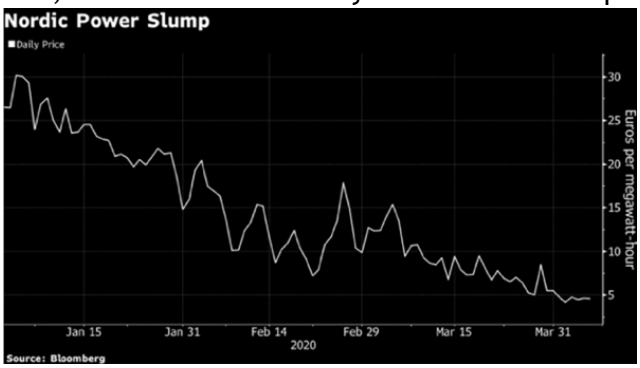
Recall some 'normal', pre-Covid, *applied* clean energy trends back early 2020. As renewable prices were falling in good & snowballing ways (unlike oil/gas). Start with Solar; costs had then hit a new record low: *only 1.35 cents per kilowatt/hour* at a big 1.5 GW solar farm going up in Abu Dhabi! True,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

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

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

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

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



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

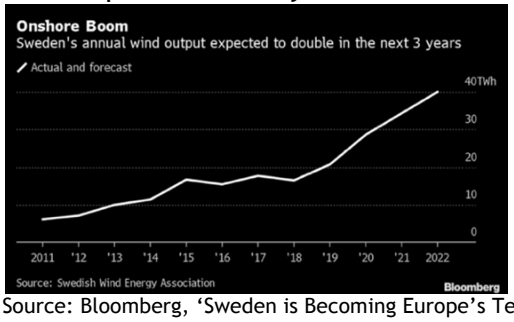
Yes, renewables wind/solar are intermittent. Winds not always blowing, no sun (night), or no rains for hydro. Yet at such times, then other renewables may be tapped. For instance, geothermal might possibly grow well as firm power. Especially when oil rig counts drop, geothermal may grow attractive. Idle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

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

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

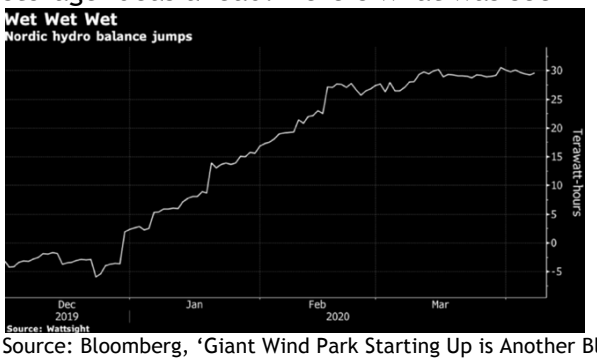
Dirty cheap northwestern China coal, had long attracted industries like PV; cheap electricity eg Liuzhou was an incentive to make EVs too. Yet Northern Nordics may potentially do it one-better ahead! If cheap/er renewable power can make green steel, aluminum - industries shall welcome that – as low embedded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

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



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

Energy-intensive industries in mountainous Northern Nordics 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, 2009, solar made only 0.1 percent of American electricity(!). Wind, less than 1 percent. So, those were vanishingly small in total US energy mix. ARRA sought to change that while creating jobs and growth. It gave a then-large $25 billion for renewables, a big $20 billion to energy efficiency, $18 billion for transit, $10 billion for improving the grid, and more for other varied green programs. Tax credits unusable to many 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 wind. By 2013, subsidized wind reached cost-competitiveness many places with coal & gas. Where winds are plentiful, wind has grown *very* favorable: America's Midwest saw power auctions just 2.5 cents per kilowatt/hour (kWh) some bidding for power, making it a best choice.

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

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

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

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

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

Or consider Perovskites for solar, where we're in early innings technologically speaking. That material's lattice structure may grow 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, then under $1/10^{th}$, maybe near $1/100^{th}$ what we'll need - to build PV fast enough. In 2020 we'd made around 100 GW/year worldwide. (Tiny, yet better than puny 0.250 GW in 2010!). We saw PV manufacturing becoming more a low-margin, commodity business. A decade of consolidation, wring out costs, more capacity, PV growth steepening. Yet 2021 and then 2022 also saw rising inflation – plus war.

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

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

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

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

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

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

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

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

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

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

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

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

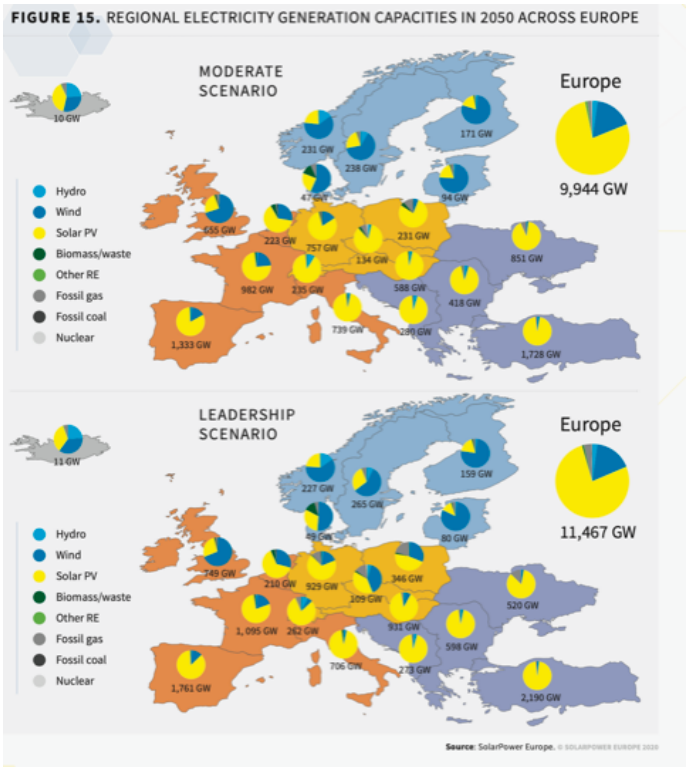
This Report recommends that policymakers should begin immediately creating a framework targeting installed 7 TW solar power – plus 1.7 TW of wind to be reached before 2040.

