WilderShares, LLC

Q4 2021 WilderHill® Quarterly Report: ECO, NEX, OCEAN, December 31, 2021

The Clean Energy Index® (ECO) started 4th Quarter near 160 and ended near 150, down for Q4 about -7%. In the year, ECO Index® began 2021 at 215 and so was down -30%. After its notable +203% gain for 2020 when this ECO decarbonization story rose hard by 6-fold, about the best performance for any Index or Fund anywhere and that followed a +58% rise for prior 2019 – a strong 2021 decline was maybe overdue. Thus it wasn't so surprising after ECO Index fell in early 2020 by ½ to 50, rising next to 280 - to see it fall again in 2021 by ½, to near 140. Volatility partly due to green policies (up) - or reconciliation bill's death (down, yet its energy portions may be resurrected). Since 2017 when volatile ECO was 38, it's up +300%.

As we emphasize, ECO, global NEX, and OCEAN each passively captures risky themes, so can & will at times 'drop like a rock'. Big gains, still bigger drops can happen here. That may go on as solar evolves to become the most affordable electricity anywhere, anytime in history. Potentially, this might mean more demand ahead for new energy from the US, Europe, Asia. If new jobs & infrastructure, low-cost clean power & equity overlap good climate solutions – there might be ongoing volatility. Perhaps not only solar, but also in onshore & offshore wind, electric vehicles, batteries, energy storage, green hydrogen, fuel cells, thinking informed by ESG and deep decarbonization of everything – unlike anything seen before.

For a last 5 years the Benchmark ECO Index live since 2004, 1st to capture climate solutions, as noted is up +300% through 2021. That in a period when any big energy gains can stand out. For over these same 5 years, CO_2-laden oil & gas despite a recent rise, are still *down by* -50%, fossils are down -80% in a last 10 years. That's in a stark contrast to decarbonization as an organizing theme in ECO, NEX, & OCEAN, for very differing sustainable energy returns.

The first *global* clean energy Index is the New Energy Global Innovation Index (NEX) live since 2006 with a tracker in Europe too: it's up about +200% for last 5 years, starkly beating fossils. NEX has often outperformed too vs. a less-pure, not so clean, independent other 'global clean energy' Index most sizable periods past 1 year, 10 years, 12 years, since their inception etc; much greater thematic purity in the NEX & equal weights here help explain that divergence. In sum WilderHill themes are clean pure-play benchmarks. And energy long dug from down deep underground & burned – increasingly is captured now in disruptive & sustainable ways – fuel that's coming to us all freely and renewably from up towards Heavens.

The Clean Energy Index® (ECO) live since 2004 is the first for clean energy and climate solutions. ECO Index® is a benchmark, with longest record & it moves differently vs. coal, oil & gas. Along with the Global clean energy NEX live since 2006, they're highly-respected pure plays, the best-known for capturing solar, wind, electric vehicles, batteries, green hydrogen, fuel cells, decarbonizing, & electrification of everything. The WilderHill® Indexes are volatile with a non-correlation to fossil fuels. They're innovative, transparent, naturally informed by sustainability & ESG thinking, and can help to build a diversified portfolio.

Source: NYSE.com

Recent Q4 and all 2021:

Clean energy & climate solutions are best and longest captured in the ECO and NEX Indexes. Here they are seen with other relevant themes 4th Quarter and all 2021, to mid-December:

Source: finance.yahoo.com

Interestingly above, a very new situation presented itself for all 2021. Unlike last 3, 5, 10 years, here clean/green ECO & NEX *were clearly at bottom, down by* -20% to -27%. At middle were the Dow, S&P500, and ACWI world clumped up +15% to +25%. At top were fossil fuels in 2021: oil was up near +60%, natural gas was up +40%. Oh my, what a reversal!

As we'll see in stepping back, this has only happened after a very long, very steep fall in all 'fossils' (fossil fuels). So that probably should be taken into account. In 2021 a new inflation and likely higher interest rates – hit the speculative clean energy theme hard. Whether there's regression to mean ahead, again like past 5 or 10 years with fossils again falling – and clean rising – is to be seen. That, doubtless, will be a keen topic in Reports ahead.

For 2021, in sum, clean themes fell hard – so passively reflected in our Indexes. ECO ended Quarter and 2021 year near a bottom – back where it had been mid-2020. Meanwhile, fossils jumped at a start of an energy transition characterized by volatility. It showed energy prices worldwide are still dominated by the fossil fuels: coal, oil & natural gas – and issues there within those fossils, had accounted for most of that turmoil over an energy-volatile-2021.

