WilderShares, LLC

Q2 2022 WilderHill® Quarterly Report: ECO, NEX, OCEAN, June 30, 2022

The Clean Energy Index® (ECO) started Q2 near 136 and ended Q2 at 95, so down -30%, and Year to Date was down by -36%. For last 3 years, ECO rose by +58% in 2019. Remarkably, it then rose by +203% in 2020 for about the best performance of any Index or Fund, anywhere. After 2 such gains not surprisingly, it fell by -30% in 2021 as a key reconciliation bill's failure pushed this theme down hard – plus as fast-rising inflation & so interest rates (down more!) outweighed any decarbonizing trends that may favor renewables ahead. After first falling in Q1 by 1/3rd to 100 - war brought a hard shift away from overreliance on (Russian) gas and in the war's first few weeks, ECO briefly jumped by +40% on the better alternatives found here. In Q2 it fell back harder hitting a low of 84 amid supply chain chaos, then rose mildly on Europe's green plans. Since 2017 when ECO was at 38, it's now up by some +180%.

Or viewed from a 280 high in 2021, this volatile theme had also plummeted by ~2/3rds. History shows the originals ECO & NEX, along with newest H2X & WNX themes can & do at times 'drop like a rock'. Jumps up, true, yet crashes happen too. Even if renewables bring an energy transition. Even if solar & wind are soon *the* best-priced electricity anytime, anywhere in history, there's sharp equity moves at times downside. Despite demand from Europe, US, & Asia. Even should bold new energy innovations bring clean climate solutions – there's still bound to be crashes. Perhaps not only in solar, but also in wind energy and other renewables, hydrogen and fuel cells, electric vehicles, batteries and energy storage, thinking informed by the decarbonization of everything and by ESG – unlike anything seen before.

Last 5 years the Benchmark ECO Index live since 2004 and the 1st for climate solutions, is up +150% through mid-Q2 2022. This over a period when any energy gains might stand out. For same 5 years, despite their huge recent gains, both oil & gas are only up +10%; they're *down* by -50% last 10 years. By contrast, decarbonization as an organizing theme at ECO is up +155% last 10 years, and NEX is up +200% showing very differing returns for sustainable energy.

The first *global* clean energy Index is the WilderHill New Energy Global Innovation Index (NEX); live since 2006 with tracker in Europe it's up +85% last 5 years starkly beating fossils. NEX has often outperformed too vs. a not-so-clean, independent (not ours) other global 'clean energy' Index for sizable periods like since inception. In sum, the 5 WilderHill Indexes now including newest themes for Hydrogen Economy (H2X) & for Wind Energy (WNX) are pure-play leaders. And energy once dirty and dug from deep underground and burned – is increasingly found in the free winds & sunlight gifted to us cleanly & renewably from up towards Heavens.

Clean Energy Index® (ECO) is the world's 1st for clean energy; ECO & NEX have the longest records, and helpfully non-correlate vs. oil & gas. Along with the 2 new themes for hydrogen (H2X) & wind (WNX), there's now 5 WilderHill® Indexes: the cleanest & most respected for decarbonizing. Each is transparent, informed by sustainability and can help build a diversified model portfolio.

Source: NYSE.com

World energy 2022 has changed greatly from 2 years, or even 1 year before. And not just in fossil fuels: one energy option some had hoped would shine in 2022 – building more nuclear - was hard hit by a huge wall of problems. One might have thought nuclear power would come 'riding to rescue' after Russia's invasion of Ukraine. That France with its fleet of nuclear power plants and know-how, could grow it full tilt. Export many extra electrons to Europe, sit pretty, unvexed by spiking natural gas prices, or a possible end to Russia's piped gas.

Instead, France in 2022 was badly handicapped: nearly ½ its existing modern nuclear power plants were stuck offline. Not long ago, they'd been the poster child for top-shelf nuclear. Proud of her sovereign technological abilities to make power. Modern, the highest-percentage of nuclear generation in the world without mega-disasters of Chernobyl or Fukishima etc. But instead, France was recently hard hit by massive, forced domestic power cuts, its lowest power levels in 30 years. With taxpayer subsidized, high electricity costs that may vex in perpetuity. All with consequences for the rest of Europe, struggling for its fossil power.

Not yet well-known, France's nuclear plants had just been acutely hard hit by unexpectedly bad corrosion issues, also by maintenance that will take years to properly sort. Besides having to look at possibly rolling blackouts, attention was again being given to maybe nationalizing her $30 Billion debt-laden giant, long a champion of building nuclear. And they weren't alone. Big current-generation, nuclear problems were rife at the Hinkley Point C power station going up in Britain. Predictably far behind-schedule, over-budget – it's nonetheless the most 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.
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> 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. Campaigners who have long seen nuclear as dangerous can now call on economists who say it is just too expensive." ….

What of spiffy nuclear plants being built elsewhere? Aren't they going up swiftly, on budget, having learned from colossal mistakes like at Hinkley? After all, nuclear-proponents talk of lessons learned. Yes, but not in the West. Take America's newest attempt to build nuclear cheaply & swiftly at modern Vogtle 3 & 4 in Georgia – first new US nuclear plants in 3 decades. Begun in 2009 with 2 understood Westinghouse AP1000 designs, their original certified costs were a big $14 Billion, to be done by 2017. Instead, the project drove Westinghouse bankrupt. By 2018 the costs were newly estimated at $25 Billion. Then 2021, costs were re-estimated at $28 Billion, with those 2 reactors still not completed in 2022! Or France's 'new' Flamanville plant began 2007, now over a decade behind schedule, not completed, hundreds of workers redo-ing its welds, costing added Billions of Euros. Likewise, a very-modern Olkiluoto nuclear plant in Finland was due to open in 2009; it only had begun very first testing in 2022.

On the other hand, some recent plans to retire *built* nuclear plants were instead put on hold, given a 2022 crisis. And China, Russia showed ability to build big nuclear plants, on schedule on budget. But to contract with Russia, for new nuclear plants now, is 'impossible'. It leaves China, but contracts with it too, being questioned. A main point is, there's No Simple Energy Answers. So much had changed dramatically, at the start of a whole new 2022.

As discussed ahead, 3 factors dominated early 2022: *Inflation across solar, wind, batteries, where rather than falling, as usual - costs rose hard 30% year over year, *rises* not before seen here; *War as all fossil energy costs spiked in turmoil; and *Supply Chains chaos as new energy projects expected to be done in 2022, got pushed off into 2023, 2024 or worse. Renewables got more costly in 2022 - as did all the dirty fossil fuels plus nuclear, those even more so.

Inflation can torment, and renewables, batteries, long accustomed to price *Declines*, to cost *drops* – instead, found no safe port as all green stocks were hammered. Costs surged for everything, labor, capital, materials, shipping. Thus, usually-declining prices for wind & solar in Europe & US – jumped. Globally, EV prices jumped too, getting less-affordable. Power Purchase Agreements so core to clean energy had spiked in North America, and in Europe. Many green energy projects were thus pushed badly back, slimmed, or even canceled.

Second, turmoil of war was by no means confined! In April, Rosneft of Russia put up 37 million barrels flagship Urals crude for May delivery at then-fire sale (though high) prices on fear Europe might halt buying: 'cheap' spot prices with 100% pre-payment. Europe began to look seriously at alternative suppliers for oil, diesel, natural gas, mindful of coming cold winters, hot summers. Even coal plants slated to close, like nuclear, were restarted, or kept going. Despite the fact, for coal, climate change will be much worse, than people recognize.

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

Supply chaos, self-inflicted own-goals. For example, just 4 countries: Vietnam, Thailand, Malaysia, Cambodia, assemble some 80% of solar panels imported to US. After a tiny US solar maker asked US Commerce Dept to investigate if they were 'Chinese-panels' so circumventing China tariffs, a 200% *retroactive* penalty grew possible - halting solar imports. Projects ground to a halt 2021. Slowed hundreds of US projects, killed a huge 24 gigawatts (GW)! One big US solar developer had to pause 2-3 GW planned projects lacking solar panels. A quasi-judicial investigation early 2022 was lugubrious, solar panels grew scarce. Vexed US solar developers thus needed both clarity & panels. In 2022, the US President gave a 2-year reprieve on solar tariffs, skirting the issue. Re-opened the spigot on panels from Asia whether Chinese or not. But it somewhat just kicked the ball down the road, following an unneeded own-goal.

Clarity required on many fronts. Like if US Congress re/extends US tax credits to help wind, solar, energy storage, electric vehicles etc. That could much be decided by 1 US Senator (who wanted a 'smaller' $1 trillion bill, mountain valley pipeline, more US nat gas to Europe). With opposing conservative party likely to gain in 2022 elections, it was 'now or never' for US clean energy/climate legislation. Needed too, was further insight on new European incentives for clean energy, efficiency, hydrogen. Given-the-war, we did see early plans for 5-fold increase in UK solar capacity, going up fast from 14 GW - to 70 GW to 2035. Germany planned for a blossoming of solar to go from 22 GW – to 215 GW by 2030. Hence part of this picture was big positive push in Europe, Asia, elsewhere for renewables. Sensibly, renewables can be a great foil against over-relying on (Russian) fossils. Meanwhile all: nuclear, fossil oil & critical diesel, coal and natural gas – saw prices spike up – and gas rationing fears flared. Meanwhile, clean energy had shifted 2020/2021 from margin expansion – to margin compression in 2022.

For Europe to wean itself off Russian gas, from 2022, wasn't going to be easy. Take German car manufacturing, core to its economy. Germany had begun to exit diesel fuel – had started to embrace EVs - that may be renewably-powered. But, what of her big auto factories? Could they too move beyond natural gas in auto manufacturing? For heat, say, in paint shops? How ready was it to shake a long addiction to cheap Russian natural gas from 2023/2024 or…?

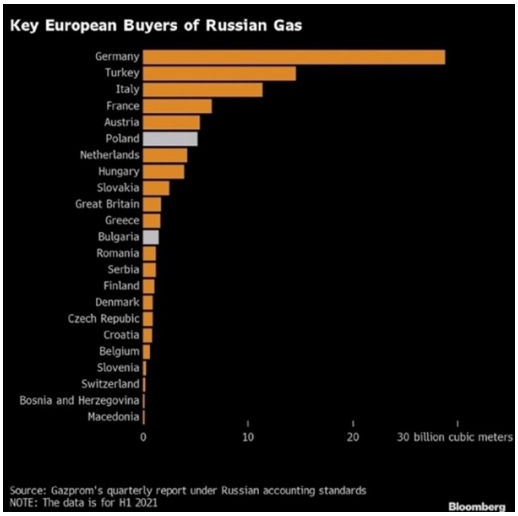
Shell-game of 'carbon offsets' & 'renewable energy certificates' had let many firms pretend they'd used less natural gas. (Claiming say, trees left on slopes so steep they can't be cut, meant carbon credits 'reducing' fossils use). Or that non-transparent, excess old European hydropower certificates – were incentives for new renewables generation. But that was oft just virtue signaling. Once Russia's gas supply was threatened – then in fact pared back – it fast exposed how utterly dependent on non-renewable fossil-heat, the auto industry was.

It was, by a lot. In 2021, over >½ German auto factory energy use was from non-renewables. Put another way, only 13% of heating needs at her 3 big carmakers was met by renewables. At Volkswagen, about 80% of heating needs was met by non-renewables. It planned to switch to cogeneration, to combined heat & power at a Wolfsburg >6.5 million square meters plant going from coal to natural gas, but war 2022 meant it stayed longer with awful abundant coal. At BMW, about 60% of energy came from fossils; mainly usual natural gas so typical across industry. One Potemkin village like, façade-pleasing-response was to site some big renewables very visibly by a factory. But those only then supplied overall some 1% of needed energy 2021 at Volkswagen, less at Mercedes, BMW. There were a few exceptions like at a BMW I3 plant in Leipzig that got 20% of its *electricity* (not heat) from 4 nearby big wind turbines.

A few exceptions, like efficient Mercedes Sindelfingen plant 56 got 30% of its *electricity* from solar. Or a Mercedes plant that saw growing use of green power sources. Still, those one-offs – were nice for marketing – but not a norm. And what of heat/energy? Major parts supplier Bosch was getting only 1% of its *energy* worldwide from on-site renewables. It aimed to reach 5% by 2030 – but that's years away & a low bar obviously. Sustainably-made *electricity* is cheap and getting cheaper thanks to wind & solar. Green *electricity* is easier to get and use. But getting and using green *energy*, very noticeably for heating needs, is much tougher.

For how available green *electricity* from renewables was getting, big auto parts maker ZF, in 2022 signed power purchase agreements to get 210 GWh wind power for manufacturing at its plants in Germany. Statkraft of Norway supplied ZF with 100 GWh from its wind farms based in Spain 2022. Then 150 GWh more in 2023. In 2024 & 2025, Enovos Energie Deutschland is providing ZF green electricity from its wind farms in Scandinavia. So ZF can get renewably-made, sustainable electricity equivalent to powering 72,000 German households. That's a modest useful start at least on a *green electric power* supply front.

But hard fact remains: *electricity* (made green or otherwise) is a very poor way to make *heat*. Homes get warmth via heat-pumps for sure. But for high industrial heat - going from fossil gas - to decarbonizing like via green hydrogen, ammonia, methanol etc would take in light of the climate crisis, too much time. On time-scale of decades, it means hothouse world different from the habitable one today. In short, both green *energy*, and heat are needed ***Now***. Given both a climate crisis – and suddenly from 2022, energy security risk. Early part 2020s decade, in neither case were 'solutions' happening swiftly enough. Not one bit. And much-needed clean industrial heat, clearly can't yet come from sustainable wind nor solar.



Source: Gazprom's Quarterly Reports; Bloomberg.

So, a big worry early in 2020s became natural gas, even gas rationing in rich Europe. That said faster moves off Russia's oil, especially off its gas, demanded more be done. In 2022, Europe looked at a 210 billion euros (USD $221 billion) REPowerEU, upping renewables from 40%, to 45% in 2030. EU renewable energy generation targets rose to 1,236 GW. To cut its 6 years of red tape for wind permits, 4 years for solar, new 'go to areas' could mean permits in 'just' 1 year. It aimed to grow EU solar PV 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 and heating for industry. But that still wasn't enough. Plus, there was much new spending on adding fossils/gas infrastructure too. Replacing in 2 to 3 years Russian piped gas - with new LNG infrastructure that brings fossil gas in by ships – only just not coming from Russia.

With that spending & attention to clean energy, it seems counter-intuitive – and yet it did not & does not - translate to persistent equity gains in clean energy and so ECO & NEX. In April, 1st month of Q2 2022, ECO dropped hard: -22%. In May, Year to Date (YTD) was down -40%. Or since an intraday peak of 287 (286.89) in Feb. 2021, ECO had painfully plummeted by 2/3rds dismally over 14 months to low 80s May 2022. After a rise on European green energy & security plans, it swooned again in June 2022 to go under <100 on fast-rising headline inflation.

To be fair, famous tech-heavy NASDAQ was also down by -13% in April, then off -30% YTD in June. From its own peak 'Naz' was far off highs; S&P500 and Dow too dropped hard YTD more than by -20% for bear markets in each one. Not as volatile as ECO, to be sure, but as 3 of the world's most-watched themes, those NASDAQ/Dow/S&P500 drops were no small-potatoes.

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

Let's take a brief look specifically at that ARKK, a well-known and also hugely-performing (active) fund in the same year 2020. If one wishes to find a Fund with similar performance to our own ECO the Past 5 years, then interestingly it presents pretty comparable chart. Theirs is younger also-innovation focused: their ARK Innovation Fund (ARKK) launched a decade *after* our ECO in a mildly differing theme. Yet moves have been roughly similar since though ARKK began much later (ARKK inception was 2014 – vs 2004 for ECO, 2005 for independent tracker; the 1st Global clean energy Index NEX, was born 2006: a tracker launched 2007). Of note the themes centered on innovation and looking at the last 5 years, clearly **ECO** (darker blue) and **ARKK** (lighter blue) had both jumped from the same time, March of 2020.

But we can see ECO then jumped higher & went farther up, than ARKK co-peaking Feb. 8, 2021. And while both painfully plummeted last 5 years, seen in this chart, ECO ends better to mid-Q2 2022 at up about +130%, vs. ARKK not so good same May 15 here up 'just' +63%:

Past 5 years to mid-Q2 (May 15) 2022: **ECO** higher at 130% (dark blue) vs. ARKK (light blue) at 63%:

Source: finance.yahoo.com

For all of our warnings about ECO & its acute risk, it went up more, then down less than ARKK. As always: innovation/tech themes are volatile with significant risks. Clean new energy wind, solar, EVs, hydrogen, etc are never havens of calm, nor safety! Early 2020s also look to be a time all *Energy* sees acute shortages, maybe rationing, perhaps calamitous blackouts.

Energy's theme is complex. Full of 'on the other hands.' Take renewables, in applied on the ground ways. Blackouts threatened worldwide 2022/2023/2024 given decrepit aging grids, war, fuel scarcity, fuel switching from Russian gas, new weather extremes and more. 'On the other hand', a positive milestone came Q2 2022 as California one windy day for the first time, briefly got 100% of its power from renewables. A less-windy sample day, May 5, 2022 – it saw 23,000 MW of demand; with 17,000 MW or 70% of that met by 3 renewables: solar, wind, geothermal. Each can be ramped greatly potentially displacing 17% coming from natural gas. That mid-day, 70% of its demand was met by solar, 23% was met by wind, 4% by geothermal (which may expand to co-produce lithium from hot brines like at a Salton Sea for US battery needs, near population centers). Yet renewables' growth arguably still needs to happen much faster; it's now far behind where it needs to be. Supply chains at sixes & sevens – bottlenecks galore. Solar panels were held back on tariff fights in 2021 and were given just a brief two-years reprieve in 2022. All at a time when eg California was badly short by 1,800 MW of much-needed power – for handling very hot Summers – and very cold Winters. Shortages threatened horrific new Blackouts soon not just in that very rich state, but globally too!

Clearly many pointedly bearish troubles overshadowed US clean energy as 2022 had opened. One, was that *only* a bipartisan $1 Trillion Infrastructure bill had been passed in 2021. Little in it was relevant to clean energy – none to climate crisis. Compared to a bigger reconciliation bill whose $550 billion would have focused on clean energy & on climate - but had stumbled/ failed in 2021, this was thin gruel indeed. For example, making an aged US electric grid net-zero may mean +60% capacity upgrades. Yet a passed Infrastructure law only gave a DOE facilitation item small $ amounts. Grid resilience got $11 billion, but power failures discussed ahead are real now, and can potentially already cripple states; $3 billion matching grants in this law nowhere near up to task. Overall, its $65 billion for overall transmission would be quickly eaten up by spending on fossils outside of pressing need for decarbonization.

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

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

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

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

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

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

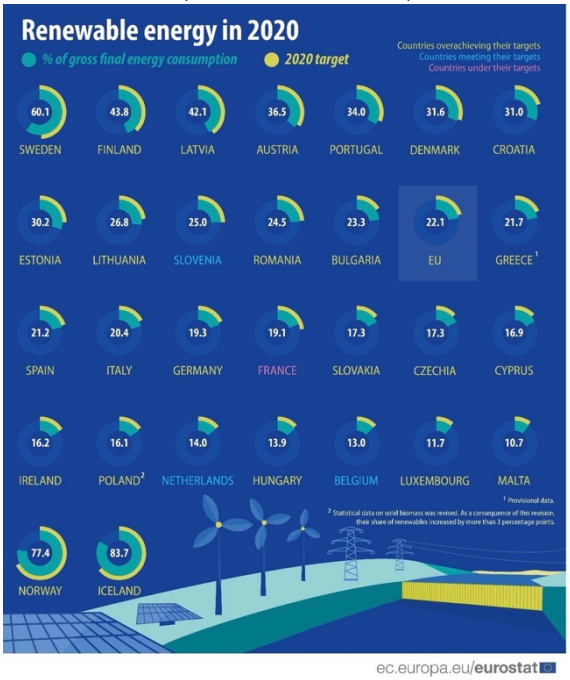
Siemens Gamesa had expanded like in England, thanks to UK's wind vision. One rotation of its most huge blades could power a house there for a day; coming bigger blades, could power a house 2 full days/per rotation! Wind's growth had meant that by 2020, 25% of UK power lately came from wind over a full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

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

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

Net result was wind & solar were 2 big renewables start of this decade and rich Europe led. Europe's gross electricity consumption met by renewables was then 1/4th, or about 25% of its demand. 2020 figures below showed that very highest/best were Norway & Iceland, at 77% and 84% respectively. And among the 27 EU members, Nordics again led: Sweden 60%, Finland 44%. Nearby Latvia and Austria were 32%, 36%. But of course, there were EU laggards as well. Belgium was then getting only 13% from its renewables; The Netherlands then just 14%. Both had only barely met targets, unusual then vs. rest of a more ambitious Europe.

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



Source: Eurostat.

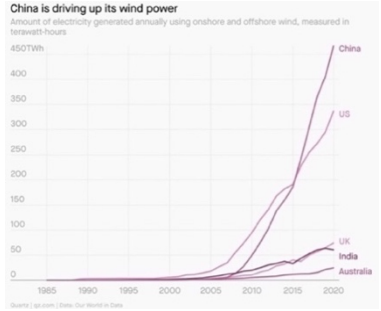
UK famously, had left a 27-member European Union in 2020, so it isn't seen above. But, the UK in 2020 had sourced 42% of its energy from renewables, thanks largely to a wind push. Expect offshore wind to go on fast rising in UK & Northern Europe. Yet curiously if renewables' Costs in UK like elsewhere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

Meanwhile a US that in 2020 had gotten only 19.8% of its energy from renewables, lagged Europe at a then 22.1%. On war 2022, Europe fast-upped its commitments to renewables – as US lagged. Of a US 20% from renewables 2020, 13% (2/3rd) was solar/wind; 7% (1/3rd) was hydroelectric. 2021 saw a record US $105 billion investments in renewables, batteries etc – for 37 GW of solar & wind. Yet gas was still making Twice, or 2x that much power, or 40%. Even as Europe pulled ahead in its renewables %, the Big picture was neither Europe, nor US made anywhere yet enough clean power. Each must grow over 2x faster on decarbonization goals. Yes, war changed much 2022; Europe & acutely Germany resolved to grow renewables fast, EVs too. Europe's light duty EV vehicle sales were already 19% late 2021 – double an 8% world average – for near 1 of every 6 cars sold in Europe (in China) were EVs. That vastly beat US at 1 EV out of 20 cars. But a fact remained for Europe: 1/3rd of its oil, and more of its gas in 2021, was still coming from Russia. Nightmarish with the invasion of Ukraine.