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

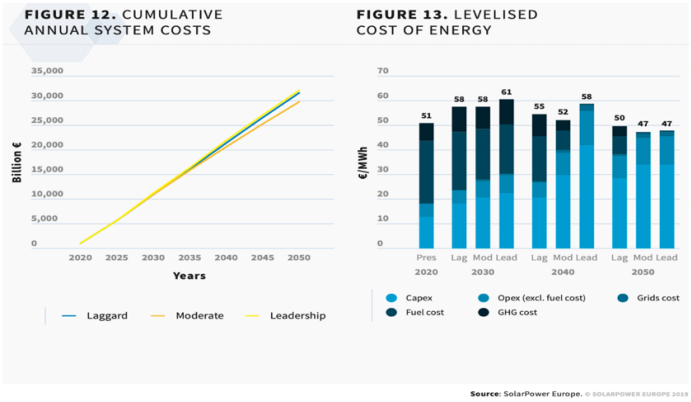
2 scenarios presented were Moderate approach – and Leadership one that's quicker. Former meets only 2 degrees C heating goal of Paris. Latter meets a more robust, better 1.5 degrees C goal. Again, it's a matter of when this ramp begins, so the angle of departure. But interestingly, the stronger and sooner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

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

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



Source: Solar Power Europe 2020.



Source: Solar Power Europe 2020.

Certainly, we can't plead ignorance. A brilliant Eunice Newton Foote born in 1819 had in 1856 published her paper 'Circumstances Affecting the Heat of the Sun's Rays', which predicted changing carbon dioxide & water vapor in air, could alter climate. In 1860s, John Tyndall added infrared radiation, methane. Arrhenius explained over a century ago the mechanisms of global cooling or heating via a carbon lever, predicted a massive 4 degrees C heating comes with each doubling of CO_2 – pretty much spot on with estimates today (and note we've gone from 315 ppm to >420 ppm in this author's lifetime). Add in the whole suite of GHGs like methane, and it's like we've climbed over 500 ppm. Roger Revelle had alerted governments further to this in 1950s & 1960s (and he'd had great impact on this author at Scripps in 1980s!). Or, we could continue as is – let vagaries of oil & gas throw energy markets and so us all for loops over & over. Take our time, plead ignorance, making any eventual turn to clean – tougher than was needed. Look at wicked oil dynamics just in say, 2020 to 2021.

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 the demand for oil dipped – 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 more production cuts worldwide. Perhaps 1 million oil patch jobs & their expertise might potentially disappear. Rig counts fast dropped, capacity tighter, wells shut-in, bankruptcies – some wells perhaps might not be (expensively) re-started. Maybe forcing the US shale producers to shut in, pain, was perhaps an initial aim like in 2015. But this time, oil's ramp in supply began just before the 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 failed: in a thriving well-lubed oil-hungry world, impacts were muted. Oil then dropped to near $50 briefly. Excesses soon were absorbed. Was not enough fall to kill America's shale; shale reserves can one-day bounce-back putting something of a high upper cap on prices oil producers might fetch.

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

Then, in 2020 on a pandemic + tank tops, oil went under <$20. To quickly revive economies & get oil demand back, was essential. Oil-rich nations may ideally want high crude prices nearer $70 - $100. Over $100 like in 2022. In theory it lets them better balance their own books, national budgets. But, regaining firmer demand comes 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 at its high vitality, while its still richly valued. Vast underground reserves if held for 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 on inevitable heat waves or cold snaps stoking demand. Free markets are how the US and its prices work, rather than by fiat, so paths were envisioned to stimulate rebound. If US States re-open 2021. If Covid is increasingly endemic, more like a seasonal virus, even if immunity is conferred only for one flu season, if effective vaccines arrive, or better yet, if robust vaccines for Covid ably can treat new variants too, there were thus hopes for some return to demand rebound towards normalcy.

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

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

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

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

So, very generally, think of US needing 20x more renewables capacity than existed in 2022. More needed for industrial processes like green heat in steel & cement. Roughly a dozen-fold plus increase in solar capacity plus great new wind capacity. One 1,300 MW (1.3 GW) Texas solar farm going online 2023 was just a start. Far more energy storage needed too from scratch. Enormous new needs, that aren't readily measured even 'x-fold'.

Consider CO_2: A Topic Gaining Importance

For 20+ years our emphasis in Clean Energy Index® Reports was on *Solutions*. Not on CO_2 - nor climate *per se* – but rather on solar, wind, EVs, storage etc as ecologically & economically better paths. Climate Crisis was a big driver - but that CO_2 itself wasn't a core theme in Index Reports. Lately however, global heating and weather extremes are coming in at worse ends of what models have foreseen. In short, CO_2 dearly matters, so let's address it directly.

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

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

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

By 1992, a global compact was reached. Signed in Rio 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 had only *implied cuts,* like calling for global emissions to be -20% lower in 2005. Instead, CO_2 as it turned out only grew - going +34% *higher by 2005*. Looking back, it went on rising another +22% higher by 2017 - to over 400 ppm in 2020s. That's higher than in at least last 3 million years. Maybe highest in last 12 million years. So mere aspirational words absent acceptance & robust action, has woefully not achieved what's needed on decarbonization for climate.