In short energy costs still reflect the fuel that lately is most dominating power supply - ensuring grid stability. Rather like income tax, is at the marginal rate for last dollar earned. Last year natural gas was key: and thus, as natural gas/fuel prices spiked worldwide late 2021 – so too, did all energy costs overall. Even America's cost of electricity from coal, which rose too by +22% in 2020-2021 though as a one-off, non-long-term trend. Many more energy crises doubtless shall recur this decade - even as costs for renewables, hold steady or decline as we'll see in pages ahead. In sum fossil prices *rose* hard in 2021 – after deep lows there. Prior years, our green themes often 'did better' than fossil fuels. But that changed in 2021, as oil, gas, and coal - admittedly coming off their own deep lows - clearly instead jumped.

Since fossils had dramatically plunged 2020 – the 2021 gains had come only *after* US coal production hit 50-year lows in 2020 as 151 mines were closed or idled. Only *after* oil had hit historic lows in 2020 on global Demand Collapse. The oil industry needs oil at least in $60s: oil down near 'just' $50 per barrel had been punishing to indebted shale producers, $40 oil may mean misery ahead for producers, even countries. Equities are inherently forward-looking so oil's volatile theme in 2020, hadn't then seemed attractive for capital investment. Thus was only after first very big supply cuts + and then renewed demand discussed ahead, that fossils rose strongly 2021 on supply constraints. And yet such spiking natural gas prices may make clean relatively very attractive ahead – again vs. gas-fired thermal power.

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

To underscore, oil's 2021 price rebound came only after first very big supply cuts, followed by slow production resumption, a resuscitating industry, tightening slack. Otherwise, were a prior 100m+ barrels/day of oil still supplied, that would have prolonged collapse. As for coal, it's no longer tracked by an ETF; no new coal plants are being built in US. Yet coal prices jumped too by +25% in 2021 - but mainly on overseas demand and a gas crunch. US coal economics are dismal, so miners look to where it's burned and Asia had the appetite 2021. And thus the fact that America's domestic coal supply had once been last century's cheapest, dirtiest, most stable source of electricity, suddenly is no longer much in its favor.

Discussed ahead too, so just touched on here, is a fast-increasing greenwashing by fossil interests wedded to oil & gas. Much hype for the new 'blue hydrogen' – though methane leaks render H_2 (hydrogen) made from gas about as awful as burning the fossil directly. Electricity made from natural gas in the US & in China, will still be huge in 2030. Given global heating, that's a huge worry, with India and China etc burning much coal. While Western Europe by 2030 *may* have reduced its gas sizably by then – its nukes & coal by more - with big stumbles along the way like acute gas shortages discussed ahead. A result is Europe, especially Germany *may* get 50%+ of its electricity from renewables 2030. Said conversely, that 2 of world's 3 big blocs may still need much dirty non-renewables at end of this decade, looms large.

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

One possibility ahead may be a look to Germany, Vietnam, Malaysia etc for acceptable poly supply. 'Clean' poly sent to China PV plants would add more distance + shipping costs. That said, European factories will soon run-on green power, manufacturing globally done more-carefully, supply chains attuned to diverse issues which is now beginning. Clean, sustainable everything and circular processes increasingly sought. Especially for industries/regions that had once relied on dirty coal power – now that renewable baseload power is available.

Change is afoot. Sometimes swifter pace than expected. Maybe an EV + battery + solar firm writing software to allow it to harness deployed PV systems to sell power directly – competing with Utilities. Maybe, spiffy electric aircraft to challenge past hegemony of fossil fuels, better efficiency for air transportation. Or cleaner power for ships. Perhaps batteries made at less-cost & on lower-carbon-lithium, sodium, graphite. 'Greener' rare Earths in wind, EVs. Possibly, recycling batteries, improving anodes/cathodes, circular economies. But given that CO_2 levels already are over 400 ppm and growing, there's no realistic possibility of holding global heating to aims of 1.5 C let alone 2 degrees C. Climate emergency is a certainty ahead. Thus, all the above maybe very welcome & necessary - yet nowhere fast enough.

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

Data from 2021, had made clear too, that there never was any hoped-for 'green recovery'. No 'post-pandemic' moves *away* from fossil fuel, since CO_2 emissions first half 2021 exceeded pre-pandemic by over 5%. They got worse 2nd half. From a climate perspective, we're losing badly. Climate facts so far are No cause for optimism. Not this decade, nor century.