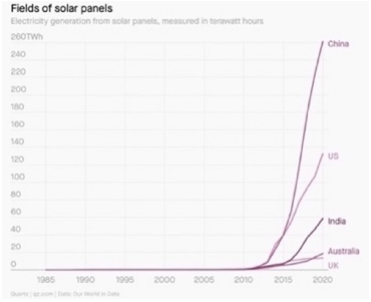
What of China? As one of - if not The most important bloc for renewables? China in 2020 was The Clear world leader in absolute green energy generating capacity. Yet its 342 gigawatts (GW) capacity then made (only) 14% of its power from renewables. Still, figures can deceive. For China's total energy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

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

Wind & Solar Growth in China surpassing all:



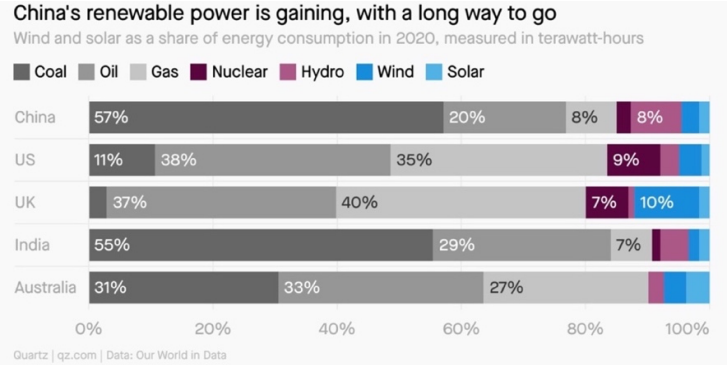
Source: Quartz / Our World in Data.



Source: Quartz / Our World in Data.

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

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



Source: Quartz / Our World in Data

Coal-loving Australia for instance relied on coal for 60% of its electric generation, early 2022. Even though renewables are a better bet. A wind farm in Badgingarra, Western Australia hit eg a big capacity rate (how much time operating) of 64%, in 2022. That competes well with coal plants that must shut for maintenance, repairs etc. And coal must pay for fuel. Like nuke plants for waste - unlike wind, solar instead getting cheaper. Even current nuclear touted by proponents as firm, faced some dire straights 2022. France even considered nationalizing a towering nuclear private company, over unforeseen corrosion issues. There was poor welding at a Flamanville reactor (like issues at reactors in Georgia, US). While worsening heat and drought threatens an ability to cool plants, vexing all current-gen-nuclear high costs.

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

Even supposed climate leaders flailed 2022. Regionally, take California. A quasi-governmental Commission there overseeing utilities, favored big centralized thermal power generation mostly on fossil fuels. It proposed to consternation of many in a green leader State – that the State should *reverse* incentives for home rooftop solar. That it move a solar payback from 7-9 years which made solar a sound economic choice – to over 20 years. Thus, making it unaffordable, or purely non-sensical to just about everyone. This, in green California!

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

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

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

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

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

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

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

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

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

So, to target a turn 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, would jump 15x from 2.6 GW it was in 2021. Longer-duration >4 hours energy storage (like pumped water) rises to 4 GW. Of course, these were just plans in 2022. How near-term, to actually replace GWs of firm natural gas – plus a lone big last nuclear plant mid-decade – with anything near as energy-rich? In 2022 the answer wasn't 100% certain, the threat of rolling blackouts soon, ahem, very real. In an energy transition so far highlighting greater demand for yet *more* natural gas – not far less.

The 2022 Plan anticipates 12 GW of renewables is brought from out of state. A 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. These GWs can't happen too soon. CAISO's draft Plan projected going from 7.8 GW California wind power, to 24 GW new wind including from the West in 2040. In past a lengthy 8-10 years was needed for permits; that's now too long, green electrons needed, fast. Helpfully, regulatory bureaucracy is being cut of late. And $30 Billion for transmission upgrades was seen as 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 these are Billions - huge sums. (As Senator Dirksen joked, 'A billion here and a billion there, and pretty soon you're talking real money'). But put that in context of the vaster sums spent for oil & gas, and $30 Billion for renewables is relatable. Particularly when it means better resilience for California's $3 Trillion economy. Were this state a nation, it'd be 5th largest in the world, ahead of India and the UK. And Blackouts Must Be Avoided.

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

Yet storage & grid takes time to be built. So, what to do soon on 2 big pieces of this puzzle: natural gas & current generation nuclear are near-term issues. This decade California needs all 25 GW of new renewables supply – plus more for about 50 GW of generation. A new 17 GW big utility scale solar was needed 'yesterday' – and even utilities support that new supply. Offshore wind capacity is just starting to spool up; later in-2020s is 3 GW+ new wind. Plus 13 GW in short-duration batteries. All of that can make California's grid in 2032, happily come 73% from renewables & be 86% greenhouse-gases free. But the next few years, are scary.

A huge climate & clean energy reconciliation bill that lately drove up green energy hopes and was almost passable in 2021, when a new President & 50/50 Senate took office: is now dead. Political capital, trillions of dollars – went first/fastest to needed Covid emergency spending. Conservatives arguably had a point that those trillions in Covid relief spending early 2021 would later be 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 not inflationary) – but rather oil prices are set by markets worldwide. Unsurprisingly after oil industry refrained from swiftly ramping back up supply given the new demand (as it had suffered huge losses in a last bust) – followed by exigencies of war – the price of oil & gas jumped.

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

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

Something a bit like that might happen in US as well. A narrow lane for US passing a $550 billion Bill for clean energy in 2021 has closed – discussed ahead. Yet maybe a more bipartisan package is plausible – but with fossils and nukes. In particular acknowledging facts on the ground: Fall 2022 elections can end a razor thin Democratic control of Senate – maybe small House advantage too. Hence in the US, there may be new energy expectations ahead.

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

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

So, to get some of their goals, progressives may be forced to swallow hard for an All the above 'energy independence' with much fossils. America won't really be energy-independent – each barrel of oil is in global supply: it isn't identifiable as barrel a, b, etc. But, if that gets the most possible new support for renewables, then that could ramp clean in this decade. Some grand compromise may happen, with oil firms wanting subsidies for 'carbon sequestration' that isn't even real in reducing GHGs. On the other hand, a tremendous downside to this all (and the world of politics, which we prefer to avoid) is that ongoing fossils use probably dooms us from the wider and more real, objective climate-perspective.

It's easy thinking above of politics, to forget how much climate change actually matters. Politics ignores this risk, though science indicates such neglect may revisit us many-fold. Yet work is happening, in future-gazing science, like getting right the models that can help us better see what may lay ahead. Clouds especially have long bedeviled forecasts. Just how clouds/water vapor will interact ahead, contributing to heating – or not - from greenhouse gases (GHGs) is vital. Potentially, clouds *may* mean Earth gets much hotter still. Or, it may mean a bit less a blazing cauldron, than what models to this point have predicted.

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

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

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

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

Moving instead to climate and Finance or equities - there's positive developments too, like growth in the size and scale of clean energy company stocks. Markets & public policy have advanced liker in global new energy innovation. Firms here now much larger than they were at turn of millennium (2 decades ago), or even a decade ago. Companies in clean/new energy have oft seen much greater market capitalizations. In an applied side-note, a market consultation done in Feb. 2022 resulted in a few changes to NEX Guidelines, March 2022. Average daily value traded (ADTV) floor generally grew to USD 1 million for Past 90 days, and to USD 750k for existing components; screens included for UN Global Compact Principles. These are noted here for the NEX, https://cleanenergyindex.com/about_nex.php

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Indeed let's turn now to stocks & clean energy and perhaps reasons 2022 opened so rough for many equities. Most broadly, investment banks were already in 2021 predicting sparse profits for all 2022. Earning targets for S&P500 firms foresaw 'lower-highs, lower-lows'. Take newish S&P500 component, Tesla: its huge market cap among S&P's biggest as it entered the 500 (funny enough maybe hesitancy over reputational risk) yet it set a tone for 2022 as its brilliant head aptly & rightly expressed concerns over supply chains risks for a whole coming year.

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

Partly, valuations began 2022 very high. A late 2021 S&P500 price/earnings (PE) ratio of 27.2 maybe meant more likelihood of falls, room to 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 future earnings will surely justify such a very rich PE of 27, was maybe a fool's errand.

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

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

Another broad headwind start 2022: rising interest rates that can, will kill equity themes. Not long-ago investors got near Zero percent for bonds - over years. So, there'd been demand for higher-risk themes, better-returns (at times) in volatile themes like here. But if lower-risk alternatives could boast respectable rates - then Treasuries, corporate/government bonds could find a flood of available capital looking for a smart place to call home. Real rates 2014-2018 had meant inflation-adjusted 10-year Treasuries yielded an expected +1.0%. They fell in Covid emergency to eyebrow-raising *negative -1%*. PEs shot up from a common 21 – to a high 27. CAPE went from 20s – to a (wow) t40. On rate hikes reverting to mean can be very bearish for stocks, especially like those here. All maybe fundamental points in early 2022.

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

Compelling forces had pushed many themes not only in green energy - down hard early 2022: *Inflation was much worse than Fed initially recognized; so *Rising Interest Rates all 2022 hammered themes reliant on future income; and *Capital Shifted to Value & risk-off; hence *Re-Priced Risk, with External issues like *war in Europe, tensions in China/Taiwan. In sum an *End of Liquidity and of easy money too sent clean plummeting. For a theme as volatile, as risky, as dependent on future earnings as ECO & NEX, it was all a poisonous setting.

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

All dour. Changing topics to lighten the mood, some coincidences can be seen *looking back in time, only*. For example ECO had hit a prior high on Dec. 26, 2007 at 297 (297.05 close) – just coincidentally its next intraday peak, Feb. 10, 2021 proved near-ish that: 287 (286.89). Or passive ECO going up/down last 2 years twice plummeted by a strangely not-imprecise ½ to nadir low in both 2020 & 2021. Thus, calendar 2020, it fell by nearly neat -50% going from a 94 intraday high (92.53 close) – down to 47 low (47.37 close). Afterwards it rose 6-fold from a 2020 nadir to February top. In 2021 it again fell unambiguously -50% from a peak 287 high (286.89 intraday) in February – down ½ to a 142 low close (142.39 intraday) late in 2021. Again, just by chance, looking *back* only at rich data. Oddly 2 non-imprecise consecutive declines both near 'perfect' -50%. Or for instance, in Q1 2022 it hit about the same bottom on 3 times near 103: on 28 January; 24 February; 28 April, and 2 May.

Just spotting coincidences in a data rich past, meaningless looking forward. Does though point out how volatile ECO is, like down -50% or more even in big gains years! Take say non-calendar 12 months from end Q1 2021 – to end Q1 2022. That Q2-Q4 was oft in 150-200 band; from a peak April 1, 2021 at 211 (211.09 intraday) – followed by 12 months to low nadir on Jan. 27th & Feb 23rd both at 107 close and 102 low intraday. (Come to think of it, funny how 2 similar lows were both not far off neat -50% from 211 – to 107 again)! Invasion of Ukraine sparked brief +40% rally in clean energy, before falling back near 84. But to so cherry-pick from data is NOT predictive. Only bit of fun looking back, coincidences playing with ample past data. As Mark Twain had humorously, aptly put it, "Lies, Damn Lies, and Statistics". Playing with ample passive data is really more a parlor trick, no real help when looking forward.

Hence one mustn't read too much into it other than to confirm great volatility here oft down! Like Jan. 2022 alone, ECO fell a near neat -30% in a blow-out selling month, yet no predictions from ephemera. Might only lend a bit of attention to 'enter on dips' – or more 'sell on rips'! Lastly just for giggles, let's say *if* year 2022's high point remains a 154 peak (154.41 intraday) seen early 1st week, Jan. 4, 2022 - then a hypothetical 3rd calendar year low ½ down - could then (playing here) - take it to a nadir of 77 in 2022. Any realistic nadir is possible of course – and all the maths indicate it's very, very unlikely to be that figure! That was a level seen Summer 2020 for a bearish look – yet may go lower still – say on global events like larger war, soaring inflation, and recession. Maybe interesting to see where that 2022 low nadir, in fact falls. Highly unlikely it's to be near 77! Simply No Telling, looking ahead. (Interestingly, we wrote this above paragraph end of January 2022; and on May 12, 2022 ECO hit intraday low of 84.34 – so that 84 was not very far off a nadir of 77 mentioned for 2022)!!

From 2021 through mid-2022

Big events overshadowed 1H 2022 as Eastern Europe invasion impacted the world. War not seen for a generation; once Russia moved beyond Crimea/Donbass, 'all hell broke loose'. In a few weeks, ECO Index at first jumped +40% from an intraday low of 101.64 on Feb. 24th - cusp of Invasion – to 141.82 on March 30th, then fell back. That up volatility was maybe on re-assessments 'round the world – especially in Europe, for a speedier transition to renewable alternatives found here. On energy security too: 13 European nations had depended on Russia for >1/3rd their oil. Then ECO fell back to 95, clean stymied by supply chain chaos.

Among global intelligence assets who'd been watching weeks of run-up to war, there were warnings. To wit 1-2 months prior to invading Ukraine, Russia moved 3 large LNG ships to its geopolitically vital, yet stranded Kalingrad Oblast on Baltic Sea. Natural gas piped from Russia ally Belarus/or Russia first must go via Lithuania to reach Kalingrad territory – that prevented Russia from possibly shutting off gas to Lithuania. So, by re-positioning unusually her 3 ships to Kalingrad, it gave Russia a new option to potentially sever all gas to Lithuania, should it maybe wish to do so. This could give Kalingrad a new 4-5 weeks+ of needed LNG gas.

A militarily-vital, Kalingrad Oblast outpost lets Russia alter NATO power in its own backyard. So, it was notable when Gazprom sent 2 LNG carriers, Energy Integrity & Velikiy Novgorod – and a big 3rd vessel converting LNG to gas. That Marshal Vasilevskiy built 2019 was named for an Officer who'd led Soviet recapture of Kalingrad in WWII; in Jan. 2022 it fit well there. But before then it was being used instead to carry LNG from Russia's Far North, to Asia. Integrity then had to travel 2x that distance to go from Cameroon to Kalingrad, instead of more typical destinations. Much Cameroonian gas had been sent to China in the last years (only 2 of 58 shipments went to Europe region, both of those to Turkey) so it was all quite unusual. Having moved its 3 LNG ships to Kalingrad, before a potential invasion, meant if conflict goes beyond Ukraine, intentionally or not, Russia maybe could keep a strategic Kalingrad outpost 4x the size of Manhattan, militarily significant, energized with gas supply for weeks.

But that narrative got flipped on its head post-invasion. Lithuania instead, halted buying piped Russian gas! Vilnius instead via floating regasification vessel could import LNG from Qatar, Norway, US. Replace the 1/4th of gas it got from Russia in 2021. Italy, Netherlands, Estonia could do same by LNG regas vessels. Germany had a problem; it needed 90 billion cubic meters (bcm)/year – far more than 2-3 bcm for Lithuania. Yet, floating LNG re-gasifiers were suddenly all the rage – a chess game played with re-gas meant Russia no longer held all the cards. Lithuania could even ban trains from carrying sanctioned goods, Russia to Kalingrad!

Germany at last began addressing long overreliance on cheap, dirty, piped Russian fossil gas. Both Germany & Russia earlier promised Nord Stream I or II would be solely commercial – not political leverage – yet war put paid to that, proving the opposite! So, Germany drafted plans to bring forward 15 years its 100% renewables target to 2035. In a shift Germany abruptly started planning so from 2022, solar capacity might grow by 20 GW/year latter this decade. Onshore wind might grow 10 GW/year. Offshore wind capacity, from scratch, slated to hit 30 GW by 2030, 70 GW by 2045. Germany's Green Party by 2022 had a voice in government, yet could see 2 big LNG terminals built fast - if it meant hitting the key aim: 100% renewables. Plans had for all of its nuclear to be shut, coal taken to zero; but with no piped Russian gas, something fast was needed to fill a gap as vast renewables got built. So attention ironically went to fast-filling its low-gas storage, from <30% to >80%; to new LNG terminals (afterwards used for green H2) 'til renewables can fully take over. While the issue in theory was fossil fuels dependence, the facts in 2022 pointed to a pressing need fast for oil and gas.

Thus real-world, on the ground, fossil oil & gas prices jumped 2021/1H 2022, like nothing in recent memory. Clean energy stocks, longest & best captured by ECO & global NEX, were here far down as seen in this chart – and fossils far at the top, 2021 - through late-June 2022. Interestingly a new situation thus presented itself in 6 Quarters up to 1H 2022: unlike a prior past 5 years, or prior 10 years etc, here instead, ECO & NEX *were clearly at bottom. Down by* -50% & -40%. Middle was a Dow, S&P500, world theme, at nil. At top oil & gas were up near +140%. Oh my, what reversal this was from what we'd long seen the prior decade!

Source: finance.yahoo.com

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

Hence 2021 to mid-2022, clean fell hard as passively reflected in our themes dropping steeply – back to where they'd been 2019. Meanwhile, fossils jumped in a (seeming) energy boom characterized by much volatility. It showed too, energy prices worldwide still are dominated by fossils: oil, gas, coal – producing much turmoil seen across a volatile-energy-space.

Overall, energy prices tend to reflect the 1 fuel that's most crucial to supply – the key to grid stability. Rather like how income tax rate reflects highest marginal rate paid on the last dollar earned. Here, natural gas was/is still key, so as its price spiked up – energy costs did too overall. Even US electricity still made from coal rose +22% in sympathy in 2021. More energy crises will doubtless recur. Even so if renewables (a minority of power supplied) rise in costs a bit - or hold steady, or likely decline, as we'll see pages ahead. In sum, fossil prices *rose* hard 2021/1H 2022 – after long deep lows and predictably so in today's energy story.

Note that Past is Prologue: such spike was only *after* fossils had plunged 2020. Only *after* US coal production had hit 50-year lows, with 151 mines closed or idled. Only after oil hit historic lows 2020 on Demand Collapse. Oil industry needs oil at least in $60s, so oil down near 'just' $50 in 2020 had punished shale producers, $40 oil is misery ahead for producers, countries. Equities are inherently forward-looking, so oil in 2020 hadn't been attractive for investment. Only after first its big supply cuts by shuts downs + then a renewed demand discussed ahead - did oil rise to $110/barrel on supply curtailments. And if Russia occupies Ukraine for a time, it might be no surprise to see say, a Nord I or Druzhba pipeline sabotaged, like a Verhunka explosion near Luhansk. At any rate spiking oil/gas prices seen 2022 and after, may once again make renewable alternatives relatively more attractive ahead.

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

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

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

Change is afoot. Sometimes at swifter pace than expected. Maybe an EV + battery + solar firm writes software to allow it to harness deployed PV to sell power directly – competing with Utilities. Maybe a spiff electric aircraft firm challenges past hegemony of fossil fuels, for more efficient air transport. Or cleaner power for ships. Perhaps batteries made for less-cost & on lower-carbon lithium, sodium, graphite. 'Greener' rare Earths in wind, EVs. Likely, recycled batteries, improving anodes/cathodes, circular economies. But given that CO_2 levels already in 2022 were over 420+ ppm and growing fast, there's no realistic possibility of holding global heating to 1.5 C aims, let alone 2 degrees C. Climate emergency seems certain ahead.

Thus, all the above may be welcome & necessary - yet nowhere near fast enough. With some irony, Russia's attacking Ukraine, and threat to Eastern Europe – may mean a new 'Marshall Plan for Energy'. Building wind, green hydrogen, solar; though, briefly(!?!) means LNG terminals and nuclear power – a compromise even Germany's Greens accepted. Of course, all that oil, natural gas, and coal in particular, was acutely a climate opportunity, lost.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Physics & chemistry give us a total carbon budget, for how much emissions can yet be spewed. If our climate crisis is to not go past 1.5 degrees C heating, then total future allowable human CO_2 emissions are 400 billion – 450 billion tonnes. Yet on current trends, we'll pass that max carbon release ceiling 'speed limit' in just 10 years, 2030. It's laughable to think we can go 10 more years – then switch off all CO_2 emissions at once. Over a century ago, Svante Arrhenius (with Arvid Hogbom) had determined How, Why, a then-forecasted 3 degrees C rise in global temperatures might result from each 3/2 rise in CO_2 (in a ratio since refined, but principle is roughly same – along with more heating at poles than equator). Linear increases for the first, meant by power law for the second; rising temperatures vary as a logarithm of CO_2.

As for BBB, end of 2021 brought it to a head. Either more compromise – or likely total failure. Senate Parliamentarian would have to agree all items spending-related, a 'Byrd Bath'. But before that, scoring/spending had to be looked at carefully by that 1 'moderate' Senator – whose vote was necessary. Things didn't look good at all. To cut big spending estimates, some Programs were simply re-written pared back from 10 years – to 3-year sunset (or even 1 year) hoping a future Congress renews. It reduced top-line costs, but those weren't real cost reductions that 1 Senator had demanded. Fearing social spending was stoking inflation, this defanged BBB also still would hurt fossils so dear to that 1 Senator's heart. Thus, it looked like that 1 smaller bill only - already passed, would be all there was 2021, maybe 2022.