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

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

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

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

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

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

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

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

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

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

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

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

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

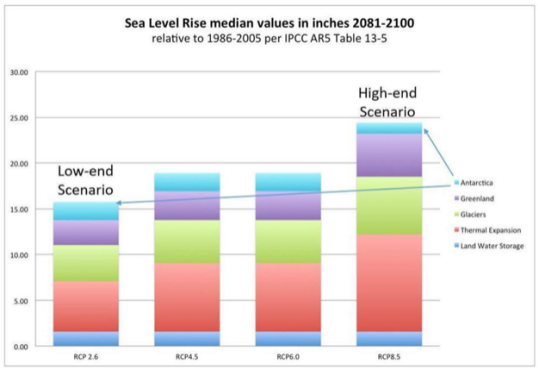
Imagine say, just ~80 years hence. Note then how projections by an Intergovernmental Panel on Climate Change (IPCC) for sea level rise in 2100, may be a bit misleading. For end of century rise may be unwinding at far more rapidly accelerating rates than what seemed to be projected by IPCC. Getting that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

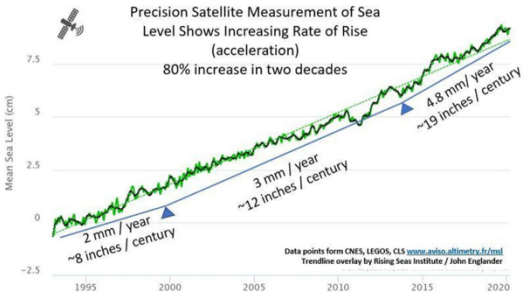
This notion actual sea levels seen in 2100, could be greater than IPCC projections is well laid out in 2020 piece, 'Twenty-first century sea-level rise could exceed IPCC projections for strong-warming futures' by M. Siegert et al., One Earth, 3 (Dec. 18, 2020). Their first paragraph nicely lays out cogently,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

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

Near-term, end of century on strong warming, seas in 2100 may be quite higher than usually accepted IPCC range of 0.61m -1.10m, what the public calls roughly 1-3 feet of 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.

Uncertainty cloaks Antarctica's immense, oft hidden, dynamics. Computer models may thus exclude mechanisms – given machinations are hazy. Shorn of important details, absent certainty, the data still suggest rise is possible *going over* 1.10 meters, above roughly 3 ft. Difficulty modeling ice sheet/glacier dynamics has, in nutshell potentially left out possible greater Antarctic contributions. It removed complex & cascading rise potential, as a major factor. Especially in higher heat scenarios where we seem to be trending - in comparing recent models to reality. Still the IPCC high-end curiously had indicated the *least* rise would come from Antarctica, even in the RCP8.5 or highest heat scenario 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.

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

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

That's to say, massive ice sheets having once retreated very swiftly before, might do so again. Especially as 'we engage in pulling all kinds of climate levers' in releasing CO_2, methane and greenhouse gases at rates not seen before. Global reshaping is what we're talking about. So put aside for a moment, noisy political debate. Ignore too impacts say of new diseases, heat, storms, famines, droughts, tornadoes, collapsing ecosystems. Follow-on impacts spreading out like ripples on a pond, like earthquakes following unburdening melting glaciers above land that affect distant tectonic plates. Just impacts of seas rising, is enough.

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

Politicians from Miami, State of Florida no doubt want their home to exist 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 near-term and distorting 2100 horizon.

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

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

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

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

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

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

An international panel in 2013 gave scenarios for rise in this century, straightforwardly on expansion of warming oceans. But they'd only allowed then for small influence from new runoff from marine ice-sheet instability, known as MISI, primarily on the assumption that Antarctic ice sheets were too stable, too 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: its likely CO_2 makes a complete failure of pouring $ billions, $ Trillions into armoring coastlines. One can imagine enormously long expensive walls, say 10 feet high topped in just a couple centuries. One can't even imagine bigger seawalls able to handle what could become oceans going 50 feet, 100 feet higher+ and rising without pause. The point here is 2100 shouldn't be regarded as a terminal year. Nor 1-3 ft of sea rise. To do so, is just folly, wrong-thinking. Life goes on, people do not end there, it's but a year in an artefact human calendar: the world's seas will not suddenly halt rising then. Things may get a wee bit better – or wee bit worse due to heating next centuries; maybe more likely a whole lot worse threatening very survival of human civilizations: but it's certain that they won't get a whole lot better.

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

Keep in mind what those big rates and scales of change mean. A difference of 'just' 7 degrees F had separated our recent "ideal" climate - from extreme conditions of an ice age. In a refresher, an Ice Age not long ago 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 had 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 – of global *heating*. Certainly, that will alter land, seas, & ecology in scales and ways hard to fathom. Looking back to Earth's record it's conceivable on a temperature rise of "only" 2 to 5 degrees F warmer, seas could rise fast in non-linear ways, say going 15 to 65 feet higher. Drowning so much today, like State of Florida. In a thought experiment, 5 degrees F of warming is imaginable, on current CO_2. So, it is reasonable to see seas fast going up 60+ feet higher. No seawall could ever stop that. It renders the shapes of whole countries as we know them, today, a distant memory.

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

On CO_2 plus inertia, we're heading to conditions unknown in human history. Earth 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.

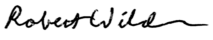
The Inflation Reduction Act/IRA of 2022 had 'felt' to many like fast progress, as a bit more than we were prepared to give in a US. Felt clean energy was replacing fossils fast enough – though it wasn't. Not given the physical CO_2 budget, yet world burning coal, gas, oil. The few hundred billion dollars in 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 are determined to wage 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 Q1 2023 at 80, & ended Q1 at 84, so slightly up by +5%. After fast gaining +25% January to 100, merely on hopes that inflation may soon slow, so Fed pivot - inflation stayed hot & ECO plummeted latter Q1 back under where it began the year. Last few years, ECO rose by +58% for 2019. Remarkably it then rose a big +203% for 2020 in about the best performance of any Index or Fund, anywhere. Unsurprising perhaps after such gains 2019 & 2020, ECO fell steeply -30% in 2021, and -46% in 2022 as inflation & recession fears, tight supply chains & war - overcame decarbonizing that may favor renewables ahead. Or since the start of 2017 when ECO was at 38, late Q1 2023 it was up by +120%.