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

A Build Back Better (BBB) reconciliation bill had one-third, $550 Billion of it devoted to climate/clean energy and needed No votes from a conservative party. It might pass if voted-for unanimously by a liberal party. Its $3.5 Trillion was a wish-list of liberal aims; it was big, climate-heavy. Text shaped first mid-2021 had Grants (carrots) for utilities to go clean power - and those that didn't, paying Fees (sticks). There'd be many big green tax credits too. For incentives, utilities *growing* clean energy 4%/year in an 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 at utilities *not* cleaning up would instead be hit by fees. Nuclear could benefit like solar, wind, hydro: each might win as being 'zero-carbon' under this proposed legislation.

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

Progressives weren't concerned over the pay-fors, nor $3.5 Trillion reconciliation size. For them taxes on wealthy work fine – or the deficit-spending used by conservatives to cut taxes. They'd noted blood & treasure was spent on wars without benefit. They feared their own party's moderates were too concerned over pay-fors, not enough about climate – so might go only for a smaller $1.2 Trillion bipartisan bill. Moderates did win a vote deadline on smaller bill, so there was tension last days Q3 to agree on the big BBB bill as well. Liberals aimed for a $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 had grown self-evident any BBB figure would be under $3.5 Trillion, so there was choc-a-bloc uncertainty. All got pushed to Q4 - when a deal might finally happen near Christmas, or all fall apart. If BBB died there'd perhaps still be a narrow lane to resurrect parts, say desired pro-clean energy tax credits in more piecemeal fashion in 2022.

Were just a $1T bipartisan bill all that can pass, that might be worse than nothing to many progressives; so, several wouldn't support such bill. Progressives' leverage was to link the 2: they knew several moderates sought $1T on roads & bridges maybe 'carbon sequestration' and nuclear too. Many progressives were thus willing to deny it, to get reconciliation done. A main progressive leader felt $6 Trillion BBB was right given scale of this problem. That higher taxes and/or deficits could pay for it. That $3.5 Trillion was already a compromise. But such leverage was soon challenged in Q4, by the real possibility of perhaps No Deal on either.

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

While the infrastructure in that moderate Senator's state was poor, their willingness to wait, or move goal posts meant a 2021 BBB window could soon close. Finding a sweet spot soon on $$ size was key. All agreed Infrastructure = jobs. That one Senator as Committee Chair helped sculpt bipartisan bill, so desired it. Goodies could also make much possible (recall Bob Byrd?) so bringing moderates off fence. But, would a $2T reconciliation BBB also happen? Or just the smaller bill? Or might internal dissension within a liberal party sink both bills/all!?? Progressives were arguably correct to try to hold to all or nothing - there was 'nothing' for climate in roads and bridges. But heated infra-party dissension could kill both. All came to a juncture just before a G-20 meeting and global COP26 Climate Conference in Scotland.

It had boiled down in November to could reconciliation with some teeth, some climate action, but 'just' at $1.5 - $2 Trillion – win unanimous support needed? Progressives had felt that it should be all, or nothing at all. They saw the weak $1T Bipartisan bill was wedded-to old fossil thinking, baby steps only, no answer. Several would vote No, if the small bill was all on the plate. But could progressives relent on slimmer $1.5-$2 Trillion big bill? They didn't want to go down to <$2 Trillion. But might be forced to. Then maybe return to well later. To agree now on $1.2T – and more compromises on BBB, it still falling apart was a nub of it.

Had the $3.5 Trillion progressives wanted, won out, an analysis had shown 7.7 million US jobs might have been created by clean energy growing US economy by $1 Trillion to 2031. Jobs in electric grid, solar, wind, growing EVs, charging, better efficiency, smart buildings that are heated or cooled new ways etc. That could all mean good green jobs. And as will be discussed ahead, notably going big now early on at very start of this decade in clean electric power - could both save money and make clean power *much less-costly* than dirty fossil fuels.

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

Several House members remained unable to support it, consistent with their concerns they'd long made clear on climate. Thus, a dozen opposing Party members were called on to vote 'Aye' – for a $1.2 Trillion Infrastructure Bill to pass. It was Not relevant to climate; just some $ for electric buses, EV charging. Instead, climate action and spending remained in the draft mired/bogged down BBB bill with its social programs, no breakthroughs there at all.

As for that BBB, 1-2 Senators at odds with their liberal Party, had mainly held firm. They'd demanded ongoing added 'compromise' cuts from the 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 BBB, 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 was to delete any/all sticks from reconciliation BBB that would draw-down the fossils. Originally, BBB had been envisioned as having both essential carrots, and key sticks.