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

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

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

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

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

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

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

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

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

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

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

Another "P' maybe relevant, but less susceptible to analysis, is 'Politics'. Maybe a factor for ECO hovering 150 – 200 in Q2 - Q4 2021 on whether BBB might pass. That bill didn't, so on BBB's 'death', new inflation, rising interest rates, Fed tapering – things did fall <100 hard, fast. In Q1 2022 with no floor like a BBB to keep the Index from falling – seeing it fall to low 80s in Q2 was no great surprise. There was an expiry date on hopes for BBB passage. California/Florida in 2021 then proposed cutting support for home solar, tariffs then hit solar making Asian panels scarce - and a floor that perhaps once held things up, faded fast.

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

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

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

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

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

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

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

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

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

Russia's gas profits grew. But another rationale may have been at play. It's been suggested perhaps that export shortfall 2021 by Russia to spot markets was to help it win needed OK for Russia's Nord Stream 2 pipeline to Germany. Europeans for their part needed uncontracted, cheap spot Russian gas. Alternatives were more gas from Nordics (in decline) – or importing 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 2021 – and 2022. Especially on a colder than usual winter, say 2023 or 2024. If sparse breezes so less wind power, nukes down for maintenance, coal shuttered by emissions permits – Germany aggressively targeting 80%+ renewables by 2030 – it can get very tight.

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

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

Past-simmering European fears of over-reliance on Russian gas, once were waved away by how bloody cheap it was at 40% of Europe's gas, more so Germany. Until that blew up in peoples' faces. Literally. Approving Nord Stream 2 was maybe an intent in Russia's cuts, to build support for pipeline; but paradigms shifted fast on fears Russia may invade Ukraine – then faster when it did so 2022. Just before that China, Japan, and S. Korea buying LNG had pushed prices >$15/per million BTUs. US gas rose too as all pricing is interconnected, from $2 mm/BTUs - to over >$5 – unheard of in shale era. Europe Market Winter gas demand competes vs JKM (Japan-Korea Market) – and geopolitical urgency meant Europe needed to fill its gas storage to >30% in 2022. That, and mild early month of 2022 helped. But all became much scarier on war. And to come, maybe a cold winter in 2023, 2024, or 2025.

Clearly, 2022 had thrust Europe's debilitating over-reliance on Russian gas in a sobering light. It underscored an immediate need for More Renewables fast, from 2023. GWs *more* solar/wind - plus long-term battery storage all needed for firm power. The lack of extant LNG gas infrastructure & storage vexed too – because clean hadn't yet grown to be big enough. In particular as Europe tries to wean itself off coal, reduce ahead gas & nukes (though latter 2 may persist a bit to let grow renewables faster) - wind & solar 2020s are at awkward stage. Growing yes, but not yet big enough to be Hero. In 2020 renewables made up only around 20% of European electricity, so not near enough early 2020s, to overcome gas' failures, yet.

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

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

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

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

After ECO/NEX gains in 2020, it was maybe 'unsurprising' to see big falls 2021/2022. From peaky February 2021, it was then unknown of course if clean energy (so ECO) might fall in a harsh backslash shaped "\" down all 2021 – maybe in 2022 etc too? Or perhaps an "L" shape: down then sideways; or given January rise an inverted "V" with ^ right leg down much further than short increase on left. For a few reasons 2021 and then 2022 could go on suffering headwinds: *No early Clarity on if big BBB $550B reconciliation passes or may die; *China's 5-year plan and its-greater energy demand could push coal use up through 2025, and so *Europe seeing a pause in green by US & China might refrain from hoped-for greater, more aggressive actions in 2020s. All despite global (empty) words about priority of climate.

To those 3 worries, 2 more were *Underlying green stocks had hit high P/E multiples 2021, plus *Inflation/Taper Risk. Thus perhaps that Feb. 2021 peak was soft ceiling? Hope for BBB succor if one's felt a bill would pass; Billions more *might* better justify rich Price targets ("P" in P/Es). But 2021 was maybe fated as an interregnum, a pause between Q1 hopes - & clarity on BBB's fate and on "E" Earnings. Plus, maybe big cumulative years of rising rates after a Fed had let things run (too) hot – with Tapering all 2022. Thus, tech stocks had shifted fast towards lowered valuations /poorer expectations throughout falling 2021 on Inflation discount of future values. Capital, unsurprisingly, went reflexively 2021/2022 from growth - to value themes (so not future-oriented clean energy!). Though markets may get re-accustomed possibly to higher, yet historically more typical non-zero interest rates like seen in past.

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

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

In sum 2021 was partly interregnum: a rough patch down, rife with uncertainty. It had opened near a peak, after this theme had spiked on hope following Presidential results and a surprise 2 seat gain by his Party. Fueled by hopes of BBB passing – so when it did not, the rest of year was weighed down by high P/Es, steepening inflation fears, uncertainty over if anything BBB could pass in 2021 – then the certainty it had failed. An air pocket 2021 Q2-Q4 'twixt election's outcome/hopes – then tougher clarity. Frankly some skepticism is always helpful, like on how truly likely it is that big green energy tax subsidies pass 2022 or after (perhaps less likely 2023 or 2024 unless together with fossils sand nuclear). Without doubt passive ECO/NEX could fall yet more ahead; a plummet in ECO to low 80s in Q2 2022 was understandable. If P/Es are a metric (useful) & Q1 2021 figures had been very high, the chances of tax credits ahead for wind/hydrogen/solar/EVs to justify such P/Es can be impactful – whether down or up.

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

Solar & wind clearly are capable of it; *these 2 have the potential to power the entire world* - many-fold over. On today's technology & on available locations, these 2 alone could power the Planet more than 100x over! They could generate 6,700 Petawatt/hours (PWh) of clean electricity (1 Petawatt/hour = 1 million Megawatt/hours, or 1 megawatt for 1 million hours). Despite vast opportunity, the world 2019 only captured 0.7 PWh solar power, and 1.4 PWh of wind. Even though these free winds & sunlight could meet *all our power needs.* Forever.

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

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

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

Western Europe wind & solar were growing, with coal cut back – until war in 2022 revived all its dirty fossils! So natural gas can be reduced there - but not quite yet! Instead, gas shortages had made all of Europe's power prices jump. Yet things change. Especially as gas portrayed as a 'transition fuel' may be last pariah fossil; as socially unacceptable one day as coal or cigarettes. Europe's Climate Law may mean border tax on imported CO_2-laden products. Clean energy should win out, EVs on a cusp, but keen need to *heat* buildings had no fast green fix early 2020s. Replacing gas boilers with heat pumps, is costly. Renewable natural gas (RNG) blended with green hydrogen (H_2) still years away. As is running ships & aircraft on green H_2, or ammonia (toxic, so carefully) or methanol - greener fuels ahead. Yet all that is clean is vital – but is only one-side of climate coin. Other side has got to be moves especially by China to cut coal/CO_2/methane/greenhouse gases. Clean gains will be for naught if the latter don't drop to near nothing. Still huge populations in China, India, & in Africa all have much economic & energy development ahead, that will likely be driven by coal.

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

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

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

There's a Huge Gap between the *promised* cuts to 2030, so the 'blah, blah, blah' - vs. reality. These data show that fast-*growing* CO_2 & GHG emissions worldwide in 2022/2023/2024 etc are led by coal. With no real action. Meanwhile cuts pledged 'round the world' are failing spectacularly, and themselves are still not near enough, to make a real difference.

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

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

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

So, overall world electricity production pie is growing; yet a thing of it, is coal's growing too. Coal is vexing from mining to waste disposal, yet more is being built on new financing. Thus, even as renewables' share of electricity grows overall, total greenhouse gas emissions have continued growing as well. Worthy of note is there's Not been a single year, yet, of *falling* global coal capacity… ever! Says nothing of coal uses in other high heat industrial processes like making steel, aluminum, cement. Nor of expansion due to war in 2022. Nor embedded CO_2 in products exported from China etc like out to US, to Europe, and worldwide.

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

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

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

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

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

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

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

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

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

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

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

The Good

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

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

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

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

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

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

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

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

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

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

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

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

The Bad

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

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

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

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

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

The Ugly

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

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

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

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

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

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

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

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

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

This last issue is so significant, it stands out as maybe *sui generis* in global crises. Potentially, heat and climate risk may devastate societies, humanity. Possibly is an existential threat. Not yet well understood, with tipping points and feedbacks, maybe 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 aren't near half as bad, nor as extreme, as non-scientific laypersons may paint them.

Not so climate. Singularly researchers are now shouting. Maybe it's conservative to heed – foolish to reject that. It may one day hit us not in spirit of bravely looking towards solutions; nor boldly advancing our better natures. Instead, may mean hastily saving what little may be saved: remember Summers lasting only 3 months? Winters? Cooling at night? Farther out, can we recall living Coral Reefs, sandy beaches? How to prevent that as a future we bequeath. Especially when sustainable no regrets paths make us healthier, happier, richer, safer, secure. Not cost spiraling blood & treasure, recurring diseases, pandemics, despair. Listening to the sea means intentionally embracing ahead wisdom: Prevention Rather than Cure.

NEX/ECO/H2X/WNX may help in looking to capture & track *maybe* sustainable paths. Decarbonizing, electrifying everything, low-carbon fuels, efficient heat & cool, green industry. Many ideas yet to emerge for particular advantage in themes, regions. Consider as ideas for instance, 14 of the most volatile, upside constituents in NEX early 2021; themes most up over past 52-weeks to early 2021, hence 14 biggest gainers seen then.

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

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

So 2019 & 2020 saw big gains here - followed no surprise, by big falls in ECO/NEX 2021 & 2022. They fell more mid-2022 when ECO went down to low 80s – and could drop much farther yet! Should draft climate bills post-2022 again die – or on a stock crash, rising rates, inflation, pandemic, war, massive power blackouts etc etc - these themes could plummet farther and swiftly so. Outliers may happen too like US Debt default, terrorism, war, pandemics, stock markets crash, etc; once-high-fliers can be more seriously hit.

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

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

Past equity gains 2019/2020 *in no way* foreshadow gains ahead - as seen 2021. Indeed such big rises may auger sharper falls later. Regression to mean, nothing's certain. Or, they *may* point towards better paths. Once upon a time fossils magnified human power many-fold. Yet we can't let sympathy for jobs in once-magic fossils now waning - mean what's bad for fading coal, oil, gas - is bad for humanity. Wiser, to set out for a once-more stable climate. Towards the broader sunlit uplands, with carbon back down near 300 ppm. This choice is seminal.

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

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

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

Perhaps foreshadowing, deadly disaster hit Texas 2021 when a freeze took down its electrical grid. That US blackout showcased too battles now going on in messaging. What will it take to build a stronger, more reliable grid going forward? More gas and nuclear – or more renewables and storage? Natural gas has long been dominant – yet lately it is finding itself at times a bit on back heels. Case in point is that amid that crisis: an argument was hastily put out during this blackout that it was due to clean energy, due to its wind turbines freezing! Whether promoted by uninformed, or politically motivated opponents – that tale was widely circulated especially by certain media outlets. An image was spread of a helicopter & vat above a frozen wind turbine – claiming it a recent photo of flailing Texas attempts to use chemicals to unfreeze turbines. They claimed it proof wind alone was ***main / or only cause*** of terrible grid outages right then in that freezing Winter February 2021 in Texas.

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

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

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

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

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

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

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

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

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

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

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

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

So the cold wasn't at fault, *per se*. Plenty of gas infrastructure works deeper-freezing places, because facilities were built with freezes in mind. Winterizing just 1 well, might cost $100K. As only 0.06% of annual Texas gas production may freeze off in a year, not all of it needs to be winterized. There's 100,000 Permian Basin wells, 250,000 active in the State; many just marginal of little consequence. Hence there needs to be some balancing. Or, the State could continue being fully hands-off, like before (with blackout risk/consequences).

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

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

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

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

Hence perhaps 'Climate Change', or 'Global Warming' are too benign for possible calamity. Better, might be 'Climate Crisis', or 'Global Heating', or even Global Weirding for decades and centuries plus of blazing Planet. An uninhabitable equator, yet temps not too far different from 'hot Poles'. Getting there may not be slow, or incremental. Maybe not just a linear, pleasant, 'nice' warming along the way, with but gradual and gentle changes only.

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

So more solar, wind, & storing clean electricity is needed. Making electricity cheaper on renewables & storage is where we'll need to focus and grow. It can be done in myriad ways, but ***more renewables, storage, & transmission*** is where attention ought be turning.

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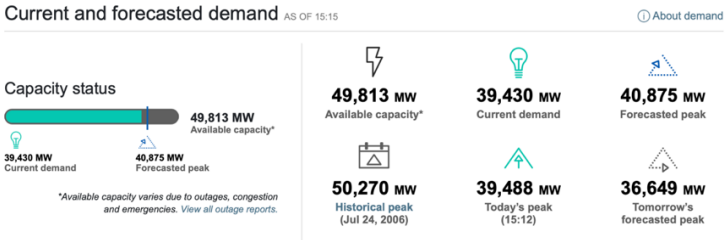
18 months later in June 2022 heatwave, Texas that spouts anti-renewables rhetoric – while thankfully fast-growing wind/solar – was saved thanks to its renewables. Amid record heat, a record 75 GWs(!) demand, its wind/solar generated 27 GWs, meeting nearly 40% of demand! While keeping electricity prices much cheaper than they would be for gas & coal-fired power. Over 2021 zero-carbon power (including nuclear) made 38% there - near a 42% from gas.

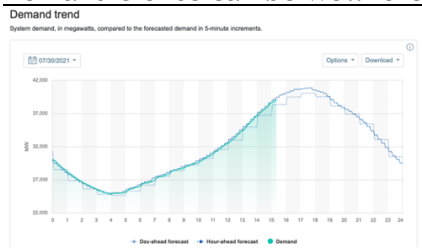
Yet grids there – and everywhere are exposed. And an attack on grid hardware, or cyberattack on software could confound attempts to keep the grid stable just above a critical 59.3 hertz. If the grid goes down, a 'black start' might be needed – and whether it can be done in 'just' a week is unknown. So besides cold/heat, we all face too an aged and exposed grid. In sum looking forward, more energy storage along with more renewables and better transmission, can help to decentralize the grid. We fundamentally need better grid resilience, fast.

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



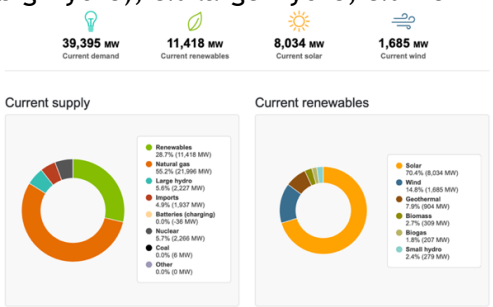
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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



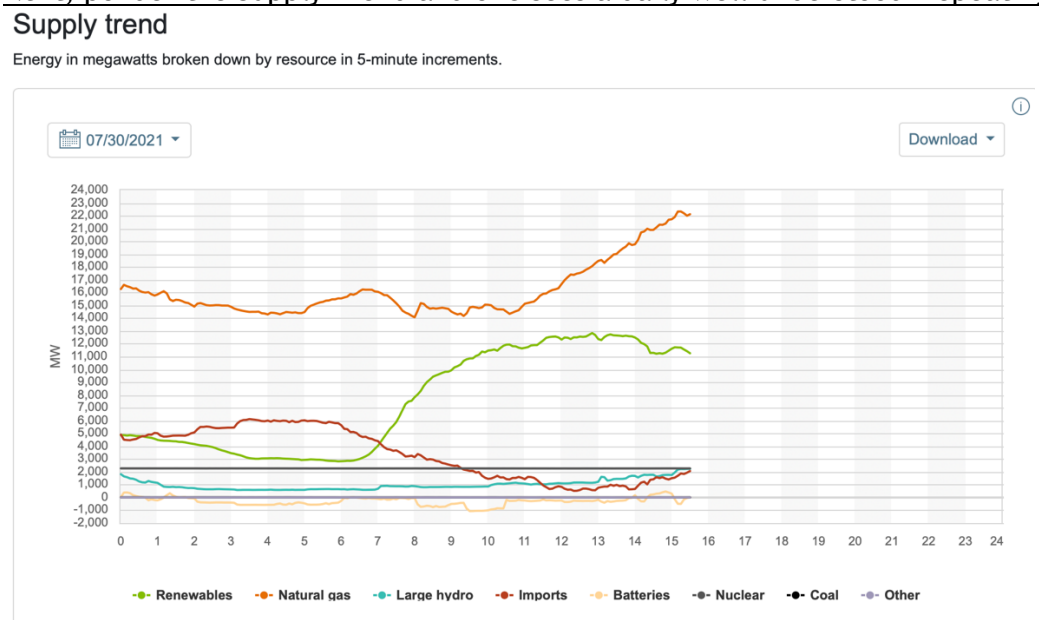
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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



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

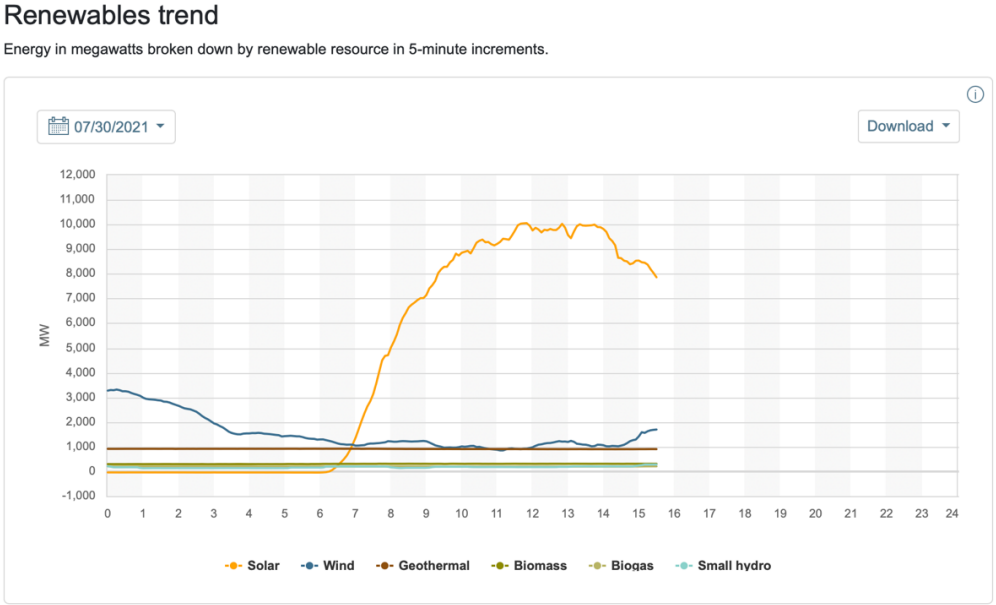
Next, ponder the Supply Trend and one sees a daily well-understood 'repeating issue':



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

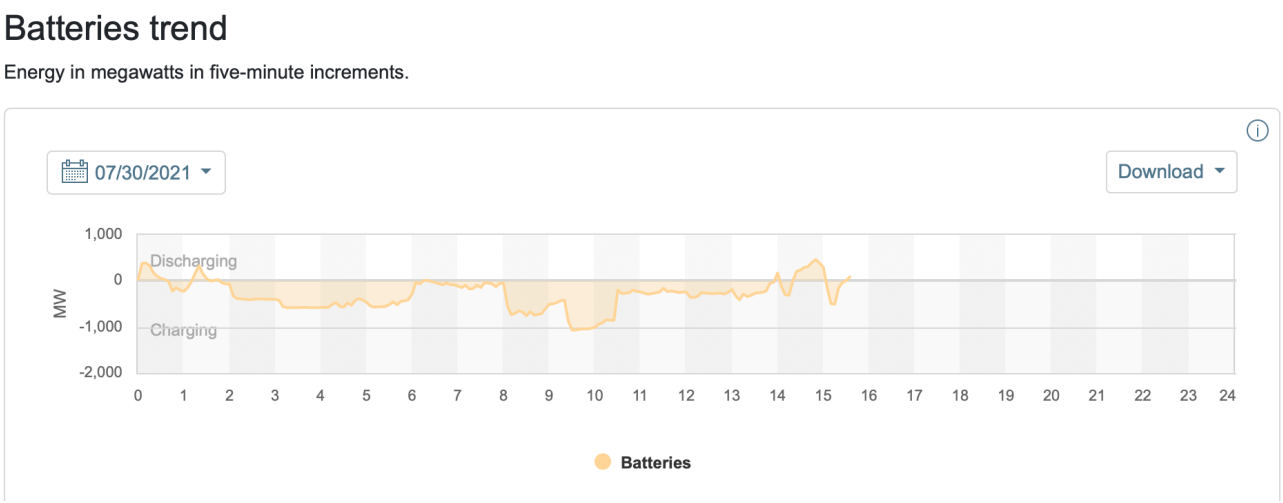
Solar power making up most of renewables' contribution in green above, is about to drop hard, as sun begins to set. Of course, eminently forecastable! So, this 11,000 MW from solar at 3 pm above used to help meet 40,000 MW of demand – will fall very hard. Firm, dispatchable natural gas is generating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

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



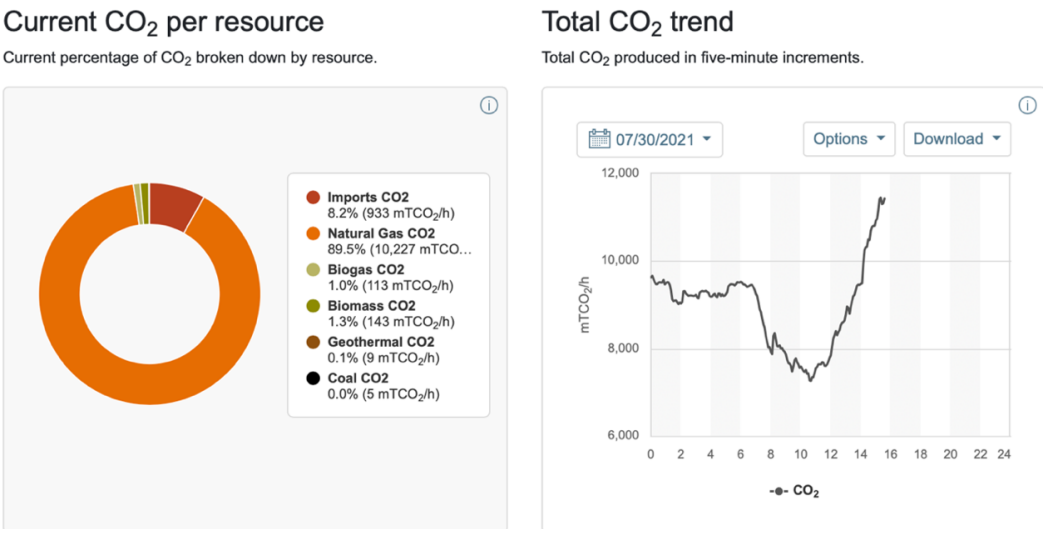
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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

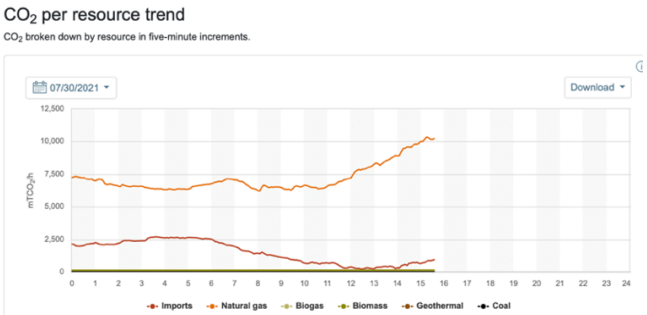


Source: CAISO.com Today's Outlook – On July 30, 2021 at approximately 3:30 p.m.