Decarbonization-themed in ECO is up +70% last 5 years, up +90% last 10 years to mid Q1, for notable sustainable energy returns. The 1st *Global* clean energy Index is the WilderHill New Energy Global Innovation (NEX) live since 2006; it's up +50% last 5 years, up +140% last 10 years: ECO/NEX starkly beat fossils. In sum 2 new themes Hydrogen (H2X) & Wind (WNX) have joined ECO live since 2004, and NEX live since 2006, for now 4 global pure-play leaders.

In fairly typical Quarterly change numbers, there were 3 Deletions from ECO for new Q2 2023: Hyzon, Lilium, Lordstown – and 4 Additions for Q2 2023: Bel Fuse, Freyr, NaaS, Nextracker. At Global NEX starting Latter Q1 2023, new screening whereby companies lacking key data are not eligible meant one-time an unusual number of changes, Deletions were Abalance, Aker, Altus, Archer, Bumhan, Cadeler, CALB, Canoo, Cropenergies, Dae, Dongkuk, Energia Innovacion, Energiekontor, Freyr, Hyundai E. Sol., Lordstown, Maxeon, Montauk, Navitas, Polestar, Renew, Sebitchem, SFC, SK IE, Solid, Sungeel, Vinatech, W-Scope, Zhejiang – while 5 NEX Additions for Latter Q1 2023 were Meyer, Subsea, Takaoka Toko, Tianneng, Wacker. Adds/Deletes for H2X & WNX Indexes are listed in their Appendixes below.

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



Rob Wilder
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Appendix I: ECO Index (via independent tracker PBW) components descending % order late-Q1 on 2/26/2023, about ~4 weeks before rebalance to start Q2 2023. 74 Stocks:

Wallbox NV	2.336	Advanced Energy	1.354
Navitas Semiconductor	2.267	Sociedad Quimica y	1.333
QuantumScape Corp	2.029	Bloom Energy Corp	1.332
TPI Composites Inc	1.998	Brookfield Renewable	1.321
Tesla Inc	1.855	Ormat Technologies	1.317
MYR Group Inc	1.821	ESCO Technologies Inc	1.306
Tritium DCFC Ltd	1.815	Fluence Energy Inc	1.276
Archer Aviation Inc	1.804	Wolfspeed Inc	1.25
EVgo Inc	1.797	5E Advanced Materials	1.243
Energy Vault	1.79	Shoals Technologies	1.234
Solid Power Inc	1.767	Array Technologies Inc	1.23
Piedmont Lithium Inc	1.728	Gentherm Inc	1.205
Universal Display Corp	1.681	Lordstown Motors Corp	1.184
Standard Lithium Ltd	1.655	SolarEdge Technologies	1.173
Gogoro Inc	1.61	ReNew Energy Global	1.148
Joby Aviation Inc	1.591	Sunnova Energy	1.144
Canadian Solar Inc	1.558	Lilium NV	1.138
FuelCell Energy Inc	1.522	Ameresco Inc	1.137
Quanta Services Inc	1.499	SES AI Corp	1.123
ChargePoint	1.474	Maxeon Solar	1.11
MP Materials Corp	1.472	Hyzon Motors Inc	1.107
Livent Corp	1.453	Sunrun Inc	1.096
FTC Solar Inc	1.445	Rivian Automotive Inc	1.067
Sigma Lithium Corp	1.437	Stem Inc	1.05
Workhorse Group Inc	1.431	NIO Inc ADR	1.038
Li-Cycle Holdings Corp	1.429	Enovix Corp	1.031
Lion Electric Co/The	1.416	Blink Charging Co	1.014
JinkoSolar Holding	1.415	Fisker Inc	1.014
Itron Inc	1.415	Azure Power Global	1.005
Emeren Group Ltd ADR	1.406	SunPower Corp	0.977
Lithium Americas Corp	1.398	XPeng Inc ADR	0.963
First Solar Inc	1.397	Gevo Inc	0.949
Altus Power Inc	1.394	ESS Tech Inc	0.926
Albemarle Corp	1.39	Enphase Energy Inc	0.803
Plug Power Inc	1.388	Vertical Aerospace Ltd	0.731
Polestar Automotive	1.375	American Superconductor	0.663
Ballard Power	1.372	Beam Global	0.479

There's strong representation above from *EV Charging/EVs, *Power Electronics, *Batteries.

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

INDEX (ECO) SECTOR & STOCK WEIGHTS FOR START OF Q2 2023. 75 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 (11 stocks @1.50% each + 1 *banded)
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 low-cost green energy.
Canadian Solar, CSIQ. Solar, vertically integrated solar manufacturer, China.
Emeren, SOL. Solar development, Europe, US, plus China, global pipeline.
First Solar, FSLR. Thin film solar, CdTe low-cost alternate to polysilicon.
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.
Nextracker, NXT. Solar trackers, optimizing PV daily performance yield.
Ormat, ORA. Geothermal, also in areas of recovering heat energy.
TPI Composites, TPIC. Wind Blades; also light-weighting transportation.

Energy Storage - 27% sector weight (19 stocks @1.39 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.
**ESS Tech,* GWH. Iron flow batteries, longer duration is non-lithium storage.
Fluence, FLNC. Battery storage, for renewables and digital applications.
Freyr, FREY. Green batteries, uses renewables, cleaner supply chain, Nordics.
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.
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 - 23% sector (17 stocks @1.32% each + 1 *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.
Blink Charging, BLNK. EV Charging, among bigger EV charging networks.
Chargepoint, CHPT. EV Charging, global including for fleets and businesses.
EVgo, EVGO. EV Charging, DC fast-charging Networks, renewable power.
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.
NaaS Technology, NAAS. EV charging, energy storage balancing wind, China.
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.
Wallbox, WBX. EV Charging, allows bi-directional vehicle to grid, V2G.
Wolfspeed, WOLF. Electrifying power, Silicon Carbide SiC, converters.