Shorn now of restrictions or sticks to cut coal, oil & gas, those could all 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; it got removed. Bulk of the plan to clean US emissions shorn off was a big blow. Efforts to keep in a few sticks, like by allowing say, fossils with 'carbon sequestration' weren't successful: that 1 Senator recognized 'sequestration' was just a marketing fudge. Nowhere actually cheaply reducing the carbon emitted from coal, oil or gas – so keeping it in wouldn't have actually helped fossils.

On the other hand, opportunities remained for some progress: much could be done ***for*** clean energy via tax credits; new incentives to grow clean energy faster on just carrots alone. Still, just 1-2 Senators had held back more massive legislation. But that also implied a liberal Party, if it does gain 2 or 3 Senate seats in future, could be disproportionately impactful ahead. Not likely at all soon; traditionally, President's Party loses seats midterms. Yet it's extremely likely this climate emergency isn't going away. So even a few US Senators might some day break from other side of the aisle, and support modest climate action. In other words, the future likely belongs eventually, to action on climate within this decade. Especially as wilder weather, escalating costs of doing nothing for climate *inaction* - gets bitingly clear.

From a scientific viewpoint, while 1 Senator 'won' by keeping coal, oil & gas fires burning, the Loser was perhaps our climate future. Given so much stronger action was needed – things likely will now get worse. That 1 Senator saw themself as useful lone moderate in an intensely divided country. A realist caring about US energy reliability vs. multiplying power crises. But that reflects a deep misunderstanding. There's no moderate redemption found in the science by pushing off action, to later years. No good 'compromise' here, like is usual in politics.

For instance, that 1 Senator had upended a proposed rule based on sound science, to tamp down at last on methane – a potent greenhouse gas (GHG) released freely like an open sewer. As a more potent GHG than carbon/carbon dioxide or CO_2, this rule might have prevented 168 million metric tons equivalent of carbon dioxide, that's like pulling 36 million gasoline-cars off the roads. (We interchangeably state carbon or CO_2, given atomic weight of carbon is about 12 atomic mass units (AMU) and of oxygen is about 16 AMU so their mass ratio between one CO_2 molecule – and one carbon atom, is 3.67 when thinking about 'one' greenhouse gas). The point here, is that just 1 person had killed a major, draft new methane rule – plus had killed other draft GHG sticks that made scientific sense, that would have been impactful.

New revenue pay-fors were suggested to cover a lesser $1.5T BBB cost. Instead of regular tax raises or new capital gains rates or on the wealthy, novel tax scenario ideas were discussed. One popular idea was a new 15% minimum corporate tax floor for American companies, some of which had avoided paying any taxes. That could help get to a needed revenue-neutrality moderates demanded. Another idea raised – fast rejected was taxing unrealized gains; it was problematic: could one deduct unrealized losses(?), and it was maybe the only tax idea that could be ruled unconstitutional given 16th Amendment requirements for realized income. So instead that 15% floor idea steered clear of increases in traditional tax rates or in capital gains taxes, and was draft joined by a proposed surtax on the very highest earners.

1 US Senator had ensured 2021 saw No new sticks or restrictions to hinder fossils so they were left unfettered; *No traditional Tax Hikes to pay for big green programs, and *No Big climate moves either that year. No brand new huge bill/s were likely, given the elections calendar - maybe just a narrow lane for piecemeal resurrection of BBB's tax-credits text in 2022. Hence 'returning to the well' for bigger fresh green actions – might be put off at least to 2023.

A fury over how badly reconciliation BBB bill had been eviscerated in 2021, was immediate. Hyperbolic-sounding criticisms fast sprung up, such as that just 1 person had forced impacts to Earth so profound, they may be visible thousands of years hence looking back at geologic record. To suppose that one single person could have influence visible in the geologic record, might normally be laughed away, as hyperbolic, no chance. But climate is so unique, singular, different. Worryingly, such a critique *should have a clear* non-zero chance of being right! But amazingly enough, there was some non-negligible risk that it might even become true.

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

Back to politics, early November the biggest greenhouse gas emitter China said it wouldn't show at COP26 in Scotland. After a prior outcry that China's 5-year Plan would not start reducing coal use 'til 2030, they'd upped their ambitions to aim to peak coal sooner in decade. But since in taking initial steps away from coal - China was hit latter 2021 by an energy crunch. It grew less certain they could keep to peak pre-2030 aims. Plus given that 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 little reason that a developing China - India or Brazil felt to offer more. Besides the leaders from Russia, Brazil, Mexico also didn't show up – since likewise they were hardly enthused about COP26 'cuts' in carbon.