Insufficient storage early 2020's means we suffer ongoing dependence on fossils. Mainly on natural gas in California, Texas, much of Europe etc – also producing huge carbon emissions. Big hydro can't be scaled up; indeed big reservoirs like Lake Powell, Lake Mead may become 'dead pools'. Natural gas may not be as odious as CO_2 from coal per ton, but the methane leaks badly vex Earth and climate nonetheless. We know *measured* CO_2 is an issue – unmeasured methane leaks in pipelines make it worse. Potent GHGs include methane.



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



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

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

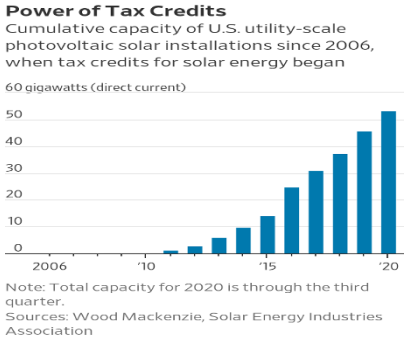
It gets worse. California grid issues early 2020s included that in a Flex Alert, CO_2 Emissions could spike to get Supply as high as possible, over >50,000 MW due to demand. Natural gas+ peaker plants can max at 100%, no maintenance, much power imported from out of State. Demand in a foreseeable Heat Wave eg seen Sept. 5, 2020 had outstripped capacity. **B**lackouts threatened. California's Demand History has shown both need for far more Renewables + for much more Batteries/Storage to grow far faster, given huge efficiency strides already made. And California is also ever-adding more electric vehicles. That swiftly means more demand ahead – while shuttering its lone, older technology 2nd generation nuclear plant. That closure if done means a big 5% loss of firm generating capacity very soon. Blackouts unsurprising.

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

In 2022 war complicated this picture since energy prices are determined globally. As Europe scrambled to avoid importing natural gas from Russia like its Arctic LNG project, it was paying (much) higher spot prices for non-Russian LNG gas - which immediately meant less for India, Pakistan on suddenly higher energy prices. They in turn, turned to burning more coal, oil. And all threatened by cold winters, hot summers 2023, 2024 etc, given gas storage levels were so insufficient and time it takes to build LNG terminals, which goes out to mid-decade.

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

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



Sources: Wood McKenzie & SEIA

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

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

Tax credits are important and change is possible. Maybe, extend solar ITC credits to 10 years at 30% plus storage. Domestic content over >55% rules can go down to 40%. Near-term, WRO and anti-circumvention dominated 'in the weeds' issues – since over 90% of global solar wafer capacity is in China; so it's important to major buyers of PV - whether panels 'built' in China - or Vietnam, Malaysia etc that there's tariff certainty. Efforts can increase both panel supply + projects installations. Ability to also use PTC (besides ITC) in solar helpful. For Wind, PTC extended 30% for 10 years, so better than annual threats of termination; direct pay option for parties not able to avail of Tax Credits. PTC again 2.5 cents/kWh + a new base rate. Domestic content requirements, greater tax benefits. Maybe diverse past tax credit programs replaced by just 3 for clean power, transportation fuels, efficiency. Or perhaps possible: assistance for more rural jobs especially in places where coal has been shuttered. Could be top line priorities in new energy policy (with maybe line items for West Virginia?!).

Last Few Years … and Indexes

ECO/NEX show a non-correlation vs fossil energy. What an example of diversification! There have been robust non-similarities: sometimes clean (alone) oft gained – or clean has often dropped hard – with dirty energy well up like 2021/2022! Themes are all *energy* – yet clean has marched to a pretty distinctly different drummer versus coal, oil, and natural gas.

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

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

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

Drilling deeper let's consider US oil & gas behemoth Exxon. In 2020 Dow Jones announced it was dropping Exxon from its leading 30-stock Dow basket. Why? Apple was splitting 4-1, and price-weighted Dow needed new component/s to better keep up with other baskets. (Dow had aizably lagged in performance then). New representation was chosen - but wasn't coming from dirty energy oil. Instead, they had added in 2020, 3 tech-heavy names. Dow Industrials dropped Exxon that various incarnations had been in since 1928; that once long-serving Dow component, was no more. Only Chevron in oil, stayed. (Due to prior decade perhaps as dirty energy fell – vs. big coming rise 2021/2022; indeed, energy became a bigger slice of an S&P500 after 9 of 11 sectors had fallen, while energy gained +14.3% in eg Sept 2021 - so in retrospect they maybe should have kept in dirty fossils – which really jumped 2021 and 2022).

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

Real-world Returns for clean energy in the 2018-2020 period up by hundreds of percent, are hardly 'non-pecuniary'! In that period, clean was up +300% (ECO) - while traditional Indexes were up by more modest +85% (Nasdaq), +40% (S&P500), +25% (Dow). And fossils, oil and natural gas were then *Down* some -60% - though they soon would spike hard up 2021/2022. Interestingly fossils AND clean energy both were non-correlating vs broad Indexes last decade. Thus, maybe was No surprise at all to see billions of dollars flowing then into ESG, breaking records. ESG assets in 2020 were more than 2x that of 2019, reached $246 billion early 2021. Q1 2021 inflows reached $55 billion, vs. $41 billion in Q1 2020. Assets in ETFs/ETPs topped $6 Trillion for a first-time in 2021. As ESG in particular grows, it will be very volatile at times, often down. And yet attention to climate (IB 2015-1) which is real, not long ago fell under unworthy attack in 2018-2020, reportedly by fossil interests and skeptics under ERISA.

In sum if proposed rules during 2018-2020 had sought to prevent a look at climate solutions, deemed 'non-pecuniary', that was a bit curious given these glaring Performance facts:

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

Source: finance.yahoo.com

The period March 2020 to March 2021, ECO had ranged from 46 to 286, rising 6-fold. Global NEX had ranged 150 to 630, up 4-fold. Like nothing in old energy. As was said then of clean equity's gains in 2020 by a brilliant man, "How strange…. Well, back to work". Doubtless future crashes like in 2021/2022 lay ahead. Yet in 2021 China aimed to go from 11% solar/wind power generation – to 16% by 2025. Wind developers jumped then on soon-expiring subsidies – they installed 72 GW of wind in 2020, 3x that of 2019 (solar up 60%). But because that government's fund for subsidies early in 2021 reached a cumulative 320 Billion yuan (USD $50 Billion) shortfall, its government had briefly proposed writing-off some owed sums. In response a big wind developer's stock fell -30% over 4 days, soon rebounding after once that proposal was dropped. Regardless of sure drops to come, ongoing volatility, decarbonization has begun to figure in with good reason, although In 2022 supply chains vexed globally.

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

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

This 'ain't our first Rodeo' seeing US fall badly behind, when it needn't have. We saw solar manufacturing decamp too from Japan/US/Germany – going to China 2 decades ago - and to cheaper Vietnam, Malaysia, Thailand. By 2020, 3 biggest PV makers were based in China (with PV on those economics, made by a very few tiny US firms). Being overtaken is a problem seemingly now happening again in crucial batteries. Such needn't occur. But the US in 2021 had only 3 big battery factories. Tesla Gigafactories could point a way, yet we may see say, only 10 big battery factories in the US in 2030. There should be many more. And that term '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 for 140 big battery factories! Europe ramping too looks to have 17 big factories. On projected US electric vehicle demand, there ought to be 20+ US battery factories in 2030. Not inspiring that in 2021, there was only half that, or 10 – on track. To be up & running say by 2026, such factories should already have been in their initial planning back in 2021, with construction having started in 2023.

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

As said by Mr. Nikola Tesla regarding later amazing inventions, like 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, rotating fields exhibited by rare earths are awesome, making possible unmatched blue-sky advances. Like batteries needing say lithium, or even a basic iron, so too do clean energy's applied technologies especially need rare earths for their magic.

Yet 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 made from hot briny waters with zero-carbon geothermal power is better than water-intensive evaporative ponds & sulfur. So too avoiding mining bankruptcies that upend cleanup. Ecologically more sensitive places surely must be protected from all mining. Meanwhile, some places are more amenable. And US states like West Virginia could welcome sourcing minerals from their ample disturbed sites, extant waste piles and old mines – creating good jobs.

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

Subsidies are given to fossil fuels: that's unlikely to change soon. A Report found $20 billion was given to oil, gas, coal 2015/2016; more subsidies going there than for clean renewables. Oil & gas can write-off its expenses like intangible drilling costs. Benefits from lost royalties in deep-water drilling. Master Limited Partnerships for fossils. While the G20 has advocated eliminating ALL dirty energy subsidies, and their removal could cut CO_2 emissions 0.5 to 2.0 gigatons or like removing to 2030 all annual emissions from Japan, it's very unlikely to change. An initial Covid relief bill initially had $8 billion tax breaks for 77 fossil firms. More was then given fossils following outbreak of war Spring 2022, in order to hasten exports. Cutting those fossil subsidies would be stridently resisted, so non-starter in both the House & Senate.

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

Yet IEA criticized too the developed nations for so much cumulative emissions, & their Pledges nowhere close to what's needed for 2 degrees goals. Calling them out it states: "Fewer than a quarter of announced net zero pledges are fixed in domestic legislation, and few are yet underpinned by specific measures or policies to deliver them in full or in time." And typically vague pledges by corporations are combined often with very distant target dates.

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

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

We'll discuss it ahead, but a point is, oil's crash in 2020 was a *crisis* for it. Until rebounding, only then could some prior production be restored. By contrast, green themes like solar/wind - can & do move very differently. And clean's future is thankfully different. Key drivers differ for green energy, where there's ongoing consolidation. For instance, in 2020, one US solar maker sold its operations & management arm to another O&M. A big integrated solar name split in two. Vertical-integration was once seen as a positive: before then it made panels, and installed/serviced them. Split by a spin newly specialized, the parent refocused downstream on just selling PV in North America. That's a big market, thin margins: new storage allows it premium branding and can get bigger. That is in-country work which can't be outsourced nor done overseas by cheap commodity competitors elsewhere. While there was rising PV inflation both in 2021 and 2022, mid/longer-term, solar should once again see *declining* prices.

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

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

Roller-coaster recent past, exhausting & thrilling. Stock chart remarkable; little like it. ECO Report over 100 pages. Overshadowing much has been a pandemic, now endemic. Job losses, Great Lockdown. Many markets cratered – and may do so again ahead. Oil imploded to places not seen in 100 years, then bounced back hard to big heights. Attention to climate and clean energy solutions briefly derailed by pandemic – resurged especially on 2022's war and in light of new ongoing weather extremes. Fresh action from Europe to get past (Russia's) fossils.

Moving on let's consider past 5 years. Here fossil fuels stand out for a long decline then rocketing back up from negative 2021/2022. Until a few years ago, ECO past 5-years periods in mid-2010s was generally 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%. At end 2020, the past 5 years was a striking divergence: clean alone was then up +300% as green jumped – while dirty themes were down -30% to -70%. Mid-2022, dirty shot up above nil, all positive.

At any rate 5 years captures a small sliver of time. Corrections happen, and trees don't grow to the sky. Clean, once was well *down* for past 5 years in prior Reports early-2010s. That has shifted. A once monolithic early 2010s had shown 'All energy far down' with clean too – but lately that's changed early 2020s, by a lot. Clean was up 6-fold in 1st year of this decade, 2020. Then clean plunged – as fossils enthusiastically jumped seen in old school Indexes like S&P500 (growing in size there too) – although to just above nil, still far below clean.

In this 5-years Chart below, clean ECO/NEX has left a down 2014-2016 period. It reflects positive up years 2019/2020, gains in clean energy big absolute ways – plus huge relative to major Indexes too. With clean ECO up over +500%, it left then major Indexes 'in the dust' even with its 2021/22 falls. Past 5 years here shows ECO tracker is strongest of all up +155%; the global new energy NEX is up +90%. Performance by a best major Index 'bogey', S&P500 is below NEX, 'only' +71% while Dow and all country world basket are near 'just' +50%. Normally, up +50% in 5 years is bit of a 'Win' so in absolute sense, 3 big bogeys – especially S&P500 did well. Just relative to clean themes ECO/NEX, did Dow and S&P500 flail – only one nearish NEX. Far at bottom are fossil oil & gas themes, each barely positive at up less than +10%.

ECO/NEX trackers vs. fossil fuels themes & major Indexes, Past 5 years June 2017 to early June 2022. Once a past 5 years had been 'tough' for All energy; now it's Differentiated – Clean ECO/NEX at top are moving far differently vs. traditional & fossil Indexes:

Source: finance.yahoo.com

Clean energy certainly plunges at times. And after a tremendous gain in 2020, drops 2021/2022 weren't so surprising. On the other hand, jumps/gains may at times outpace broad Indexes, going up more. Consider August 2020 as Dow gained +7% for its 7th best August since 1984; an S&P500 was up +7%, its 8th best August since 1986. Meanwhile same month ECO was up August by +20%, NEX was up +15% (nor were those greatest monthly gains in that year: November and then Dec. 2020 saw larger gains, before a Feb. 2021 peak- and plummet).

Next page is a past 10 years rolling, again positive for clean. Until recently, the clean story for last 10 years had been a relative 'dog' (our apologies to all dogs). What changed? From a strict charting sense, it's partly due to having left steep declines seen long ago earliest 2010s. Those were final legs of steep renewables plunge; including any bit of that in 10 years since, had bent performance downwards. In sum clean energy at times can relatively outperform vs. dirty - but obviously did Not in 2021/or first part 2022! Still, plunges warrant attention. Thus, next is a rolling chart for the rough past 10 years, 2012 - to 2022. For a change of view too, in place of a broader S&P500, Dow, and an all country world theme – there is instead an active managed alternative energy theme, and passive solar-only theme.

Here interestingly, for past 10 years, now a passive excellent solar-only theme is at top: up some +320%. And the *Global* NEX tracker is still well up the 2nd most at about +210%. While ECO is 3rd best, up about +150% - it had fallen greatly in 2011 and 2022 and that has allowed an active-managed alternative energy fund that for years was beaten badly by ECO – to finally at least tie in this unique time window with passive ECO given latter had fallen so.

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

Rolling Past 10 Years from June 2012 to start of June 2022:

Source: yahoofinance.com

Hard to see for being so far down, oil and gas in orange/yellow are down here around -60%! Of course, they'd jumped later, 2021/2022 – but put in context of the past 10 years, that did little to make up for the arduous and prolonged decline they've suffered for a decade!

3 major, broader Indexes' lines – for the Dow, the S&P500, and an all country world theme have been removed from here as noted for better visual clarity. As we see, all of 2010-2019 was tough: an independent ECO tracker at start of 2010 was 55: it ended 2019 at 34 so down. An independent global NEX tracker in 2010 was at 16: it ended 2019 at 14 so down.

Notably, clean is starting to do well here, from 2020. Solar-alone, and clean new energy innovation NEX are the most positive of these 5 themes last 10 years, over +300% and +200%. NEX in light blue and excellent solar-only basket in pink rise hard above. ECO in darker blue has fallen a lot – but is still is up +150% - like active alternative energy. All good – versus fossils! A tale of two cities for Past 10 Years: there were first Big Declines in Dirty energy – vs Clean all Well-Up to varied degrees. Until of course, next, 2021/2022 gains in both oil & gas - while clean then plummeted - that *might, possibly* begin a new narrative. As time rolls on, earlier tough years for green Indexes like global NEX *may* begin telling a new story. As shown next, just how a theme like NEX captures the global new energy story, the theme's own definition is no backroom matter; it's very consequential.

NEX: the first Global Clean Energy Index – vs. a younger, narrower not-as-clean theme:

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

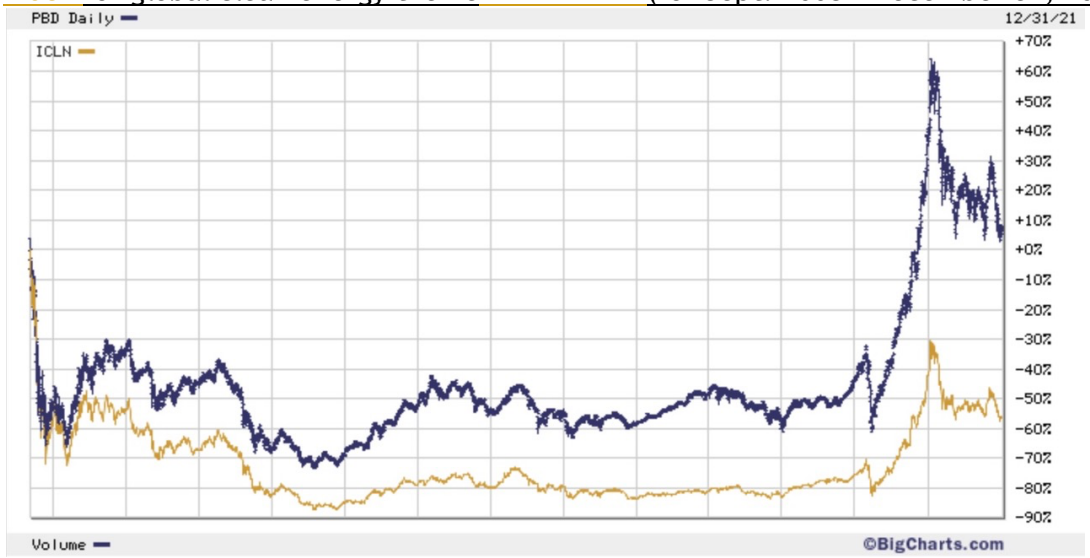
For example, the NEX is quite clean: it has a rating for low & zero-carbon that's far better, more deeply green – than that other Index. NEX is also steeped in diverse new energy innovation – so unlike old GICS (Global Industry Classification System) 1999 nomenclature that puts that other global basket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

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

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

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

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



Source: Bigcharts.com

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

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

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

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

Shorter periods, say past 1 or 5 years - these 2 Indexes at times trade leadership back & forth – but over longer periods, the NEX does 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 included and heard: each one has a voice. Given such huge performance gap over long periods, it seems equal weights allows passive NEX (& tracker) to better capture more - especially smaller & mid cap inherently clean purer plays. *Please note though neither approach is 'right': they're simply 2 differing methodologies.* 2 varied ways for global clean stories to be captured. The other's been very concentrated, allows some dirty names, and biased to big – while the NEX has been notably clean and is wider-ranging.

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

After a useful public consultation early 2021, that other Index made numerous understandable changes for Q2 2021 & going forward. From having fixed 30 only components, it added at first a 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 new energy's story grows ahead. That could allow too for the other Index to better reflect an evolving story over time.

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

After mid-2021, that other global Index could & did hold non-clean names. For just 3 examples 1) that other Index added at big 5% weighting in 2021 a utility getting only 8% of its earnings from renewables: it fracked natural gas with near enough pipeline to reach New York to Paris and back: it can't be either clean or sustainable for decades at the soonest. 2) They added another dirty energy name that also can't be in NEX, heavily in natural gas and long in nuclear too; so not eligible for NEX that's global clean energy. And 3) that other Index added in 2021 another utility also ineligible for clean NEX as it's generating electricity from oil & even burning diesel (among last US Utilities to do so)! In 2020 only 35% of that dirty utility's power was coming from renewables though in a region blessed with sunshine & wind. Later, that other Index did another market consultation to allow more changes but notably, it explicitly still allowed for much gas(!) just weighted a bit less. And it kept unfortunately a Carbon 'Intensity' scoring metric. That metric could allow for inclusion of dirtiest fossil fuels, by a distorted false numeracy. Clearly fossil fuels don't belong in an ESG basket. Nor should they be in any genuine global *Clean Energy* theme. So, that Index fixing some distortions, arguably made changes post-2021 that allowed itself to become dirtier. It did so again in 2022 with more gas and nuclear – becoming only sort of, 'kind of' clean energy.

We recall years back, as small caps grew popular, how big inflows had made it hard for active funds in general to hold smaller equities. Even $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 whether in active Funds – or passive Indexes. Consider now, ESG thinking today. Green words see 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, should & must be fixed. A greater 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, could oil & gas be included in a green ESG basket?!! Or, make any 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 gas to be say 60% natural gas, 30% oil, 10% biofuels – and claim clean'! CH_4 /natural gas spews somewhat less CO_2 - vs. oil or coal – so higher $$ profits might misleadingly lead to green claims. Nothing of the sort is actually true, of course. But 'carbon-intensity' schemes can lend some false numeracy, a seeming quantitative rigor, when opposite is true. Left side of equation is correct: carbon footprint measurable in tons of CO_2 Scope 1, 2, 3. But right side of equation, 'intensity' grafts 'value', revenues in Dollars, Renminbi, Euros. *The air cares not a whit 'how profitably' each CO_2 molecule was made,* whether with more *revenues* - or less! But the (ahem, intended) upshot, is 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 in going from oil – to gas. Clever for marketing, it enables fossil firms entry point even into 'kind of clean' (really, brown) baskets – ESG funds. Such ill-conceived notions like 'revenues'/per ton of CO_2 makes 'intensity' slippery indeed.