Energy Conversion - 23% sector weight (16 stocks @1.40% 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.
Bel Fuse, BELFB. Transformers, power supplies, circuit protection, AC/DC.
Bloom Energy, BE. Stationary fuel cells, not-yet cleanest/renewable fuels.
Energy Vault, NRGV. Gravity energy storage; can repurpose old wind blades.
Enphase, ENPH. Microinverters, also energy storage systems and software.
ESCO Technologies, ESE. Power management, shielding, controls, testing.
FuelCell Energy, FCEL. Stationary fuel cells, distributed power generation.
Gentherm, THRM. Thermoelectrics, heat energy, battery management.
Joby Aviation, JOBY. Electric aircraft, cleaner, more energy efficient.
Li-Cycle, LICY. Battery Recycling, closed-loop of lithium, other materials.
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, UK based.

Greener Utilities – 9% sector weight (6 stocks @1.41% 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 – 1% sector weight (1 stock @1.00% each)
Gevo, GEVO. Biofuels, lower carbon liquid fuels from renewable sources.

Appendix III: **WilderHill New Energy Global Innovation (NEX)** via independent tracker (PBD) on 2/26/2023- shortly before the end of month rebalance for Latter Q1 2023. 129 stocks:

Abalance Corp	1.619	Zhejiang Leapmotor	1.107
Ecopro BM Co Ltd	1.148	SMA Solar Technology AG	1.098
Cadeler A/S	1.115	Yadea Group Holdings Ltd	1.091

Nordex SE	1.038
Universal Display Corp	1.008
Nibe Industrier AB	0.989
TPI Composites Inc	0.979
Mercury NZ Ltd	0.979
China Datang Corp	0.968
SPIE SA	0.956
BYD Co Ltd	0.947
Xinyi Energy Holdings Ltd	0.943
GS Yuasa Corp	0.942
Soltec Power Holdings SA	0.941
Navitas Semiconductor Corp	0.934
QuantumScape Corp	0.931
Motech Industries Inc	0.931
Vestas Wind Systems A/S	0.927
Prysmian SpA	0.921
Signify NV	0.9
Teco Electric and Machine	0.899
PowerCell Sweden AB	0.892
Vina Tech Co Ltd	0.892
Kingspan Group PLC	0.891
McPhy Energy SA	0.88
Landis+Gyr Group AG	0.879
Ceres Power Holdings PLC	0.878
Sungeel Hitech Co Ltd	0.875
Sebitchem Co Ltd	0.872
NEL ASA	0.865
SolarEdge Technologies Inc	0.856
L&F Co Ltd	0.852
SK IE Technology Co Ltd	0.85
Canadian Solar Inc	0.85
First Solar Inc	0.845
Terna - Rete Elettrica Nazionale	0.842
Archer Aviation Inc	0.841
Hubbell Inc	0.841
Nexans SA	0.839
Hannon Armstrong Sustainable	0.838
Itron Inc	0.835
Sino-American Silicon Products	0.83
Acciona SA	0.824
Solaria Energia y Medio Ambie	0.82
JinkoSolar Holding Co Ltd ADR	0.819
Bloom Energy Corp	0.807
Doosan Fuel Cell Co Ltd	0.805
Verbund AG	0.805
OX2 AB	0.804
United Renewable Energy	0.802
SFC Energy AG	0.801
Bumhan Fuel Cell Co Ltd	0.799
Orsted AS	0.796
Samsung SDI Co Ltd	0.796
ITM Power PLC	0.794
Corp ACCIONA Energias	0.789
Encavis AG	0.787
NFI Group Inc	0.787
Elia Group SA/NV	0.786
Xinyi Solar Holdings Ltd	0.784
Iljin Materials Co Ltd	0.781
CS Wind Corp	0.775
XPeng Inc ADR	0.775
Flat Glass Group Co Ltd	0.766
Li-Cycle Holdings Corp	0.762
Fugro NV	0.756
Neoen SA	0.756
EDP Renovaveis SA	0.755
Array Technologies Inc	0.75
NKT A/S	0.748
Boralex Inc	0.747
Iljin Hysolus Co ltd	0.746
Grenergy Renovables SA	0.745
Altus Power Inc	0.739
Ganfeng Lithium Group Co Ltd	0.735
W-Scope Chungju Plant Co Ltd	0.727
CALB Co Ltd	0.727
Dongkuk Structures & Construct	0.726
Brookfield Renewable Corp	0.726
LG Energy Solution Ltd	0.72
Shoals Technologies Group Inc	0.717
Ballard Power Systems Inc	0.715
Sociedad Quimica y Minera	0.704

Ormat Technologies Inc	0.702	Energix-Renewable Energies Ltd	0.627
Innergex Renewable Energy Inc	0.698	Enlight Renewable Energy Ltd	0.623
Polestar Automotive Holding	0.697	West Holdings Corp	0.619
Novozymes A/S	0.696	Gevo Inc	0.606
FuelCell Energy Inc	0.69	Scatec ASA	0.603
Alfen N.V.	0.682	ReNew Energy Global PLC	0.601
Montauk Renewables Inc	0.676	Maxeon Solar Technologies Ltd	0.599
Hyundai Energy Solutions Co Ltd	0.673	Sunnova Energy International	0.593
NIO Inc ADR	0.672	Sunrun Inc	0.582
Plug Power Inc	0.672	Lucid Group Inc	0.573
PNE AG	0.668	Enphase Energy Inc	0.55
EVgo Inc	0.666	Fisker Inc	0.55
DaeMyoung Energy Co Ltd	0.659	SunPower Corp	0.529
Ameresco Inc	0.657	Lordstown Motors Corp	0.516
Livent Corp	0.65	Solid Power Inc	0.509
Energiekontor AG	0.643	Proterra Inc	0.505
CropEnergies AG	0.641	VERBIO Vereinigte BioEnergie	0.492
RENOVA Inc	0.64	Stem Inc	0.459
ChargePoint Holdings Inc	0.635	FREYR Battery SA	0.458
Wolfspeed Inc	0.635	Canoo Inc	0.413
Aker Horizons ASA	0.633	Rivian Automotive Inc	0.41
REC Silicon ASA	0.63		

There's strong representation above from *EVs, *Batteries, and *Wind.