Anyway most all nations were fossils addicted. Despite many flowery words to the contrary. Not just China. India, Russia, Saudi Arabia, Qatar etc etc – and rich G-20 polluters too who proclaimed virtue like a US, Japan, Australia, Germany, Canada, UK, and many others. All of whose addictions were at odds with pretty promises at G-20 events and Climate Conferences. As HRM the Queen of England had wisely, aptly remarked in lead to COP26, it's irritating the way global leaders "talk", but "don't do." Private companies were more of the same. As were state-owned fossil firms with vague promises, glossy blue hydrogen ads, and distant 'carbon neutrality' 2050 talk – that conflict with reality. COP26 that followed a rich world's G-20 only days apart, all failed regardless of the just-in-draft-only BBB US legislation.

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

Physics and chemistry give us a total carbon budget for how much emissions can be spewed, for this climate crisis to not go past 1.5 degrees C of heating. Total future allowable human CO_2 emissions is 400 billion – 450 billion tonnes. Yet on current trends, we'll reach that maximum carbon release 'speed limit' in just 10 years, on today's trends. 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 (and Arvid Hogbom) had determined the How, and the Why, a big forecasted 3 degrees C rise in global temperatures would result from each 3/2 rise in CO_2 (a ratio since refined, but principle same – along with more heating at poles than equator). Linear increases for one, by power law for the other; temperatures varying as a logarithm of CO_2.

December 2021 it came again to a head. More compromises in BBB – or it might all be a failure. As a reconciliation bill, the Senate Parliamentarian had to agree all draft items would be spending-related, a 'Byrd Bath'. But before that, scoring/spending was 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 BBB Programs simply were re-written to go from 10 years – down to 3 years sunset (even 1) hoping a future Congress renews, reducing top-line cost. But those weren't real cost reductions this 1 Senator had demanded – and feared social spending would stoke inflation. A defanged BBB still could hurt fossils, dear to that 1 Senator's heart. It looked like a smaller bill, already passed, might be all there was in 2021.

Even after being eviscerated the $550 Billion in the draft BBB for climate would still have gone farther than ever by US on climate. Partly (arguably not all) paid for, it had revenue raisers so needn't have relied on raising income taxes nor on capital gains as feared by moderate conservatives. In sum it was arguably hugely a missed chance in 2021 – given what this bill might have been, and it would have taken GHGs like methane more seriously.

A 2021 draft BBB that looked at a wide raft of options, was bit of a roadmap, for its focus on *renewables; *EVs; *low-carbon-fuels; *tax advantaged Master Limited Partnerships (MLPs) once for just fossils – to include say, clean energy too. Low-CO_2 hydrogen might have gotten tax credit of $0.60-$3.00/kg depending on carbon avoided so not just green hydrogen but fossils-derived (blue) hydrogen too if carbon 'captured'. Electrolyzer-makers might have gotten hydrogen boosts. Provisions to say bring smart glass into the ITC for US manufacturers (with warranty accrual overhang helped). Or if BBB failed end of 2021, it looked then as if a narrow lane existed for its energy aspects nonetheless to *just possibly* be resurrected 2022. And this draft 2021 BBB language showed which was the wind was blowing.

Consider: BBB text 2021 had implied low-carbon hydrogen might get its first-ever tax credit. ITC also for smart glass in buildings. 10% more ITC if project is 40% US-manufactured content. 100% for US steel that helps US solar tracker manufacturers. Residential PV could see 30% ITC renewed for longer periods; trackers and inverters also being aided. Interestingly ITC could have grown if located near a former coal mine's closure since 2000, or coal power since 2010. Maybe a 45Q tax credit for 'carbon capture & utilization', possibly direct air capture. As for those proposed new Federal methane fees: those might have been mitigated by EPA grants, even maybe for oil & gas companies (ever an unlikely flank of added support).

Then end of December that 1 US Senator declared BBB as written, 'Dead'. No great surprise, that Senator had criticized its size, scope, direction, especially social programs outside of energy/climate, and Pre-K, from the start. This proved Progressives right; their Party ought to have kept linkage as between the smaller bill that Senator had wanted - and BBB intact, to get both. Still the objections most voiced by that 1 Senator were often over other aspects – unrelated to pro-green text - for non-energy spending in an enormous omnibus-like bill. Like in the 'Princess Bride', maybe it wasn't 'dead' – but just 'mostly dead' to start 2022?