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

For how true passive clean Index performs, return to Weighting Methodologies. Interestingly, we've seen equal-weighted NEX has far outperformed the last 10 years, from inception etc – vs. a market cap weighted Index. On equal-weighting benefits, consider a Chart below:

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

Source: The Economist (2021)

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

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

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

The Economist makes a very good relevant point: it's a dismaying to see huge fossil fuel names - in any ESG fund. Likewise in global clean energy Indexes or funds. European SFDR 'dark green' article 9 aims nicely to rectify that. And NEX floor of $1m average daily trading value (ADTV)/$750k for continuing components, may look at ESG risk ratings, and carbon; alongside the NEX & ECO being much greener anyway so avoids that 'greenwash' pitfall.

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

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

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

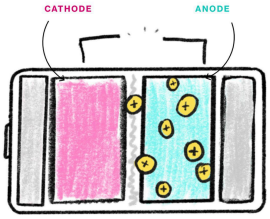
So great uncertainties abound, giving rise to volatility, tremendous risk. Myriad sub-themes *may* see advances: some incremental, some may be non-incremental, perhaps disruptive. Advanced green energy storage & batteries plainly merit focus 2020s, areas ECO & NEX have had exposure to since 2004. New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

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

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

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

a) 4 basic battery parts:



Source: Bloomberg Businessweek

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

Source: Bloomberg Businessweek

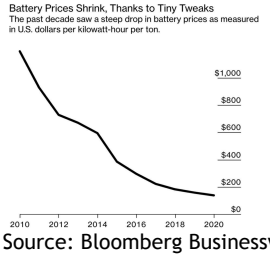
c) NMC as seen in a Nio:

Source: Bloomberg Businessweek

d) Tesla 3 has used NCA:

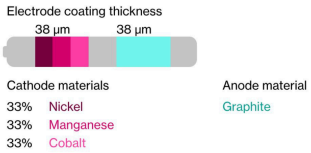
Source: Bloomberg Businessweek

Battery prices are falling hard:



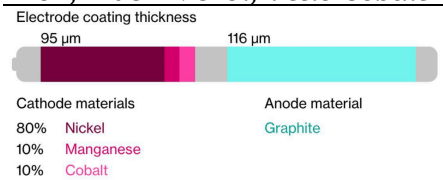
Source: Bloomberg Businessweek

NMC Composition back in 2012:



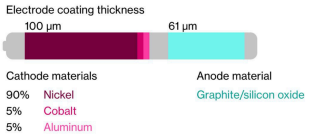
Source: Bloomberg Businessweek

Then, much Nickel, little Cobalt = thicker:



Source: Bloomberg Businessweek

NCA, light strong battery, no manganese:

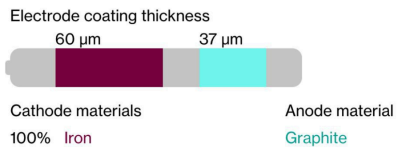


Source: Bloomberg Businessweek

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

e) Electric Buses using LFP lower-cost iron:

Source: Bloomberg Businessweek



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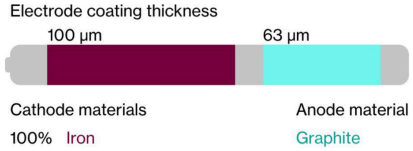
f) Modern LFP, a bit less-energy dense:

Source: Bloomberg Businessweek

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



Source: Bloomberg Businessweek

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

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

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

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

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

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

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

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

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

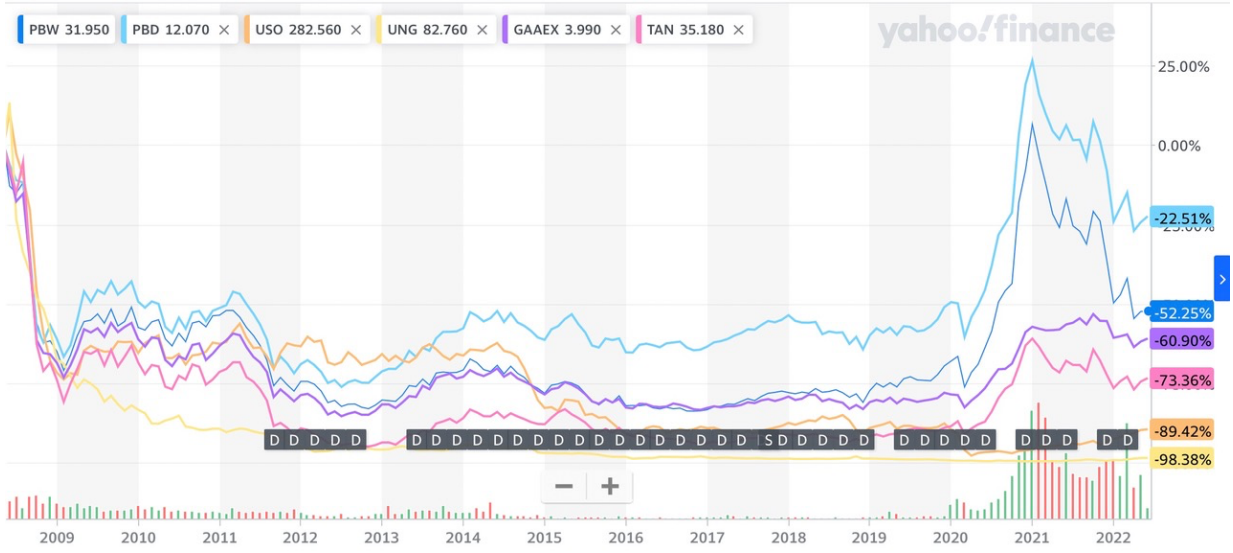
First a little point about Charts. An issue with **rolling** Charts of past 1, 5, 10 years ahead, is these *may* show very different returns in future for ECO & NEX. Plus, as charts leave big falls behind 2008-2012, tough energy times 2014 & 2021, then with relative drops removed, ECO/NEX *may* show far greater relative gains. For that reason, a view is needed too with great ECO declines like 2008, 2021 etc preserved: hence this Chart below. From a fixed (not rolling) 2008, it looks onwards. A long-running ECO+tracker could have begun in 2005, yet those other trackers didn't commence until later – and so an earliest feasible start was 2008.

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

Farther back we'd note an ECO predecessor, the original WilderHill Hydrogen Fuel Cell Index was informally shown 1999-2007. It was the world's first here – calculated in-house and posted Online with Commentary, as an original worldwide. It differed from and yet informed the work we subsequently did for a formal hydrogen economy index 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, this chart below preserves like in amber, some big drops latter 2000s. Like 2008 as some trackers commenced, near peaks, all soon plunged. That 2008/09 crash hit countless themes globally. A bog & deep mire afterwards stretching across clean and dirty energy for years mid-2010s, is brightly preserved below forever.

Starting from bottom we can see fossil fuels oil & gas are Far Down here some -90% or more(!). 'Above' them/down less is that excellent solar-only theme here off -73%. An active managed alternative energy fund is off -60%. 'Above' them yet still well down, rising steeply at times with big falls is ECO at -53%. Clearly 'highest'/least down energy theme is the global NEX though down -23%. The broader major Indexes (not seen here) all did *far* 'better' – though they differ sizably – for energy is only a sliver there. Generally speaking, volatile ECO/NEX may really rise in climbing markets; they can & do *plummet* hugely in declining periods:

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

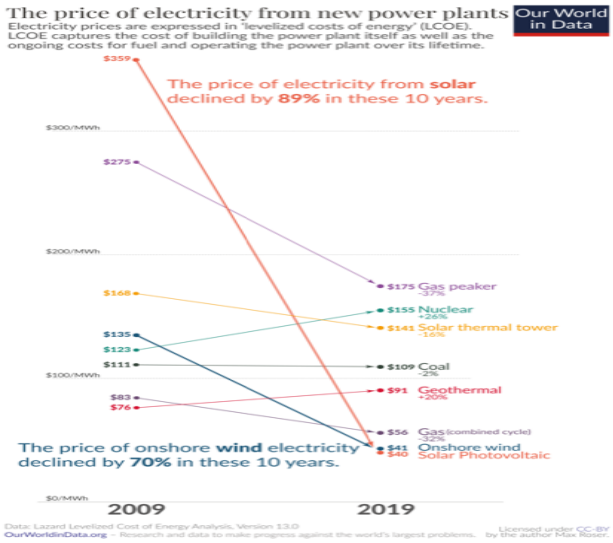


Source: yahoofinance.com

So that's looking backwards a decade or more to the past, when clean energy was just born. Flip side to US having had nearly-zero-green power in 2010 - is despite some growth - where we stood on renewables absolute terms in 2022 was *Awful*. By 2022, offshore wind 'should' already have been hundreds of GWs, instead it was near-non-existent. US had total only 7 offshore wind turbines in 2021; Europe had 5,400! Solar in 2021 made but 3%, wind 8% of US electricity. When solar & wind *Could* Have Met All US electricity demand. Instead, electrified cars, trucks, ships, airplanes were but a tiny rounding error in 2022. It may feel like we've come a long way – *but that's due to how dismal we began.* Look at Our World in Data figures: dirty fossils made 79% of energy production worldwide in 2019. Vexed fossils were bloody cheap so that was no surprise. Being low-cost meant all. Plus, they alone, along with current-generation nukes uniquely offered firm, dispatchable power. But not for much longer.

Solar is forecast to wallop dirty on cost ahead; its price plummeted 89% in 10 years to 2020 as costs for solar, like wind & storage too dropped hard. 2021 was an exception given inflation, and coal, oil, gas by contrast grew relatively-(much) costlier: they all pay for fuel. Fossils are bound to be costly to operate on their fuel costs - plus they must pollute and are powerless to reduce cost follies by much. Unsustainably, they'd created 87% of global emissions of CO_2. Estimates are their air pollution alone has caused 3.6 million deaths every year. That's 6-fold more than all annual war deaths, terrorist attacks, and murders combined!!

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



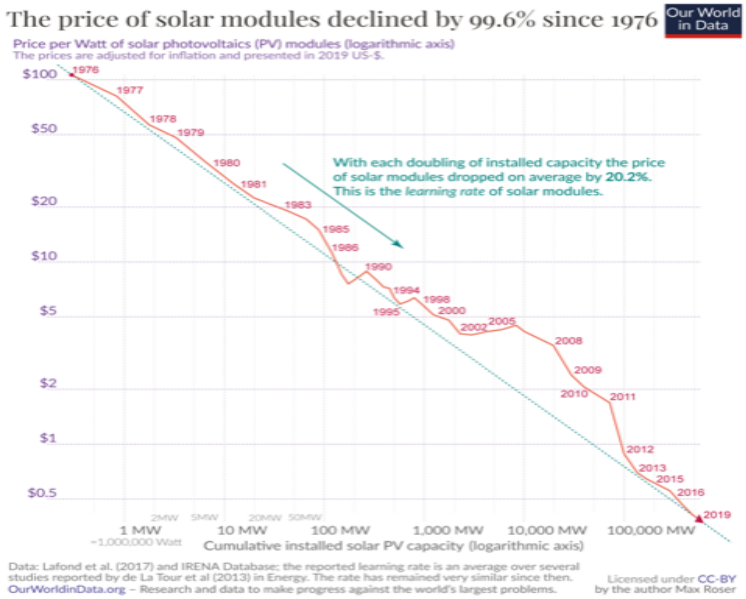
Source: Roser, Why Did Renewables Become So Cheap So Fast? Our World in Data (Dec. 2020).

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

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

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

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



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

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

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

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

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

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

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

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

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

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

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

As pointed out, part of FTSE 100's issue is an absence of organic growth in its components. Sage plc has enterprise software, Next plc has clothing retail, but much had entered top 100 by mergers & acquisitions – not a good long-term ramp for growth. An innovative Nasdaq 100, Nasdaq Composite - or S&P500 are different. As noted in MoneyWeek, the S&P had had 19 technology stocks in 2005 – when FTSE 100 had but 1. In 2020 more tech names joined FTSE 100. Still, by contrast, US Indexes are reflecting considerably more tech. A mid cap/smaller FTSE 250 had enjoyed more momentum in 2021 with innovative-equities, than FTSE 100.

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

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

Source:YahooFinance.com

Some ways FTSE 100 is similar to FTSE 250 – other ways different. As name implies latter is top 250 by market cap listed in London. From 1985 to Jan. 2021, it returned a better +8.5%. That's put it well ahead of large cap FTSE 100 that was up too, but 3.6% less per year.

Of course, all in hindsight only. It's impossible to say, beforehand, what Indexes, like which companies, will do well ahead. Some factors may be additive like emphasis on small cap/ innovation was recent years - big/conservative can do better in down years. In the FTSE 100 those big older energy firms in 2021 were 9% of it, plus mining/materials 13% - for 22%. By contrast those 2 old themes were just 5% of US market; 10% of Europe. In the US, tech was 28% & healthcare was 14% of S&P500; in a Europe-wide Index (ex-UK) they were 10% & 16%. By contrast, those 2 were just 1.3% & 10% in UK. To quote The Economist from Nov. 27, 2021, "The London Stock Exchange (LSE) increasingly looks like a care home for old-economy companies, rather than a cradle for new-economy ones. Less than 2% of the FTSE 100's value is accounted for by tech firms, compared with 40% of the S&P500's." And tastes change; Britain's Statistics Office in mid-2022 removed coal, and men's suits from its basket for the consumer price index, putting in antibacterial wipes, and sport bras. In sum, Index rules & construction, & goals - like definitions vitally shape a theme. They matter. Next, let's look at a few possibilities for clean new energy ahead in a world that's fast changing.

Recent Changes – and perhaps possibilities ahead:

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

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

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

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

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

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

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

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

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

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

Problem is, BP paying so much at a start makes it harder to reap high returns later. Arguably 10% returns are a very tough target anytime, especially aiming for no-risk. Too, oil & gas had earlier shown poor returns in years prior to 2021. US behemoths like ExxonMobil had been hit considerably. Even with 2021's gains, past times were hard to match. A 23-year-old oil rig roughneck once earned $100K+ working part-time: that bubble is largely now gone. Hard to think of a new job that matches what fossils had once paid, letting workers stay same place their whole lives. Today in green energy a worker in wind, years of experience & training may make good salary around $80Ks/year. Geothermal with drilling, $80Ks. Solar with some years of experience, $70Ks. But unionization rates have dipped everywhere including fossil production. Areas like pipefitters, unionization rates are relatively higher and it come with sizably better Wages and Benefits. Hence the fossils have been hard for anything to beat.

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

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

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

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

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

Source: GoogleFinance

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

Big Oil Europe has moved to offshore wind ahead of the US – much faster. 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 BP/ with 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 new Geothermal. Big oil could help like by pumped air in existing caverns (not CO_2 sequestration!). Weights for a gravity storage mounted on old rigs (although gravity provides only puny energy/power) etc. More potential is Geothermal - with lithium-rich hot brine for cleaner power – & 'lower-carbon lithium'; a lower CO_2 'greener lithium' may help displace hard rock mining water-intensive evaporative ponds using sulfuric acid.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Back in 2020, in the EU-27, wind, solar, hydro, bioenergy then made 40% of electricity overall. Fossil fuels were 34%. With some notable standouts: Austria then had made 93% mainly thanks to its renewable hydropower, Portugal had made 67% from its renewables, Germany 54%. In Denmark, 2020, wind & solar made 64% of its electricity; Ireland 49%. Germany 42%. In absolute terms Germany was continuing then to build enormous growing fleet of renewables - with moves away from coal. Its wholesale electricity prices went *down* near just 3 cents per kilowatt/hour (kWh). By contrast at neighboring more coal-dependent Poland, wholesale electricity costs burning its dirty coal were higher - more near 5 cents kWh. But that was Before the horrible war that erupted in 2022, throwing German energy into disarray.

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

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

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

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

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

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

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

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

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

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

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

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

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

Lashing new lithium batteries to new AC motors for electric cars, one recent example. So too ahead, novel thinking about solar: oversizing renewables may actually save money – thanks to advanced storage! This might seem weirdly brain-spinning, oversize solar farms. Yet there's room for it: just 0.3 per cent of world's land, 450,000 sq km of 150 million sq km could power the globe with solar. That's less land than used by coal, oil & gas infrastructure; dirty energies use 126,000 sq km. If solar grows super-low cost, 'over-sizing' solar may compensate for costs of storage. 'Oversizing' solar – given fuel's free – may mean No penalty like over-sizing a coal, or nuke, or gas plant. Moreover, solar power may in time be shared widely via grid, green H_2. Ever say, over-size a nuclear plant? 'Fuggetabouddit'!! That nuke plant would be so costly and inflexible, so vexed by wastes needing to be stored for centuries /millennia, that it is a cul-de-sac of an idea like for any fossil fuel, or all current 'old' 2nd generation nuclear.

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

Leaving academic musings aside let's return to the applied: to markets and decarbonizing. ECO/NEX saw sharp equity gains in 2020 – oil, gas & coal flailed by comparison. Thus did clean energy 'beat' brown in that year - but then, in turn, fossil fuels walloped clean in 2021/2022. And even solar with all of its green credentials, like much else new, suffers from unneeded undesirable risks. We'll address a sad unneeded risk next, one unnecessary, shocking of late. This is a possibility of unneeded/unwanted forced labor within a unique region.

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

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

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

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

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

US 2021 imported 80% of needed rare Earths from China including for defense systems. That dominance may give China great tactical and strategic advantages & leverage, as clean new energy innovation gains steam. End of 2021, new US rebuttable presumption language of 'guilty until proven innocent' was passed into law, in UFLPA (Uyghur Forced Labor Prevention Act – but with long lead time giving industry time to prove the Absence of forced labor. They could say adopt traceability protocols, or move to sourcing all out of the Uyghur region.

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

We avoid politics ourselves. So just a side-note is zero hope had existed in 2020 for US green energy stimulus. 180 lawmakers did ask House Leaders for relief when 600,000 clean energy jobs were lost in pandemic. But a calculus then for US green funding – even 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 onwards, backdrops change. Mainly incremental. Yet new $ Trillions *may* be spent globally in this decade on new climate solutions. Infrastructure improvements to grow green. In the US, utility-scale solar for example might grow by over >100 GW/year. US battery storage could grow by >50 GW/year, in time approaching today's total installed electric generating capacity. Here the US has long been a laggard.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

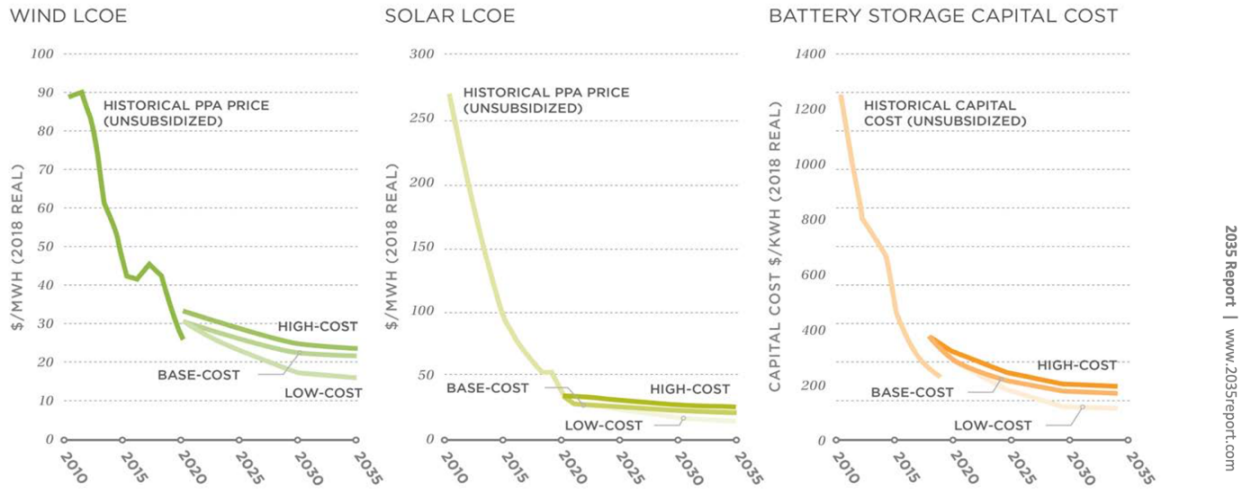
US energy generation growth had gone big before; natural gas grew by 65 GW in 2002. Now what's needed, changed: *energy storage* is 3rd leg triad to solve intermittency of renewables. Key new storage deployment needs to grow by 25% each year. Starting from a measly 523 megawatts storage in 2019, it should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

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

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

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

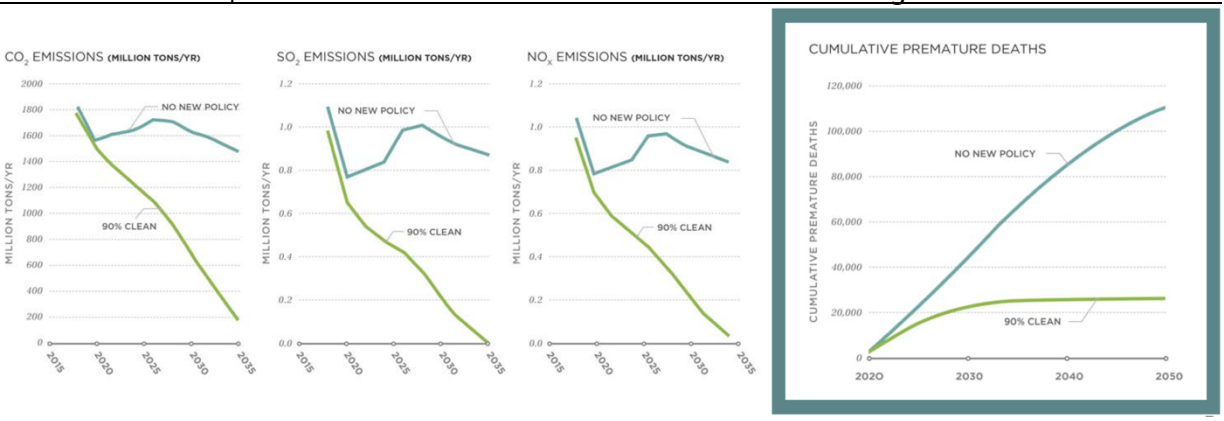
<u>Dramatic Declines in Costs Have Arrived 2020 Far Sooner than Expected:</u>



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

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

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



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

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

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

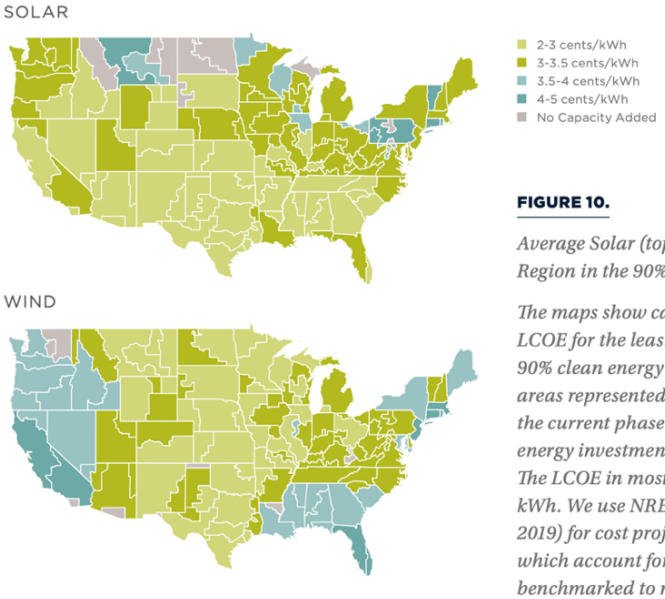


FIGURE 10.