Appendix IV:
WilderHill New Energy Global Innovation (NEX) - for Latter Q1 2023. 105 Stocks.

Name	Description	Sector	Curr.	Activity
Acciona SA	Sustainable infrastructure, separate is renewables.	RWD	EUR	SPAIN
Alfen NV	Electric Vehicle charging, smart grid, energy storage.	EEF	EUR	NETHER.
Ameresco	Energy savings, performance contracts, renewables.	EEF	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	Hydropower, wind, solar, energy storage, H2.	ROH	USD	US
BYD Co.	Electric vehicles, batteries, rail, and more.	ENS	HKD	CHINA
Canadian Solar	Solar, vertically integrated solar manufacturer, China.	RSR	USD	CANADA

Ceres Power	Fuel cells, high temperature steel units.	ECV	GBP	UK
Chargepoint	EV charging, an early leader with global presence.	EEF	USD	US
China Datang Renewable	Wind, among largest listed wind operators in China.	RWD	HKD	CHINA
Corporacion Acciona En.	Renewables, one of world's biggest, wind, solar etc.	RWD	EUR	SPAIN
CS Wind	Wind power, both onshore, and also offshore.	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
Energix Renewable En.	Wind & solar, producer in Israel, Poland, US, elsewhere	RWD	ILS	ISRAEL
Enlight Renewable	Solar & wind power, clean 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
FuelCell Energy	Fuel cells, high temperature and hydrogen.	ECV	USD	US
Fugro NV	Geo-data, subsea offshore wind construction, cables.	ROH	EUR	NETHER.
Ganfeng Lithium	Lithium, 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
Hubbell Inc.	Electrical equipment, for grid infrastructure and utilities.	EEF	USD	US
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
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	SWITZER.
Li-Cycle	Recycling lithium-ion batteries, recover raw material.	ENS	USD	US
Livent	Lithium, production of compounds, batteries.	ENS	USD	US
Lucid	Electric Vehicles, premium, higher-voltage, range.	EEF	USD	US
McPhy Energy	Hydrogen, electrolyzers using water, H2 storage.	ECV	EUR	FRANCE
Mercury NZ	Clean power, 100% renewable hydro, geothermal.	ROH	NZD	NEW ZEA.
Meyer Burger	Solar, modules, heterojunction high efficiency.	RSR	CHF	SWITZER.

Motech	Solar, cells and modules manufacturing.	RSR	TWD	TAIWAN
Nel ASA	Hydrogen, in fuel cell vehicles, renewably, Norway.	ECV	NOK	NORWAY
Neoen SA	Renewable energy, mainly in solar, some wind.	RSR	EUR	FRANCE
Nexans SA	Cables, for grid power infrastructure.	EEF	EUR	FRANCE
NFI Group	Fuel cell and electric drivetrains, for large buses.	EEF	CAD	CANADA
Nibe Industrier AB	Heating & cooling, sustainable technologies, Sweden.	EEF	SEK	SWEDEN
Nio	Electric Vehicles, design, manufacture, premium EVs.	ENS	USD	CHINA
NKT A/S	AC/DC cables, grid infrastructure improvements.	EEF	DKK	DENMARK
Nordex SE	Wind turbines, based in Germany/Europe, worldwide.	RWD	EUR	GERMANY
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
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
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
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
Shoals Technologies	Solar, electric balance of system, wiring, combiners.	RSR	USD	US
Signify NV	Lighting, systems increasing efficiency, Netherlands.	EEF	EUR	NETHER.
Sino-American Silicon	Solar, semi-conductor silicon wafer materials, Taiwan.	RSR	TWD	TAIWAN
SMA Solar Technologies	Inverters for solar, industrial scale storage, Germany.	RSR	EUR	GERMANY
Sociedad Quimica Chile	Lithium, a key element in advanced batteries, Chile.	ENS	USD	CHILE
SolarEdge	Inverters, panel-level solar optimizers, micro-inverters.	RSR	USD	US
Solaria Energia	Solar, renewable power generation, Iberia.	RSR	EUR	SPAIN
Soltec Power SA	Solar module trackers, also solar power production.	RSR	EUR	SPAIN
Spie SA	Energy sustainability, decarbonization, design, build.	ECV	EUR	FRANCE
Stem	Smart battery storage, AI energy management.	ENS	USD	US
Subsea 7 SA	Offshore wind, and power cables; has Seaway 7.	RWD	NOK	UK
Sunnova	Residential solar and energy storage installation.	RSR	USD	US
SunPower	Solar, efficient PV panels with rear-contact cells.	RSR	USD	US
Sunrun	Residential solar, leasing, PPA or purchase rooftop PV.	RSR	USD	US
Takaoka Toko	Wind power on grid, EV charging, manufacturer.	ECV	JPY	JAPAN
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
Tianneng Power	Hydrogen fuel cells, batteries for wind and solar.	ECV	HKD	CHINA
TPI Composites	Wind Blades; also light-weighting for transportation.	RWD	USD	US
United Renewable Energy	Solar, also energy storage, hydrogen and fuel cells.	RSR	TWD	TAIWAN
Universal Display	Organic light emitting diodes, efficient displays.	EEF	USD	US
Verbio Vereinigte BioEn.	Biofuels, manufacturer supplier to Germany, Europe.	RBB	EUR	GERMANY
Verbund AG	Electricity supplier, hydro, a large provider for Austria.	ROH	EUR	AUSTRIA
Vestas Wind Systems A/S	Wind, wind turbine manufacturing & services, Denmark.	RWD	DKK	DENMARK
Wacker Chemie AG	Solar polysilicon maker, a leader but based in Europe.	RSR	EUR	GERMANY
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

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105 stocks/100 =
Weights; Components
NEX Latter Q1 2023 **EQUAL WEIGHT EACH = 0.952380%**

105 NEX Stocks for Latter Q1 2023.		#	Approx. Weight %
Energy Conversion	ECV	14	13%
Energy Efficiency	EEF	22	21%
Energy Storage	ENS	17	16%
Renewables - Biofuels & Biomass	RBB	3	3%
Renewables - Other	ROH	6	6%
Renewable - Solar	RSR	28	27%
Renewable - Wind	RWD	15	14%
		105	100%

Appendix V: Historical Weightings in past: 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 4 leading WilderHill Indexes for clean & green themes:

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

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

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

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

Appendix VII:
WilderHill Hydrogen Economy Index (H2X) for latter Q1 2023 (56 components):

NAME	Description	Sector	Activity
Abb	Electrification systems and engineering for green H2.	HS	SWITZERLAND
Alfa Laval	Heat exchangers for green H2 production, electrolyzers.	HS	SWEDEN
Arcadis NV	H2 network, Netherlands, Europe, in planning.	HI	NETHERLANDS
Ballard Power Systems Inc	Fuel cells, H2 in buses, trucks, trains, backup power etc.	HT	CANADA
Belden	DC power from fuel cells, or intermittent wind & solar.	FC	USA
Bloom Energy Corp	Fuel cells, SOFC high temps can use variety of fuel sources.	FC	USA
Brookfield Renewable Energy	Teaming to produce green hydrogen from hydroelectricity.	HI	USA
Ceres Power Holdings PLC	Fuel cells, high SOFC temperature allows variety of fuels.	FC	UK
Chart Industries	Liquid hydrogen, storage and transport expertise.	HS	USA
China Datang Renewables	Wind & hydro in China, that's developing H2 projects.	HG	CHINA
Chung-Hsin Electric	Fuel cells. Hydrogen, methanol reformers.	HG	TAIWAN
Compagnie Plastic Omnium	H2 storage, high pressure tanks, vehicles, fuel cells.	HT	FRANCE
Corp. Acciona Energias Ren.	Green H2, new GreenH2Chain to ensure green H2 origins.	HI	SPAIN
Doosan Fuel Cell	Fuel cells, high temperature for a variety of fuels.	FC	S. KOREA
Fluence Energy	Energy storage software, hardware for green H2 on grid.	HI	USA
Fuelcell Energy Inc	Fuel cells, high temperature so over range of fuel sources.	FC	USA
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
Iljin Hysolus	Compressed hydrogen tanks for fuel storage.	HS	S. KOREA
Infineon Technologies	Power electronics, in green hydrogen, wind, solar.	GH	GERMANY
ITM Power PLC	Fuel cells, PEM; also electrolyzer manufacturing green H2.	GH	UK
Johnson Matthey	Catalyst-coated membranes, in fuel cells, electrolyzers.	FC	UK
Linde PLC	Industrial gases production, including hydrogen.	HG	UK
Littelfuse	Hydrogen & fuel cell sensors, temperature probes.	HS	USA
Lotte Fine Chemical	Green hydrogen, production launch, ammonia.	GH	S. KOREA
Mcphy Energy SA	Hydrogen production, use, and storage; H2 in industry.	HI	FRANCE
Nel ASA	Electrolysis for H2 from water, using alkaline and PEM.	GH	NORWAY
Neoen SA	Water Electrolysis and renewable energy for green H2.	HG	FRANCE
Neste Oyj	Renewable hydrogen and diesel, SAF, but some fossils.	HG	FINLAND
Nexans SA	Cables, can carry both H2 + electricity, H2 pipelines.	HT	FRANCE
NFI Group	Hydrogen fuel cell electric power in buses,	HT	CANADA
OCI N.V.	Green Ammonia, building up from biogas, hydrogen.	HG	NETHERLANDS
Orsted A/S	Green hydrogen directly from wind power, early stage.	GH	DENMARK
OX2 AB	Green H2 infrastructure, pipelines, generation in review.	HS	SWEDEN
Plug Power Inc	Green hydrogen, and fuel cell systems in development.	HI	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
SGL Carbon SE	Polymer electrolyte membrane in PEM fuel cells.	FC	GERMANY
SKF AB	Advanced bearings, for H2 by compressed transmission.	HS	SWEDEN
SMA Solar Technology	Electrolyzer converters, green H2 from renewables.	GH	GERMANY
Spie SA	Hydrogen in mobility, H2 production, distribution.	HT	FRANCE
Takaoka Toko	Stabilizing the power grid, use of green H2 on grid.	HS	JAPAN
TE Connectivity	Hydrogen pressure sensors, fuel cell connectors.	FC	SWITZERLAND
Tianneng Power	Hydrogen, fuel cells, Li-ion and other batteries.	FC	CHINA
Toray Industries	Membranes for H2 purification, generation, fuel cells.	HI	JAPAN
Varta AG	Hydrogen gas generating cells, ultrapure.	HG	GERMANY
Verbio Vereinigte Bioenergie	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
Wolfspeed	High power fuel cell systems, SiC, GaN.	HT	USA
Workhorse Group	H2 fuel cells work on electric trucks.	HT	USA
Yara International	Green hydrogen catapault, aims for H2 <$2/kg.	GH	NORWAY

Adds to H2X for Latter Q1 2023: Alfa, Arcadis, Belden, Chart, Fluence, Infineon, Johnson, Littelfuse, Neste, Nexans, OX2 AB, Takaoka, TE, Tianneng