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

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

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

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

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

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

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

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

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

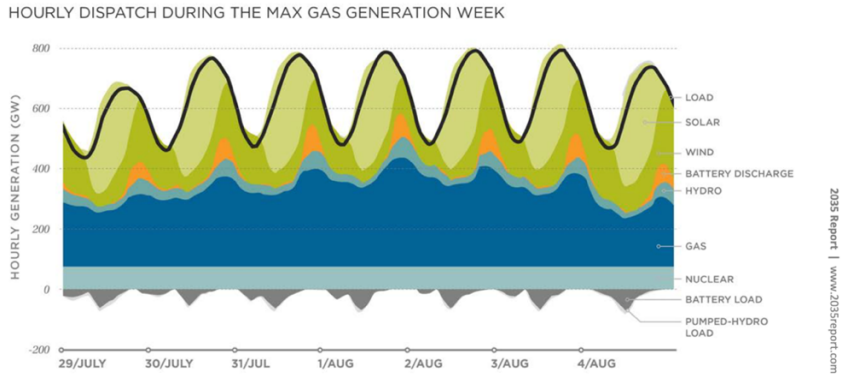
Over 7 weather years modeled, in normal conditions, wind, solar, battery storage generally, regularly provided 70% of annual generation; hydropower & nuclear provide 20%. But when there's very low generation by renewables solar/wind – and/or unusually very high demand, existing natural gas plants, hydro,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

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

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

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

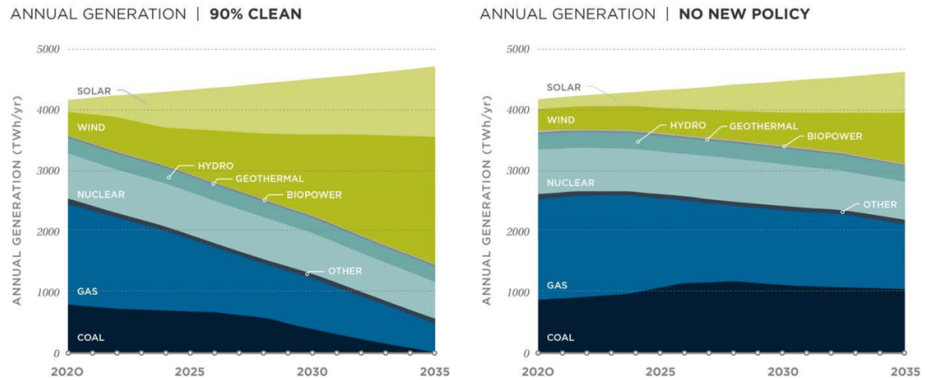
A Worst-Case Generation Period for Renewables: Still Moving Off of Fossil Fuels/Nuclear:



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

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

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



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

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

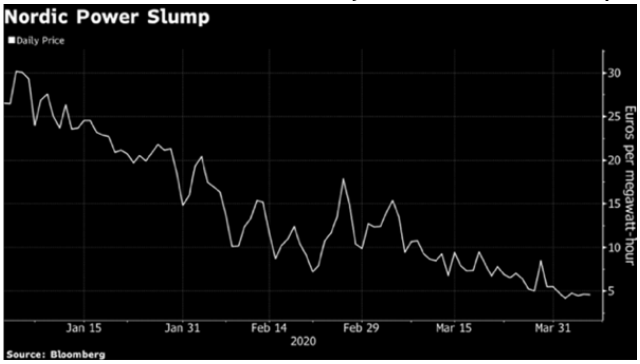
Recall some 'normal', pre-Covid, *applied* clean energy trends back early 2020. As renewable prices were falling in good & snowballing ways (unlike oil/gas). Start with Solar; costs had then hit a new record low: *only 1.35 cents per kilowatt/hour* at a big 1.5 GW solar farm going up in Abu Dhabi! True,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

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

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

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

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



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

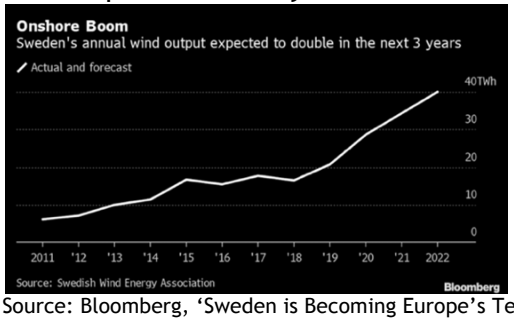
Yes, renewables wind/solar are intermittent. Winds not always blowing, no sun (night), or no rains for hydro. Yet at such times, then other renewables may be tapped. For instance, geothermal might possibly grow well as firm power. Especially when oil rig counts drop, geothermal may grow attractive. Idle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

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

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

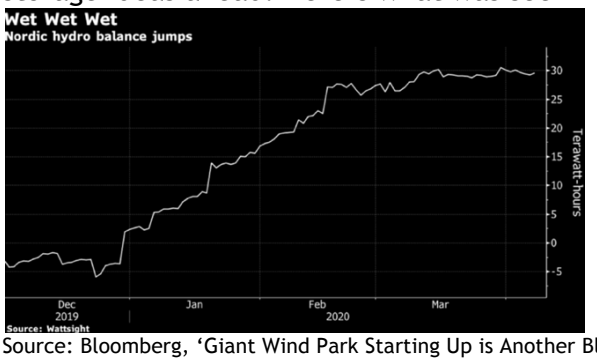
Dirty cheap northwestern China coal, had long attracted industries like PV; cheap electricity eg Liuzhou was an incentive to make EVs too. Yet Northern Nordics may potentially do it one-better ahead! If cheap/er renewable power can make green steel, aluminum - industries shall welcome that – as low embedded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

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



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

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



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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

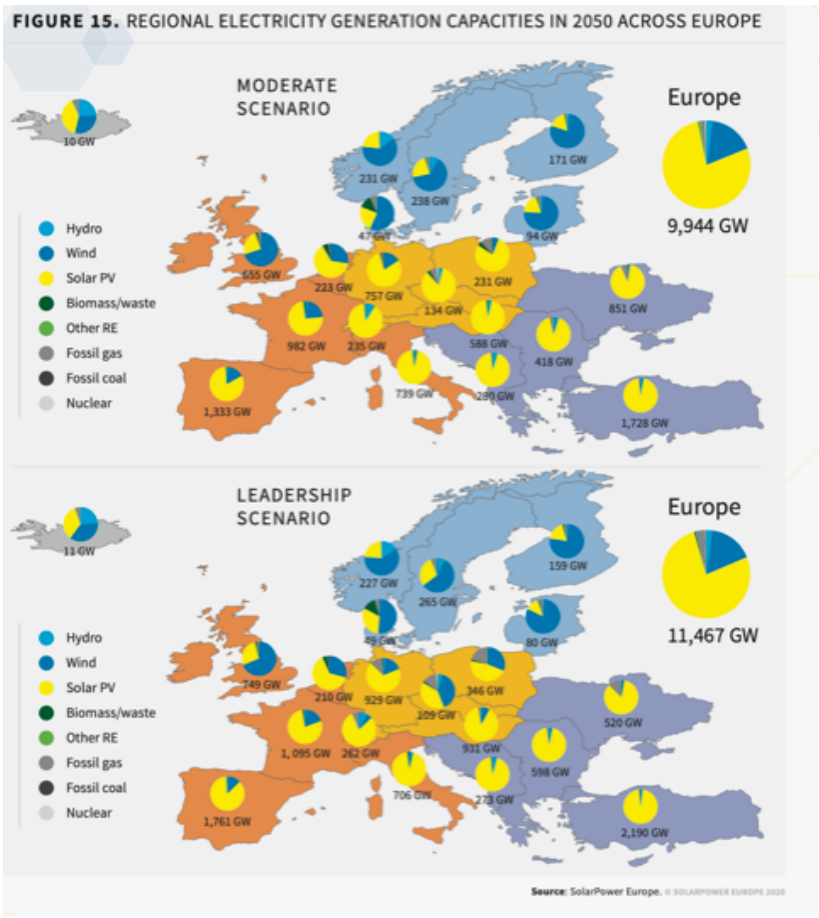
This Report recommends that policymakers should begin immediately creating a framework targeting installed 7 TW solar power – plus 1.7 TW of wind to be reached before 2040.

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

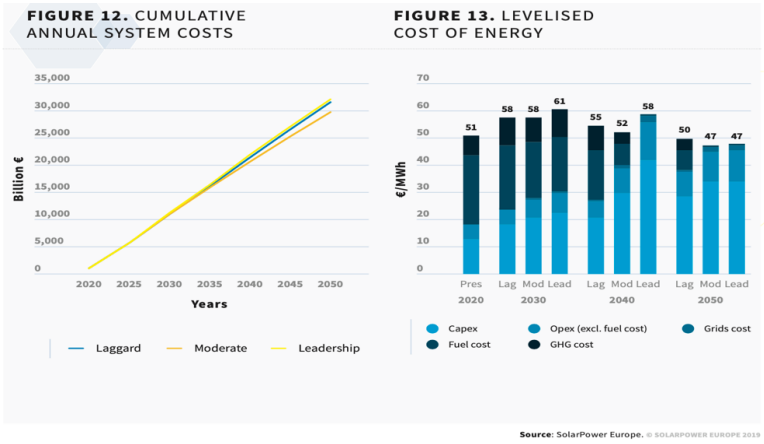
2 scenarios presented were Moderate approach – and Leadership one that's quicker. Former meets only 2 degrees C heating goal of Paris. Latter meets a more robust, better 1.5 degrees C goal. Again, it's a matter of when this ramp begins, so the angle of departure. But interestingly, the stronger and sooner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

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

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



Source: Solar Power Europe 2020.



Source: Solar Power Europe 2020.

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

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

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

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

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

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

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

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

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

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

Then, in 2020 on pandemic + tank tops, oil went <$20. To quickly revive economies & get oil demand back up was essential. Oil-rich nations might ideally want higher crude prices nearer $70 - $100. Or, over $100 like in 2022. In theory it lets them better balance their own books and national budgets. But then regaining firmer demand came first. Proposed conventional new oil projects were anyways uneconomic, without oil at least well above the $50s.

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

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

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

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

It was about getting past an immediate crisis, re-starting oil demand in 2021. Crude might then rise organically – on demand rebirth or inevitable heat waves or cold snaps. Free markets are how the US and its prices work, rather than by fiat, so paths were envisioned to stimulate rebounding. If say US States begin re-opening 2021. If Covid-19 grows increasingly endemic more like a seasonal virus; even if immunity is conferred only for one flu season, if effective vaccines arrive, or better yet, robust vaccines for Covid ably can treat new variants too, there were thus hopes for some return to demand rebounding towards normalcy.

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

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

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

It didn't: for as many in the oil patch fervently hoped, oil demand rebounded latter 2020. On fast-reviving economies, as well as production cuts by OPEC+ largely complied with (Iran pumped rather freely). So, 2020 that had begun with oil tops on everyone's lips, gave way to 2021 with tops largely unnoticed – or at least prior excess no longer much concern.

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

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

Consider CO_2: A Topic Gaining Importance

For 20 years an emphasis in Clean Energy Index® Reports was first *Solutions*. Not focused on CO_2 nor on climate, *per se* – but rather helping solar, wind, electric cars etc along ecologically & economically better paths. Global heating was a big driver here - but CO_2 hadn't been a core theme in these Reports. Lately, however, climate crises have come in at a worse end of what models had foreseen. In short, CO_2 increasingly matters, so let's address it here.

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

So, we take an increasing look in these Reports at climate issues so relevant to clean energy's story. And consider too Environmental, Social & Governance/ESG factors (especially 'E'). First, note: CO_2 has been a hero to our species – in moderation. Earth without CO_2 may have had 0 C surface temperatures. Instead, a heating thanks to CO_2 in tiny concentrations under 400 ppm, has meant greenhouse gases naturally gifted us average temperatures near ideal for us 59 degrees F. We'd habituated into that over ten thousand years plus.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

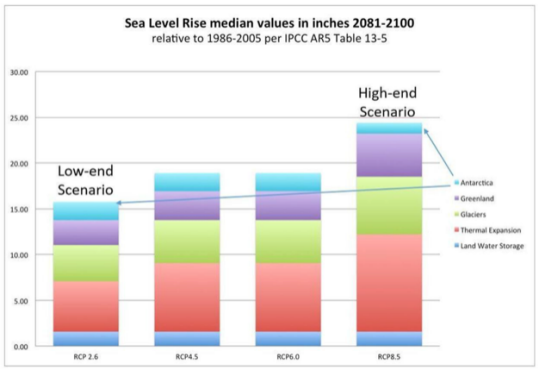
Imagine say, just 80 years hence. Note aspects of projections by an Intergovernmental Panel on Climate Change (IPCC) for sea level rise in 2100, may be a bit misleading. End of this century, rise may be unwinding at more rapidly accelerating rate, than what had seemed projected by IPCC. Getting that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

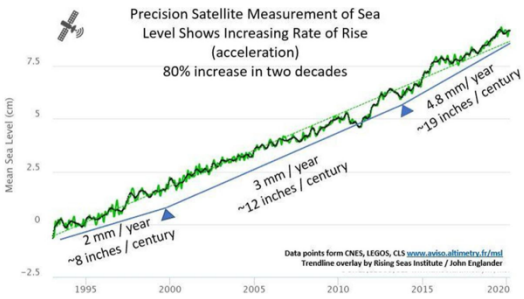
That actual sea levels seen in 2100, could be greater than IPCC projections is well laid out in 2020 piece, 'Twenty-first century sea-level rise could exceed IPCC projections for strong-warming futures' by M. Siegert et al., One Earth, 3 (Dec. 18, 2020). Their first paragraph nicely lays out cogently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

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

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

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





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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

For where we're going at CO_2 already over 420 ppm in 2022 & rising fast, think first Pliocene. About 3-5 million years ago, a hot Earth had a forested arctic. We might reach such climate rather soon. Of course, it'll take a lot longer for equilibrium, for flora & fauna to react, vast changes to come then along with mass-extinctions. But those temps existed a couple million years before humans later evolved (in a more comfortable world nearer 230 ppm). We can get hotter still, like Miocene, 400-600 ppm. Perhaps coasts submerged. Interestingly, at 'just' a 400 ppm Pliocene much of Greenland's ice sheet was gone; glaciers may be sensitive to 'modest' warming. Millions of years ago, CO_2 changes occurring naturally took thousands of years to unwind, maybe tens of thousands of years+ to slowly rise or fall. By contrast in a single human lifetime now, we're exploding CO_2 by an astounding 100 ppm + (!!), so flora & fauna only beginning to react. Cascading exterminations, extinctions unavoidable. It's not just the Fact of this Change – but rather also the Extreme Pace of Change, that's deadly.

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

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

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

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

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

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

An international panel in 2013 gave scenarios for rise this century, that was straightforward on expansion of warming oceans. They'd only allowed then for a small influence from new runoff as from marine ice-sheet instability, known as MISI, primarily on the assumption that Antarctic ice sheets were too stable and vast to irreversibly shrink during this century.

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

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

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

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

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

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

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

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

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

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

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

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

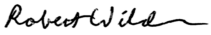
Based on what we once were prepared to give, 2020s may feel like progress. Clean energy now seems to be 'fast' (not really) replacing fossils. But on the CO_2 budget, even 'ambitious' action puts us in a perhaps unbearably hot future. Fast rising seas or worse. Once, we'd dug most energy as fossils from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

Conclusion:
The Clean Energy Index® (ECO) started Q2 near 136 and ended Q2 at 95, so down -30%, and Year to Date was down by -36%. For last 3 years, ECO rose by +58% in 2019. Remarkably, it then rose by +203% in 2020 for about the best performance of any Index or Fund, anywhere. After 2 such gains not surprisingly, it fell by -30% in 2021 as a key reconciliation bill's failure pushed this theme down hard – plus as fast-rising inflation & so interest rates (down more!) outweighed any decarbonizing trends that may favor renewables ahead. After first falling in Q1 by 1/3rd to 100 - war brought a hard shift away from overreliance on (Russian) gas and in the war's first few weeks, ECO briefly jumped by +40% on the better alternatives found here. In Q2 it fell back harder hitting a low of 84 amid supply chain chaos, then rose mildly on Europe's green plans. Since 2017 when ECO was at 38, it's now up by some +180%.

For last 5 years, Benchmark ECO Index live since 2004 and the 1st for climate solutions is up +150% to mid-Q2 2022. This over a period when any energy gains might stand out. For the same 5 years, and despite huge recent gains, oil & gas are only up by +10%; they're *down* by -50% last 10 years. By contrast decarbonization as an organizing theme at ECO is up +155% last 10 years, and at NEX is up +200% showing very differing returns for sustainable energy. In sum 5 WilderHill Indexes now with Hydrogen Economy (H2X), and Wind Energy (WNX), are purer-play benchmarks. And energy long dug from underground and burned – increasingly is captured in sustainable ways, gifted to us freely & renewably from up towards Heavens.

4 Additions to ECO for start of Q3 2022 were Brookfield Renewable Corp, Gogoro, Heliogen, Sigma Lithium – and 1 Deletion was: Romeo. At Global NEX for Q3 2022, the 8 Additions were Aker Horizons, Brookfield Renewable Corp., Dongkuk Structures, Infrastructure and Energy Alternatives, JL Mag Rare Earth, Lilium, OX2 AB, Renew Energy Global – and 9 NEX Deletions for Q3 2022 were Aker Offshore Wind, Azure Power, Cloudberry, Electreon Wireless, Fastned, Gencel, Gurit Holding, Siemens Gamesa, Wallbox.

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



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Appendix I: ECO Index (via independent tracker PBW) Descending Weights late-Q2 on 6/12/2022, or about ~2 weeks before the rebalance to start Q3 2022. 78 Stocks:

Name	Symbol	Weight
Daqo New Energy Corp ADR	DQ	2.20
JinkoSolar Holding Co Ltd ADR	JKS	1.96
Sociedad Quimica y Minera de Chile SA ADR	SQM	1.83
Albemarle Corp	ALB	1.77
Enphase Energy Inc	ENPH	1.76
Ormat Technologies Inc	ORA	1.73
Gentherm Inc	THRM	1.71
Livent Corp	LTHM	1.70
Array Technologies Inc	ARRY	1.66
Maxeon Solar Technologies Ltd	MAXN	1.61
View Inc	VIEW	1.61
Quanta Services Inc	PWR	1.61
TPI Composites Inc	TPIC	1.60
ESCO Technologies Inc	ESE	1.58
Itron Inc	ITRI	1.55
Canadian Solar Inc	CSIQ	1.55
Advanced Energy Industries Inc	AEIS	1.53
Sunlight Financial Holdings Inc	SUNL	1.51
SolarEdge Technologies Inc	SEDG	1.49
ReNew Energy Global PLC	RNW	1.49
Li-Cycle Holdings Corp	LICY	1.49
MYR Group Inc	MYRG	1.48
First Solar Inc	FSLR	1.47
FTC Solar Inc	FTCI	1.46
SunPower Corp	SPWR	1.44
Joby Aviation Inc	JOBY	1.41
Sunnova Energy International Inc	NOVA	1.40
Tritium DCFC Ltd	DCFC	1.37
XPeng Inc ADR	XPEV	1.37
Archer Aviation Inc	ACHR	1.36
Sunrun Inc	RUN	1.36
Enovix Corp	ENVX	1.34
ChargePoint Holdings Inc	CHPT	1.32
Shoals Technologies Group Inc	SHLS	1.32
NIO Inc ADR	NIO	1.31
Lilium NV	LILM	1.29
Stem Inc	STEM	1.29

MP Materials Corp	MP	1.28
Energy Vault Holdings Inc	NRGV	1.27
Azure Power Global Ltd	AZRE	1.25
Bloom Energy Corp	BE	1.24
Hyzon Motors Inc	HYZN	1.22
EVgo Inc	EVGO	1.19
Solid Power Inc	SLDP	1.19
ReneSola Ltd ADR	SOL	1.19
American Superconductor Corp	AMSC	1.18
Wallbox NV	WBX	1.18
Wolfspeed Inc	WOLF	1.18
Standard Lithium Ltd	SLI	1.18
Fisker Inc	FSR	1.18
UNIVERSAL DISPLAY CORPORATION	OLED	1.18
Piedmont Lithium Inc	PLL	1.16
Navitas Semiconductor Corp	NVTS	1.15
Ameresco Inc	AMRC	1.13
Infrastructure and Energy Alternatives Inc	IEA	1.12
Tesla Inc	TSLA	1.10
Fluence Energy Inc	FLNC	1.09
Lithium Americas Corp	LAC	1.09
Blink Charging Co	BLNK	1.04
REE Automotive Ltd	REE	1.04
Plug Power Inc	PLUG	1.02
Workhorse Group Inc	WKHS	1.01
ElectraMeccanica Vehicles Corp	SOLO	1.01
Lightning eMotors Inc	ZEV	1.00
ESS Tech Inc	GWH	0.98
QuantumScape Corp	QS	0.97
FuelCell Energy Inc	FCEL	0.97
Ballard Power Systems Inc	BLDP	0.96
Rivian Automotive Inc	RIVN	0.96
Lion Electric Co/The	LEV	0.93
Lordstown Motors Corp	RIDE	0.92
SES AI Corp	SES	0.88
Canoo Inc	GOEV	0.88
Arcimoto Inc	FUV	0.87
Gevo Inc	GEVO	0.80
Beam Global	BEEM	0.79
Eos Energy Enterprises Inc	EOSE	0.73

Romeo Power Inc	RMO	0.64

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

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

INDEX (ECO) SECTOR & STOCK WEIGHTS FOR START OF Q3 2022. 81 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 - 15% weight (12 stocks @1.25% each)
Array Technologies, ARRY. Solar, tracker mounts follow sun through the day
Azure Power Global, AZRE. Solar, India; aims for very low-cost green energy.
Canadian Solar, CSIQ. Solar, vertically integrated solar manufacturer, China.
Daqo New Energy, DQ. Solar, polysilicon/wafer manufacturer; China-based.
First Solar, FSLR. Thin film solar, CdTe a low-cost alternate to polysilicon.
FTC Solar, FTCI. Solar panel trackers mounting systems, Utility-scale.
JinkoSolar, JKS. Solar, wafers through solar modules, China-based OEM.
Maxeon, MAXN. Solar, efficient PV panel manufacturer after spinoff.
Ormat, ORA. Geothermal, also in areas of recovering heat energy.
Renesola, SOL. Solar, project development, operations, China & globally.
Sunlight Financial, SUNL. Solar residential financing, credit provider.
TPI Composites, TPIC. Wind Blades; also light-weighting transportation.