Deletes from H2X; Latter Q1 2023: 5E, ABalance, Aker, Bumhan, Cropenergies, Dae, Montauk, Navitas, SFC, SK IE, Vinatech

Equal weighted = 100/56 components = each 1.785714%

Appendix VIII:
WilderHill Wind Energy Index (WNX) for Latter Q1 2023 (55 components):

Name	Description	Sector	Activity
Abb Ltd.	Wind turbines, generators and converters.	WM	SWITZERLAND
Acciona	Sustainability infrastructure, engineering.	SG	SPAIN
Alfen NV	Smart power grid, energy storage systems.	SG	NETHERLANDS
Arcadis NV	Engineering, EPC, develops wind projects.	WI	NETHERLANDS
Belden	Wind cables, turbine data communications.	WM	USA
Boralex Inc	Development and operation of wind farms.	WF	CANADA
Brookfield Renewable Corp.	Pure plays renewables wind, hydro, solar.	WF	USA
China Datang Renewable Power	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 Wind	Wind power, both onshore, and also offshore.	WF	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

Energix Renewable	Wind, solar, independent power producer.	WF	ISRAEL
Enlight Renewable Energy Ltd	Builds and operates wind, also solar sites.	WF	ISRAEL
ERG SpA	Wind, going from fossils to clean renewables.	WF	ITALY
Fluence	Energy storage, using intermittent wind in grid.	SG	USA
Fugro NV	Marine geoconsulting, subsea offshore wind.	WI	NETHERLANDS
Greenvolt Energias	Wind, residual biomass & urban demo waste.	WF	PORTUGAL
Grenergy Renovables SA	Wind projects in Chile, Peru, elsewhere.	WF	SPAIN
Hubbell	Electrical gear, modernizes grid, utilities.	SG	USA
Hydro One	Electricity transmission, distribution, Ontario.	SG	CANADA
IMCD NV	Wind lubricants, 100% recycled blade foam.	WM	NETHERLANDS
Infineon Tech AG	Converters and inverters, wind power systems.	WM	GERMANY
Innergex Renewable Energy	Independent renewable producer, wind.	WF	CANADA
Landis&Gyr	Smart Grid management, advanced meters.	WM	SWITZERLAND
Littelfuse	Wind controls, sensors, circuit protection.	WM	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
Renova Inc	Independent renewable power producer.	WF	JAPAN
Rexel SA	Smart electrical systems, energy efficiency.	WM	FRANCE
SBM Offshore NV	Offshore wind energy installations, wave too.	WF	NETHERLANDS
Schneider Electric	Advanced grid, wind energy management.	SG	FRANCE
SGL Carbon SE	Composite and graphite materials in wind.	WM	GERMANY
SKF AB	Wind gear bearings, seals, mechatronics.	WM	SWEDEN
SMA Solar Technology	Wind power conversion; green H2 from wind.	SG	GERMANY
Spie SA	Energy infrastructure sustainability, Europe.	SG	FRANCE
Stem	Software, optimizes wind + battery + grid.	SG	USA
Subsea 7 SA	Offshore wind installations, also Seaway 7.	WI	UK
Takaoka Toko	Wind power use on the grid, transformers.	SG	JAPAN
TE Connectivity	On+Offshore wind connectivity, sensors, cable.	WM	SWITZERLAND
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
Vestas Wind Systems A/S	One of first, largest, wind turbine makers.	WI	DENMARK
WESCO International	Utility electric for grid, assists renewables.	WM	USA
Wolfspeed	Silicon Carbide SiC in wind, better efficiency.	WI	USA

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55 components = 100/55 = 1.818181% equal weighted each

Adds to WNX for Latter Q1 2023: Belden, ERG, Fluence, IMCD, Infineon, Landis, Littelfuse, Rexel, Takaoka, TE, Wesco.
Deletes from WNX for Latter Q1 2023: 5E, Aker, Bumhan, Cadeler, CS Bearing, Dae, Dongkuk, E. Vault, Energiekontor, Freyr, Navitas, Renew Energy

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Lastly, the following Announcement for these 3 Indexes NEX, H2X, WNX was made early Q1 2023 - and it took effect starting with the Latter Q1 2023 Rebalances for all 3 with Solactive:

Rationale for Methodology Change

Solactive has determined that in order for the indices to comply with SFDR requirements around good governance practices, companies missing critical ESG data are not eligible for selection. Involving the 4 datasets from Sustainalytics for screening purposes: Global Standards Screening (GSS), Controversy Score, ESG Risk Ratings (ESG RR), and various Product Involvement fields (PI), companies missing GSS, Controversy Score, ESG RR or all PI fields, would be removed from the eligible universe.

Changes to the Index Guideline

The following Methodology changes will be implemented in the following points of the Index Guideline:

2.2 SELECTION OF THE INDEX COMPONENTS
From (old version):
For the avoidance of doubt, companies not covered by Sustainalytics research under any of the above categories will remain eligible for selection in the INDEX.

To (new version):
Companies not covered by Sustainalytics research under any of the above categories will be ineligible for index selection.

Defined terms used in this announcement, but not defined herein, have the meaning assigned to them in the respective index guideline of the Affected Indices. The amended version of the index guideline will be available on the effective date.

See, https://www.solactive.com/methodology-change-several-wilderhill-indices-effective-date-30-01-2023
https://solactive.com/downloads/Guideline-Wilderhill-NEX-5.0.pdf

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

For more on all 4 WilderHill Indexes, see: https://wildershares.com
ECO rebalances are end of March, June, Sept, Dec. For NEX/H2X/WNX end of Feb., May, Aug., Nov.
Our prior Clean Ocean Index (OCEAN) for cool climate was retired in 2022, https://climateandclean.com
The 1990s antecedents seen in original Wilder-hill Hydrogen Fuel Cell Index, are at http://h2fuelcells.org

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