Energy Storage - 26% sector weight (20 stocks @1.27 each + 1 *banded)
Albermarle, ALB. Lithium, specialty materials in batteries for energy storage.
Chemical & Mining of Chile, SQM. Lithium, large producer in energy storage.
Enovix, ENVX. Silicon-anodes, 3D for improving new lithium-ion batteries.
**Eos*, EOSE. Zinc grid batteries, 100% depth discharge, longer-life not li-ion.
ESS Tech, GWH. Iron flow batteries, longer duration is non-lithium storage.
Fluence, FLNC. Battery storage, for renewables and digital applications.
Lion Electric, LEV. Urban electric trucks, buses, vans; vehicle to grid storage.
Lithium Americas, LAC. Lithium, deposits in State of Nevada U.S. & Argentina.
Livent, LTHM. Lithium, and compounds used in batteries for energy storage.
Lordstown Motors, RIDE. Electric commercial pickup trucks, American startup.
NIO Inc, NIO. EVs, China-based startup premium vehicles, battery as a service.
Piedmont Lithium, PLL. Lithium, US domestic source battery-grade lithium.
Quantumscape, QS. Battery, solid state lithium-metal energy dense fast charge.
Rivian, RIVN. Electric vehicles, trucks and commercial fleets, charging
SES AI Corp, SES. Li-metal anode battery, may be safer, faster-charging.
Sigma Lithium, SGML. Lithium, in planning & pre-construction, sites in Brazil.
Solid Power, SLDP. Solid electrolyte battery, Earth-abundant materials.
Standard Lithium, SLI. Lithium, from brine in U.S., vs. traditional ponds.
Tesla, TSLA. Electric vehicles, pure-play across EVs, advanced energy storage.
Workhorse, WKHS. Electric Vehicles, large electric delivery trucks, early-stage.
Xpeng, XPEV. Electric vehicles, advanced mobility, swappable batteries, China.

Power Delivery & Conservation - 27% sector (19 stocks @1.34% each + 3 *banded)
Ameresco, AMRC. Energy saving efficiencies, net zero CO_2, decarbonization.
**American Superconductor,* AMSC. Wind, grid conditioning; superconductors.
Archer Aviation, ACHR. Electrifying aircraft, vertical takeoff & landing.

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

Energy Conversion - 22% sector weight (17 stocks @1.29% each)
Advanced Energy, AEIS. Power conditioning: inverters, thin film deposition.
Ballard Power, BLDP. Mid-size fuel cells; PEM such as in transportation.
Bloom Energy, BE. Stationary fuel cells, not-yet cleanest/renewable fuels.
Energy Vault, NRGV. Gravity energy storage; can repurpose old wind blades.
Enphase, ENPH. Microinverters, also energy storage systems and software.
ESCO Technologies, ESE. Power management, shielding, controls, testing.
FuelCell Energy, FCEL. Stationary fuel cells, distributed power generation.
Gentherm, THRM. Thermoelectrics, heat energy, battery management.
Hyzon Motors, HYZN. H_2 fuel cell powered heavy trucks, buses, coaches.
Li-Cycle, LICY. Battery Recycling, closed-loop of lithium, other materials.
Lightning eMotors, ZEV. Electric powertrain conversions, heavy vehicles.
MP Materials, MP. Rare Earths, domestic U.S. source Neodymium, NdPr.
Navitas Semiconductor, NVTS. Gallium Nitride GaN fast charging EVs.
Plug Power, PLUG. Small fuel cells, for eg forklifts; drop in replacements.
SolarEdge Technologies, SEDG. Inverters, solar optimizers, inverters.
Tritium, DCFC. Ultra-fast EV charging networks, Australia and worldwide.
Wolfspeed, WOLF. Electrifying power, Silicon Carbide SiC, converters.

Greener Utilities – 8% sector weight (6 stocks @1.25% each + 1 *banded)
**Beam,* BEEM. EV Charging, rapidly deployable portable PV power platform.
Brookfield Renewable, BEPC. Renewables hydro, wind, solar; energy storage.
ReNew Energy, RNW. India renewables, among largest there in solar & wind.
Stem, STEM. Microgrids, smart new energy storage via machine learning.
Sunnova, NOVA. Solar provider, operating fleet for residential, plus storage.
SunPower, SPWR. Solar system provider, storage and distributed generation.
Sunrun, RUN. Residential solar systems, PPA, lease or purchase rooftop PV.

Cleaner Fuels – 2% sector weight (2 stocks @1.00% each)
Gevo, GEVO. Biofuels, lower carbon liquid fuels from renewable sources.

Heliogen, HLGN. Concentrating solar mirrors, hydrogen with no fossil fuels.

Appendix III: **WilderHill New Energy Global Innovation (NEX)** late-Q2 via independent tracker (PBD) on 6/12/21, about ~2 weeks before Rebalance to start Q3 2022. 125 stocks:

Name	Weight
Yadea Group Holdings Ltd	1.46
BYD Co Ltd	1.28
Ecopro BM Co Ltd	1.23
Daqo New Energy Corp ADR	1.21
L&F Co Ltd	1.17
Sociedad Quimica y Minera de Chile SA ADR	1.13
Grenergy Renovables SA	1.11
RENOVA Inc	1.10
JinkoSolar Holding Co Ltd ADR	1.08
Livent Corp	1.02
Energiekontor AG	1.00
Boralex Inc	0.99
Array Technologies Inc	0.98
Acciona SA	0.97
Enphase Energy Inc	0.97
SMA Solar Technology AG	0.97
Corp ACCIONA Energias Renovables SA	0.97
LG Energy Solution Ltd	0.96
NKT A/S	0.96
Solaria Energia y Medio Ambiente SA	0.95
Elia Group SA/NV	0.95
Xinjiang Goldwind Science & Technology Co Ltd	0.94
Encavis AG	0.93
Alfen Beheer BV	0.93
Samsung SDI Co Ltd	0.92
Nexans SA	0.91
Ormat Technologies Inc	0.91
Terna - Rete Elettrica Nazionale	0.91
Ganfeng Lithium Co Ltd	0.91
Unison Co Ltd/South Korea	0.90
Archer Aviation Inc	0.90
Xinyi Energy Holdings Ltd	0.90
Maxeon Solar Technologies Ltd	0.90
TPI Composites Inc	0.90
SK IE Technology Co Ltd	0.89
Tritium DCFC Ltd	0.88

Iljin Hysolus Co ltd	0.88
EDP Renovaveis SA	0.88
Verbund AG	0.88
Canadian Solar Inc	0.88
Eolus Vind AB	0.87
Neoen SA	0.87
Itron Inc	0.86
NIO Inc ADR	0.86
Xinyi Solar Holdings Ltd	0.85
Stem Inc	0.85
Aker Offshore Wind AS	0.84
Novozymes A/S	0.83
Sino-American Silicon Products Inc	0.83
Joby Aviation Inc	0.83
Iljin Materials Co Ltd	0.82
Shoals Technologies Group Inc	0.82
Cloudberry Clean Energy ASA	0.82
Hexagon Composites ASA	0.82
XPeng Inc ADR	0.81
Mercury NZ Ltd	0.81
Prysmian SpA	0.81
Sunnova Energy International Inc	0.80
Innergex Renewable Energy Inc	0.80
Siemens Gamesa Renewable Energy SA	0.80
SunPower Corp	0.80
Doosan Fuel Cell Co Ltd	0.80
Arcosa Inc	0.79
Cadeler A/S	0.79
Sunrun Inc	0.79
Orsted AS	0.78
United Renewable Energy Co Ltd/Taiwan	0.78
Flat Glass Group Co Ltd	0.78
CropEnergies AG	0.77
ChargePoint Holdings Inc	0.77
First Solar Inc	0.77
West Holdings Corp	0.76
Landis+Gyr Group AG	0.76
MP Materials Corp	0.75
CS Wind Corp	0.75
Li-Cycle Holdings Corp	0.75

SolarEdge Technologies Inc	0.75
FTC Solar Inc	0.75
SFC Energy AG	0.74
China Datang Corp Renewable Power Co Ltd	0.74
Hannon Armstrong Sustainable Infrastructure	0.74
Fastned BV	0.74
Lithium Americas Corp	0.73
GS Yuasa Corp	0.73
Vestas Wind Systems A/S	0.73
Solid Power Inc	0.72
Motech Industries Inc	0.71
Kingspan Group PLC	0.71
Proterra Inc	0.70
Nibe Industrier AB	0.69
Lucid Group Inc	0.69
Bloom Energy Corp	0.69
FREYR Battery SA	0.68
Signify NV	0.68
Fisker Inc	0.67
Gevo Inc	0.66
Enlight Renewable Energy Ltd	0.66
ReneSola Ltd ADR	0.65
Piedmont Lithium Inc	0.65
UNIVERSAL DISPLAY CORPORATION	0.65
EVgo Inc	0.64
Wallbox NV	0.64
VERBIO Vereinigte BioEnergie AG	0.64
Ameresco Inc	0.64
Lordstown Motors Corp	0.64
Wolfspeed Inc	0.63
Ceres Power Holdings PLC	0.63
McPhy Energy SA	0.63
Azure Power Global Ltd	0.63
NEL ASA	0.61
Plug Power Inc	0.61
QuantumScape Corp	0.60
PowerCell Sweden AB	0.60
Rivian Automotive Inc	0.60
Lion Electric Co/The	0.57
Ballard Power Systems Inc	0.55

Gurit Holding AG	0.53
ITM Power PLC	0.53
AFC Energy PLC	0.53
FuelCell Energy Inc	0.53
Nordex SE	0.51
Scatec ASA	0.51
Canoo Inc	0.48
Gencell Ltd	0.47
Electreon Wireless Ltd	0.43

There's strong representation above from *Lithium & Battery Materials, and *EVs; non-US-listings.

Appendix IV:
WilderHill New Energy Global Innovation (NEX) - for start of Q3 2022. 124 Stocks.

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

Name	Description	Sector	Currency	Activity
Acciona SA	Sustainable infrastructure, separate renewables.	RWD	EUR	SPAIN
AFC Energy	Fuel cells, alkaline has greater H2 fuels tolerance.	ECV	GBP	UK
Aker Horizons	Offshore / onshore wind, solar, clean hydrogen, grid.	RWD	NOK	NORWAY
Alfen NV	Electric Vehicle charging, smart grid, energy storage.	EEF	EUR	NETHERLANDS
Ameresco	Energy savings, performance contracts, renewables.	EEF	USD	US
Archer Aviation	Electric aircraft, eVTOL vertical takeoff and landing.	EEF	USD	US
Arcosa	Wind tower structures, grid power and infrastructure.	RWD	USD	US
Array Technologies	Solar, ground-mounted axis sun trackers.	RSR	USD	US
Ballard Power Systems	Fuel cells, PEMs used in transportation and more.	ECV	CAD	CANADA
Bloom Energy	Stationary fuel cells, distributed but non-renewable.	ECV	USD	US
Boralex	Renewables generation, operates wind, hydro, solar.	RWD	CAD	CANADA
Brookfield Renewable Corp	Hydropower, wind, solar, energy storage, H2.	ROH	USD	US
BYD Co.	Electric vehicles, batteries, rail, and more.	ENS	HKD	CHINA
Cadeler A/S	Offshore windfarm installation vessels, specialized.	RWD	NOK	DENMARK
Canadian Solar	Solar, vertically integrated solar manufacturer, China.	RSR	USD	CANADA
Canoo	Electric delivery vehicles, configurable, multipurpose.	EEF	USD	US
Ceres Power	Fuel cells, high temperature steel units.	ECV	GBP	UK
Chargepoint	EV charging, an early leader with global presence.	EEF	USD	US
China Datang Renewable	Wind, among largest listed wind operators in China.	RWD	HKD	CHINA
Corporacion Acciona Ener.	Renewables, one of world's biggest: wind, solar etc.	RWD	EUR	SPAIN
CropEnergies AG	Bioethanol, from cereals and sugarbeet, Germany.	RBB	EUR	GERMANY
CS Wind	Wind power, both onshore, and also offshore.	RWD	KRW	S. KOREA
Daqo New Energy	Solar, high-purity polysilicon for solar wafers, China.	RSR	USD	CHINA

Dongkuk Structires	Wind towers, growing wind energy emphasis.	RWD	KRW	S. KOREA
Doosan Fuel Cell	Fuel cells, high temperature and hydrogen, S. Korea.	ECV	KRW	S. KOREA
Ecopro BM	Battery materials, cathode and precursor for Li-ion.	ENS	KRW	S. KOREA
EDP Renovaveis SA	Wind power, among largest producers in world, Iberia.	RWD	EUR	SPAIN
Elia Group SA	Smarter grid, high voltage transmission Europe.	EEF	EUR	EUROPE
Encavis AG	Solar, large solar park operator, also wind, Germany.	RSR	EUR	GERMANY
Energiekontor AG	Wind farms, also solar parks in Germany.	RWD	EUR	GERMANY
Enlight Renewable	Solar & wind power, energy storage infrastructure.	RSR	ILS	ISRAEL
Enphase	Inverters, micro-products for solar panels, storage.	RSR	USD	US
Eolus Vind	Wind power, also consulting services for wind.	RWD	SEK	SWEDEN
Evgo	EV charging, an early leader in fast charging.	EEF	USD	US
First Solar	Thin film solar, CdTe low-cost alternate to polysilicon.	RSR	USD	US
Fisker	Electric cars, electric SUVs, contract manufacturer.	ENS	USD	US
Flat Glass Group	PV panel glass, solar plants engineering & construction	RSR	HKD	CHINA
Freyr Battery SA	Batteries, decarbonization includes cell manufacturing.	ENS	USD	NORWAY
FTC Solar	Solar, ground mounted trackers; also PV software.	RSR	USD	US
FuelCell Energy	Fuel cells, high temperature and hydrogen.	ECV	USD	US
Ganfeng Lithium	Lithium, production metals, for batteries.	ENS	HKD	CHINA
Gevo	Biofuels, lower carbon liquid fuels, renewable sources.	RBB	USD	US
Grenergy Renovables SA	Solar 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
Hexagon Composites	Compressed hydrogen gas storage for vehicles, etc.	ENS	NOK	NORWAY
Iljin Hysolus	Hydrogen tanks, for fuel cell cars, trucks, ships, planes.	ENS	KRW	S. KOREA
Iljin Materials	Rechargeable battery materials, elecfoils for batteries.	ENS	KRW	S. KOREA
Infrastructure and Energy	Green infrastructure, EPC for wind and solar energy.	RWD	USD	US
Innergex Renewable	Renewable power, run-of-river hydro, wind, solar.	ROH	CAD	CANADA
ITM Power plc	Fuel cells, uses PEM technology; also hydrogen.	ECV	GBP	UK
Itron	Meters, Utility energy monitor, measuring & manage.	EEF	USD	US
JinkoSolar	Solar, wafers through solar modules, China OEM.	RSR	USD	CHINA
JL Mag Rare-Earth	Rare Earths, magnets in EVs; wind turbines; Nd-Fe-B.	ECV	HKD	CHINA
Joby Aviation	Electric Aircraft, more efficient transportation.	EEF	USD	US
Kingspan Group plc	Efficient Buildings, insulation for conservation, Ireland.	EEF	EUR	IRELAND
Landis+Gyr Group AG	Advanced meters, modernizing grid, Switzerland.	EEF	CHF	SWITZERLAND
L&F Co.	Cathode active materials, closing battery loops.	ENS	KRW	S. KOREA
LG Energy Solutions	Li-ion battery leader, in grid, EVs, transport etc.	ENS	KRW	S. KOREA
Li-Cycle	Recycling lithium-ion batteries, recover raw material.	ENS	USD	US
Lilium NV	Electric jet aircraft, vertical takeoff/landing, Germany.	EEF	USD	GERMANY
Lion Electric	Electric Vehicles, urban trucks, buses, V2G.	ENS	USD	CANADA
Lithium Americas	Lithium, projects in Nevada USA, and in Argentina.	ENS	USD	US

Livent	Lithium, production of compounds, batteries.	ENS	USD	US
Lordstown Motors	Electric Vehicles, pickup trucks, telematics.	ENS	USD	US
Lucid	Electric Vehicles, premium, higher-voltage, range.	EEF	USD	US
Maxeon Solar	Solar panel manufacturer, a spinoff from Sunpower.	RSR	USD	US
McPhy Energy	Hydrogen, electrolyzers using water, H2 storage.	ECV	EUR	FRANCE
Mercury NZ	Clean power, 100% renewable hydro, geothermal.	ROH	NZD	NEW ZEALAND
Motech	Solar, cells and modules manufacturing.	RSR	TWD	TAIWAN
MP Materials	Rare Earths, US sourced strategic Neodymium, NdPr.	ECV	USD	US
Nel ASA	Hydrogen, in fuel cell vehicles, renewably, Norway.	ECV	NOK	NORWAY
Neoen SA	Renewable energy, mainly in solar, some wind.	RSR	EUR	FRANCE
Nexans SA	Cables, for grid power infrastructure.	EEF	EUR	FRANCE
Nibe Industrier AB	Heating & cooling, sustainable technologies, Sweden.	EEF	SEK	SWEDEN
Nio	Electric Vehicles, design, manufacture, premium EVs.	ENS	USD	CHINA
NKT A/S	AC/DC cables, grid infrastructure improvements.	EEF	DKK	DENMARK
Nordex SE	Wind turbines, based in Germany/Europe, worldwide.	RWD	EUR	GERMANY
Novozymes A/S	Biofuels, enzymes used in partnerships, Denmark.	RBB	DKK	DENMARK
Ormat	Geothermal, works too in recovered heat energy.	ROH	USD	US
Orsted A/S	Sustainable wind, also biomass, thermal, Denmark.	RWD	DKK	DENMARK
OX2 AB	Wind and solar farms, from design to development.	RWD	SEK	SWEDEN
Piedmont Lithium	Lithium, US-based source for battery-grade lithium.	ENS	USD	US
Plug Power	Small fuel cells, e.g. in forklifts; drop in replacements.	ECV	USD	US
Powercell Sweden	Fuel cells, transportation, marine, stationary uses.	ECV	SEK	SWEDEN
Proterra	Electric transit buses, EV charging solutions.	EEF	USD	US
Prysmian SpA	Cables, renewable power transmission, global.	EEF	EUR	ITALY
Quantumscape	Lithium metal batteries, solid state, quicker charge.	ENS	USD	US
ReneSola	Solar, project developer and operator, worldwide.	RSR	USD	CHINA
Renew Energy Global plc	India renewables, wind, solar energy Utility scale.	RWD	USD	INDIA
Renova	Wind, Solar, Biomass, power generation in Asia.	RWD	JPY	JAPAN
Rivian	Electric trucks and vehicles, fast charging network.	ENS	USD	US
Samsung SDI	Batteries, innovative energy storage, EVs, South Korea.	ENS	KRW	S. KOREA
Scatec ASA	Solar power, develops, owns and operates worldwide.	RSR	NOK	NORWAY
SFC Energy AG	Fuel cells, direct methanol (DMFC) technology.	ECV	EUR	GERMANY
Shoals Technologies	Solar, electric balance of system, wiring, combiners.	RSR	USD	US
Signify NV	Lighting, systems increasing efficiency, Netherlands.	EEF	EUR	NETHERLANDS
Sino-American Silicon	Solar, semi-conductor silicon wafer materials, Taiwan.	RSR	TWD	TAIWAN
SK IE Technology	Battery materials, separators and ceramic coated.	ENS	KRW	S. KOREA
SMA Solar Technologies	Inverters for solar, industrial scale storage, Germany.	RSR	EUR	GERMANY
Sociedad Quimica Chile	Lithium, a key element in advanced batteries, Chile.	ENS	USD	CHILE
Solid Power	Towards solid state batteries, sulfude eectrolyte.	ENS	USD	US
SolarEdge	Inverters, panel-level solar optimizers, micro-inverters.	RSR	USD	US

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

124 stocks/100 = Indiv. Weights for Q3 2022 **WEIGHT EACH COMPONENT = 0.806451**

124 Stocks for Start of Q3 2022.		**#**	**% Approx. Weight**
Energy Conversion	**ECV**	**15**	**12%**
Energy Efficiency	**EEF**	**24**	**19%**
Energy Storage	**ENS**	**26**	**21%**
Renewables - Biofuels & Biomass	**RBB**	**4**	**3%**
Renewables - Other	**ROH**	**5**	**4%**
Renewable - Solar	**RSR**	**28**	**23%**
Renewable - Wind	**RWD**	**22**	**18%**
		124	**100%**

8 NEX adds for Q3 2022: Aker Horizons, Brookfield, Dongkuk, Infrastructure, JL Mag, Lilium, OX2, Renew Energy Global

9 NEX deletes for Q3 2022: Aker Offshore Wind, Azure, Cloudberry, Electreon, Fastned, Gencel, Gurit, Siemens Gamesa, Wallbox

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Comparisons and Differences among the 5 WilderHill Indexes:

Index Name and (symbol)	**WilderHill Clean Energy (ECO)**	**WilderHill New Energy Global Innov. (NEX)**	**WilderHill Hydrogen Economy (H2X)**	**WilderHill Wind Energy (WNX)**	**WilderHill Cool Climate (OCEAN)**
Theme / Year went Live:	First-ever for Clean Energy - since 2004	First-ever for Global Clean Energy - 2006	New for Hydrogen – went live 2022	New for Wind Energy – went live 2022	Healthy oceans/climate – since 2019
Index Components are listed:	On US Exchanges: NYSE and NASDAQ	Global, on Solactive's developed nations list plus Taiwan, S. Korea[i]	Global, on Solactive's developed + Taiwan, S. Korea, China	Global, on Solactive's developed nations + Taiwan, S. Korea, China	Global, on Solactive's developed nations + Taiwan, S. Korea, Chile
Index Weighting Method:	Modified-equal weight, gives voice to all in ECO.	Straight-equal weight; gives a voice to all components	Straight-equal weight; gives a voice to all components	Straight-equal weight; gives a voice to all components	Straight- equal weight; gives a voice to all components
Components minimum floor requirements>	Must be over >$50m minimum market cap past 3 months. Share price must also be >$1.00 average past 3-months. Any companies under <$200m in market cap at rebalance, are *Banded with a 0.50% weight each.	Over >$100m market cap past 3 months. Over >$750k ADTV floor past 3 months on existing components; Over >$1 million ADTV for new components. No breach of the UN Global Compact principles. No severe controversies per categories and thresholds provided[ii]	Over >$100m market cap past 3 months. Over >$750k ADTV floor past 3 months on existing components; Over >$1 million ADTV for new components. No breach of UN Global Compact principles / nor severe controversies. Severe ESG Risk Ratings are excluded.	Over >$100m market cap past 3 months. Over >$750k ADTV floor past 3 months on existing components; Over >$1 million ADTV for new components. No breach of the UN Global Compact principles / nor severe controversies. SESG Risk Ratings are excluded.	Must be over >$150m market cap. ADTV 30 days >$500k
Independent ETF/UCITS?	Yes: PBW	PBD in US; GCLE.L in Europe			
Clean - avoids fossil fuels & nuclear?	Yes	Yes, & meets EU BMR in Europe.	Yes, & meets EU BMR in Europe.	Yes, & meets EU BMR in Europe.	Yes
Volatile – has purer plays?	Yes	Yes	Yes	Yes	Yes

[i] Solactive List of developed countries from eg 2019 is at, https://www.solactive.com/wp-content/uploads/2019/11/Solactive-Country-Classification-Framework-v1.1_2019.pdf

[ii] For more details on fields for exclusion as well as the thresholds applied for exclusion, please refer to table at, https://cleanenergyindex.com/pdf/Solactive%20_%20NEX%20Methodology%20Change%20_%20Wilderhill%20New%20Energy%20Global%20Innovation%20_%20Effective%2016%20March%202022.pdf

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

NEX Historical Sector Weight Information

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

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

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

Appendix VII:
WilderHill Hydrogen Economy Index (H2X) at the live launch in Q2 on 17 June 2022:

Hydrogen (H2X) - components	Theme	Sector	Activity
2G Energy AG	Hydrogen, in combined Heat and Power (CHP) systems.	HI	GERMANY
Abb	Electrification systems and engineering for green H2.	HS	SWITZERLAND
AFC Energy PLC	Alkaline fuel cells, can use a wide variety of fuel sources.	FC	UK
Aker Horizons ASA	Decarbonizing and sustainable energy	GH	NORWAY
Archaea Energy	Landfill waste to renewable natural gas, and H2.	HI	USA
Ballard Power Systems Inc	Fuel cells, H2 in buses, trucks, trains, backup power etc.	HT	CANADA
Bloom Energy Corp	Fuel cells, SOFC high temps can use variety of fuel sources.	FC	USA
Brookfield Renewable Energy	Teaming to produce green hydrogen from hydroelectricity.	HI	USA
Ceres Power Holdings PLC	Fuel cells, high SOFC temperature allows variety of fuels.	FC	UK
China Datang Renewables Corp	Wind & hydro in China, that's developing H2 projects.	HG	CHINA
Chung-Hsin Electric	Fuel cells. Hydrogen, methanol reformers.	HG	TAIWAN
Compagnie Plastic Omnium SE	H2 storage in high pressure tanks for vehicles, fuel cells.	HT	FRANCE
Corp. Acciona Energias Ren.	Green H2, new GreenH2Chain to ensure green H2 origins.	HI	SPAIN
CropEnergies AG	Renewable H2 from sustainable ethanol production.	HI	GERMANY
Doosan Fuel Cell	Fuel cells, high temperature for a variety of fuels.	FC	S. KOREA
Fuelcell Energy Inc	Fuel cells, high temperature operate range of fuel sources.	FC	USA
Gevo Inc	Biofuels, energy dense net-zero carbon liquid fuels.	HG	USA
Greenvolt Energias	Biomass to hydrogen without need for combustion.	HG	PORTUGAL
Hexagon Composites ASA	Composite high pressure storage, transport of hydrogen.	HS	NORWAY
Hexagon Purus	High pressure tanks in FC EV battery E-mobility.	HT	NORWAY
Hyosung Advanced Materials	Advanced composite materials for hydrogen tanks.	HS	S. KOREA
Hyster-Yale	Fork lifts and trucks running on hydrogen fuel cells.	HT	USA
Hyzon Motors Inc	Hydrogen powered commercial trucks run on fuel cells.	HT	USA

Iljin Hysolus	Compressed hydrogen tanks for fuel storage.	HS	S. KOREA
ITM Power PLC	Fuel cells, PEM; also electrolyzer manufacturing green H2.	GH	UK
JL Mag Rare Earth	Rare earths, in fuel cells & SOFCs, electrolyzers.	HI	CHINA
Linde PLC	Industrial gases production, including hydrogen.	HG	UK
Lotte Fine Chemical	Green hydrogen production launch, ammonia.	GH	S. KOREA
Mcphy Energy SA	Hydrogen production, use, and storage; H2 in industry.	HI	FRANCE
Nel ASA	Electrolysis for H2 from water, using alkaline and PEM.	GH	NORWAY
Neoen SA	Water Electrolysis and renewable energy for green H2.	HG	FRANCE
OCI N.V.	Green Ammonia, building large-scale from Hydrogen	HG	NETHERLANDS
Orsted A/S	Green hydrogen directly from wind power, early stage.	GH	DENMARK
Plug Power Inc	Green hydrogen and fuel cell systems in development.	FC	USA
Powercell Sweden AB	Fuel cell systems, both clean H2 and fossils for fuels.	FC	SWEDEN
Proterra	Heavy Bus electrification systems, early H2.	HI	USA
Scatec ASA	Green Hydrogen produced by solar power.	GH	NORWAY
Schneider Electric SE	Gas analysis, automation for advanced H2 storage.	HS	FRANCE
SFC Energy AG	Direct methanol and H2 supplied small fuel cells.	FC	GERMANY
SGL Carbon SE	Polymer electrolyte membrane in PEM fuel cells.	FC	GERMANY
Siemens Gamesa	Electrolyzers with intermittent renewables, green H2.	GH	SPAIN
SK IE Technology	Converts low-purity 60% H2 to high-purity 99% H2.	HI	S. KOREA
SMA Solar Technology	Electrolyzer converters, green H2 from renewables.	GH	GERMANY
Toray Industries	Membranes for H2 purification, generation, fuel cells.	HI	JAPAN
United Renewable Energy	Hydrogen fuel cell powered motorcycle.	HI	TAIWAN
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
Xebec Adsorption	Hydrogen maker, renewable gases from Agriculture.	HG	CANADA
Yara International	Green hydrogen catapault aims for H2 <$2/kg.	GH	NORWAY

EQUAL WEIGHT 51 components = % **1.960784% Weight Each**

Hydrogen Index Sector

FUEL CELLS (FC)	9
GREEN HYDROGEN (GH)	10
HYDROGEN GENERATION (HG)	10
HYDROGEN INNOVATION (HI)	11
HYDROGEN STORAGE (HS)	5
HYDROGEN in TRANSPORT (HT)	6

Appendix VIII:
WilderHill Wind Energy Index (WNX) at the live launch in Q2 on 17 June 2022:

Wind Energy (WNX) - components	Theme	Sector	Activity
Abb Ltd.	Wind turbines, generators and converters.	WM	SWITZERLAND
Acciona	Sustainability infrastructure, engineering.	SG	SPAIN
Aker Horizons	Sustainable energy icludes wind, hydrogen.	WI	NORWAY
Azure Power Global	Expanding to wind, from solar farms, India.	WF	INDIA
Boralex Inc	Development and operation of wind farms.	WF	CANADA
Brookfield Renewable Corp.	Pure plays renewables wind, hydro, solar.	WF	USA
Cadeler A/S	Offshore windfarm installation vessels.	WI	NORWAY
China Datang Corp Renewable	Among largest listed wind operators in China.	WF	CHINA
China High Speed Transmission	Wind turbine gearboxes, heavy duty.	WM	CHINA
Corporacion Acciona Energias	Wind, global energy exclusively on renewables.	WI	SPAIN
CS Wind	Wind power, both onshore, and also offshore.	WF	S. KOREA
Dongkuk Structures	Wind tower steel structures.	WM	S. KOREA
EDP Renovaveis SA	Wind, among the world's largest generators.	WI	PORTUGAL
Elia Group SA	High voltage power transmission, Europe/UK.	SG	BELGIUM
Encavis AG	Wind energy plants across Europe, solar too.	WF	GERMANY
Energiekontor AG	Wind Farm Developer, and group ownership.	WF	GERMANY
Energy Vault	Energy storage, re-purposing old wind blades.	WI	USA
Enlight Renewable Energy Ltd	Builds and operates wind, also solar sites.	WF	ISRAEL
Fastned BV	EV Chargers use local renewable wind power.	SG	NETHERLANDS
FREYR	Wind used for new green battery manufacture.	SG	NORWAY
Greenvolt Energias	Wind, residual biomass & urban demo waste.	WF	PORTUGAL
Grenergy Renovables SA	Wind projects in Chile, Peru, elsewhere.	WF	SPAIN
Gurit Holding AG	Wind turbine blade tooling, composites.	WM	SWITZERLAND
Hexagon Composites ASA	Composite material inspection technology.	WM	NORWAY
Infrastructure and Energy Alter.	Initial layout to construction of wind farms.	WM	USA
Innergex Renewable Energy Inc	Independent renewable producer, wind.	WF	CANADA
JL Mag Rare Earth	Rare Earths, in wind turbines, EVs, fuel cells.	WI	CHINA
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
Prysmian SpA	Cables for new offshore wind and grid.	SG	ITALY
Renew Energy Global	Utility scale wind farms, India.	WF	INDIA
Renova Inc	Independent renewable power producer.	WF	JAPAN
Schneider Electric	Advanced grid, wind energy management.	SG	FRANCE

SGL Carbon SE	Composite and graphite materials in wind.	WM	GERMANY
Siemens Gamesa Renewable	Among largest offshore & onshore wind.	WI	SPAIN
SKF AB	Wind gear rolling bearings, seals, mechatronics.	WM	SWEDEN
SMA Solar Technology	Wind power conversion; green H2 from wind.	SG	GERMANY
Terna Rete	Europe's largest independent grid operator.	SG	ITALY
Toray Industries	Carbon fiber for wind turbine blades.	WI	JAPAN
TPI Composites Inc	Wind blade manufacturer, assemblies.	WM	USA
Unison Co Ltd	Wind turbine manufacturing, S Korea.	WM	S. KOREA
Vestas Wind Systems A/S	One of first, largest, wind turbine makers.	WI	DENMARK
Voltalia SA	Renewables wind, solar, hydro, biomass, H2.	SG	FRANCE
Xinjiang Goldwind Science & Tech.	Wind turbine maker onshore & offshore, China.	WM	CHINA

48 components = 100/48 = 2.08% **Weight Each**

4 WilderHill Wind Index Sectors	**#**
SMARTER GRID (SG)	11
WIND FARMS (WF)	15
WIND INNOVATION (WI)	11
WIND MATERIALS (WM)	11
Total =	48

Appendix IX, Cool Climate™ Clean Solutions Index (OCEAN) for latter Q2 2022, 103 components:

WilderHill Cool Climate OCEAN comp.	Theme	Activity	Sector
Aalberts NV	Flow control, integrated piping, efficiency.	Netherlands	WT
Acciona SA	Water treatment; greener transportation.	Spain	WT
Acciona Energia	Renewables energy generation, exclusively.	Spain	CE
Advanced Drainage	Water management, drainage products.	USA	WT
AFC Energy	Fuel Cells, alkaline, may use ammonia.	UK	GT
Aker Horizons ASA	Sustainable energy, offshore wind.	Norway	CE
Alfa Laval AB	Fluid Handling, controls, on vessels.	Sweden	WT
Alfen NV	Smart power grids, energy storage.	Netherlands	PP
American States Water	Water and Wastewater Services.	USA	WT
American Water Works	Water and Wastewater Systems.	USA	WT
Badger Meter	Water Metering.	USA	WT
Ballard Power	Fuel cells, future power in Ports and Shipping.	Canada	GT
Beyond Meat	Plant-based meats, less impactful proteins.	USA	PP
Bloom Energy	H2 fuel cells, power ahead ports, shipping.	USA	GT
Bollore SE	Better Sustainability in Ports & Terminals.	France	GT

BYD	Batteries, zero emission vehicles.	China	PP
California Water Service	Water and Wastewater Utility Services.	USA	WT
Canadian Solar Inc	Solar, panel manufacturer.	Canada	CE
Canoo	Electric vehicles, multi-purpose.	USA	PP
Cargotec OYJ	Better Sustainability in Ports & Terminals.	Finland	GT
Ceres Power	H2 fuel cells, power ahead ports, shipping.	Britain	GT
Chargepoint	EV residential and commercial charging.	USA	PP
Corbion NV	Algae, sustainable alternative in aquaculture.	Netherlands	PP
CS Wind	Wind, tower structures.	S. Korea	CE
Danimer Scientific	Bioplastics, biodegradable materials.	USA	PP
Doosan Fuel Cells	Fuel cells, future power in Ports and Shipping.	S. Korea	GT
EDP Renovaveis SA	Renewables, among world's largest in wind.	Spain	CE
Encavis AG	Renewable Energy, solar & wind in Europe.	Germany	CE
Energiekontor AG	Wind, Solar, from planning to operations.	Germany	CE
Enlight Renewable	Solar, construction and operations, also wind.	Israel	CE
Eolus Vind AB	Wind power projects in Sweden, US, Estonia.	Sweden	CE
Essential Utilities (was Aqua)	Water and Wastewater Services.	USA	WT
Evoqua	Water, wastewater treatment.	USA	WT
Fisker	EV designs, with 3rd party manufacturing.	USA	PP
First Solar	Solar, thin film panels.	USA	CE
Flat Glass Group	Glass, specialized solar panels.	China	CE
Franklin Electric	Water, pumping, systems.	USA	WT
FREYR Battery	Batteries, made from green renewable energy.	Norway	CE
FuelCell Energy	H2 fuel cells, power ahead ports, shipping.	USA	GT
Geberit AG	Waste treatment, supply, piping.	Switzerland	WT
Georg Fischer AG	Water transport, piping systems.	Switzerland	WT
Grenergy Renovables SA	Solar power parks, wind power.	Spain	CE
Grieg Seafood ASA	Seafood, aquaculture with high ESG scores.	Norway	SF
Halma plc	Water analysis, monitoring, treatment.	Britain	WT
Idex	Water, pumps, flow meters, fluid systems.	USA	WT
Innergex Renewable	Run-of-river Hydro power, Wind, Solar.	Canada	CE
Intertek Group plc	Cargo and Trade services, quality assurance.	Britain	PP
ITM Power PLC	Electrolysis for green hydrogen, zero CO2.	Britain	PP
Itron	Smart Grid Power and Water Management.	USA	PP
Kingspan Group PLC	Building Insulation.	Ireland	PP
Kuehne und Nagel	Shipping Logistics, clean cargo group.	Switzerland	PP
Kurita Water	Water Treatment, wastewater systems.	Japan	WT
Leroy Seafood Group	Seafood, with high FAIRR Report score.	Norway	SF
Maxeon Solar	Solar, higher-efficiency premium PV panels.	USA	CE
McPhy Energy SAS	Hydrogen, for decarbonization.	France	PP

Mercury NZ	100% Renewables by hydro, geothermal, wind.	New Zealand	CE
Metawater	Water purification, sewage treatment plants.	Japan	WT
Middlesex Water	Water supply, and infrastructure.	USA	WT
Mowi ASA	Seafood, with high FAIRR Report score.	Norway	SF
MP Materials	Rare Earths, used in EVs, wind turbines etc.	USA	PP
Mueller Water	Water Metering, and infrastructure.	USA	WT
Nel ASA	Hydrogen, made from renewable resources.	Norway	PP
Neoen S.A.	Renewables, using wind, solar, biomass.	France	CE
Nibe Industrier AB	HVAC, other areas in sustainability.	Sweden	PP
Nio	Battery electric vehicles, China based.	China	PP
Organo Corp.	Water treatment engineering, Japan.	Japan	WT
Origin Materials	Carbon negative materials, processes.	USA	PP
Orsted A/S	Wind, offshore and onshore; also solar power.	Denmark	CE
P/F Bakkafrost	Seafood, with high FAIRR Report score.	Norway	SF
Pentair PLC	Water Efficiency and Treatment.	Britain	WT
Plug Power	H2 fuel cells, power ahead ports, shipping.	USA	GT
PowerCell Sweden	H2 fuel cells, power ahead ports, shipping.	Sweden	GT
Primo Water	Water, less waste large refillable exchanges.	Canada	WT
Proterra	Electric buses, trucks, vans, EV systems.	USA	GT
Quantumscape	Solid state lithium-metal batteries.	USA	PP
SalMar ASA	Seafood, aquaculture with high ESG scores	Norway	SF
Samsung SDI	Li Ion Batteries.	S. Korea	CE
Scatec Solar ASA	Solar, developer across emerging nations.	Norway	CE
SFC Energy AG	Fuel Cells, direct methanol.	Germany	GT
Shoals Technologies	Solar, electric Balance of System for PV.	USA	CE
Siemens Gamesa Renewable	Wind turbines, and focus on renewables.	Spain	CE
Signify NV	LEDs, was Philips Lighting.	Netherlands	PP
Sino-American Silicon Products	Solar feedstock, wafers.	Taiwan	CE
SolarEdge	Solar MicroInverters	USA	CE
Solaria Energia y Medio	Solar, Wind, power from renewables plants.	Spain	CE
Stantec	Consulting, Water, Buildings, Energy.	Canada	WT
Sunnova Energy	Residential Solar and Energy Storage.	USA	CE
SunPower Corp	Solar, services plus storage.	USA	CE
Sunrun Inc	Solar, residential Installer.	USA	CE
Terna SpA	Grid Efficiency for more Renewables.	Italy	CE
Tomra Systems ASA	Recycling wastes, materials recovery.	Norway	PP
Trimble	Precision Agriculture, greater efficiency.	USA	PP
Veolia Environnement	Water and Wastewater Treatment.	France	WT
Verbund AG	Renewable Energy, hydropower.	Austria	CE
Vestas Wind Systems A/S	Wind power, in both products and services.	Denmark	CE

Wartsila OYJ	Ports, Terminals, energy with sustainability.	Finland	GT
Watts Water Technologies	Water quality, rainwater harvests, flow control.	USA	WT
Wolfspeed (was CREE.OQ)	Electrifying power, Si-C.	USA	PP
Xinjiang Goldwind Science & Tech.	Wind, turbine manufacturer, also in services.	China	CE
Xinyi Solar Holdings Ltd	Solar glass, has spun off solar farms.	China	PP
Xpeng	Electric vehicles, connectivity.	China	PP
Xylem	Water Technologies.	USA	WT
Zurn Water Solutions	Water efficiency, products design.	USA	WT

For Rebalance in latter Q2 2022 of OCEAN Index

6 Deletes: AOW.OL, AZRE.N, EOSE.OQ, GWH.N, METEX.PA, XBC.TO

1 Addition: AKH.OL

Equal Weight = 100/103 = 0.925925% each. 0.9708737

SECTOR	#	Approx %
GREENER TRANSPORT (GT) =	13	13%
CLEAN ENERGY (CE) =	32	31%
WATER (WT) =	27	26%
SUSTAINABLE FOODS (SF) =	7	7%
POLLUTION PREVENTION (PP) =	24	23%
TOTAL CONSTITUENTS =	**103**	

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

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

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

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