Hence, it's easy to imagine that old BBB energy text instead made focused legislation ahead. For example, big Tax Credits for solar & wind power being put in separate bills or tax extender packages in 2022. Maybe old BBB much criticized text that had singled out aid for unionized EV makers – not helping a big EV manufacturer in Senator's home State - replaced with new, signable text that helps all EV makers. For clean energy a better path is to Remove All Subsidies, including for dirty Fossil Energy too – maybe movement that way later ahead. But clearly here, US clean energy momentum was hit – so think of global leadership elsewhere.

In practical ways, China was a carbon linchpin in 2021. So wedded to coal, it resisted speaking of a coal 'phase-out' – rather it spoke of a 'phase-down.' But, consider possibilities there in solar power. China more than anyone, can make vast solar growth happen. Reminiscent of a US mobilizing in 1941. In 2021 China already had 250 Gigawatts (GW) of solar power capacity, nicely 2x that called-for in earlier Plans. 1/3 of the global solar capacity that was being commissioned, was for domestic China demand with reverberating benefits planet-wide.

What's possible, at the utmost? In theory if all China's areas that can easily have solar power, had it, mainly in its sparsely-populated northwest (most people live in southeast), then 'technical potential' of all its solar in 2020 was to make 100 petawatt-hours. That's 13x all of China's then total 7.5 PW/hr electricity demand (2x its then-total demand for all energy including heat). By 2060, as solar panel efficiencies improve, its solar potential might rise +50%, to about 150 PW/hr, when China plans net-zero emissions. At least half of its potential solar-areas were already capable of PV being cheaper than coal in 2020; 80% as less costly than coal in 2022. As solar improves, by 2030, solar gets cheaper than coal in all China!

From solar costs in China averaging 4.93 cents/kWh in 2020, projected costs drop to 1.3 cents/kWh by 2030. Then, solar goes on getting cheaper – to 0.3 cents per kWh by 2060! Or if a price is put on coal's pollution, or a carbon tax, the cost difference gets immense. Coal thus can't compete ahead; all sides know it. But coal has meant jobs & most vital of all, gave a firm, dispatchable, uninterruptible vast domestic power that nation needs. So solar power that's hobbled by intermittency, dearly needs energy storage. Put together, storage + solar grows 100% dispatchable and by 2030 is projected 5.2 petawatt-hours of solar-with-storage might be available in China. All as cheaper than coal – vs. a 7.5 PW energy demand.

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

These sorts of costs and efficiency considerations, can impact investing strategies.

Look back 5 years ago, and it may have been propitious then to have 'entered into photons' – that is in the solar theme that rose afterwards. Later on in 2021, with surging inflation it turned out commodities like an oil theme did relatively well. Looking ahead, whether some 'entry into protons' – risky green energy storage and conversion technologies theme, may be propitious ahead – even inflationary times, might be a fascinating matter. What's certain, is that a 'protons' theme in early 2020s is hugely risky; maybe more so than was 'photons'.

Solar was then on a steep cost-cutting trend, given advances in technology/manufacturing – like seen in ever-cheaper computer chips. New energy conversion is qualitatively different by contrast; and surely very risky. More risks vis-à-vis many breakthroughs still needed in protons - than photons where solar PV tech was already on steady & sharp cost-reduction curve.

A third "P' is relevant, but less susceptible to such analysis. It's politics, maybe a factor for this basket being in a band of 150 - 200 for most of Q2 to Q4, but for its first and last 2 weeks. Given BBB's 'death' late 2021, and clearly great risks of inflation, higher interest rates, Fed tapering - things could fall very hard, fast ahead – those held maybe a bit of a lid on the Index Q2 – Q4 2021. On the other hand, possibility aspects of BBB may yet pass ahead(?) was maybe bit of a floor that kept it from falling very much below 150 most of Q2-Q4. But there was an expiry date on that, as was seen last 2 weeks of 2021 when California proposed huge cuts in support for home solar. When BBB passing too fell apart end 2021, unless it's more narrowly resurrected early 2022, a floor that was once had held things up, could fade very fast.

That was *politics* in 2021. As for actual *work* of growing clean energy faster, a worrying fact was steep Inflation. Input materials costs soaring. As supply chains got stretched on demand, inflation looked far stickier than a brief 'transitory' case initially laid out by a Fed. Clearly, rising prices have been/and are thorny ahead for clean energy. From efficient 'just in time deliveries', to 'what if worries', & much higher costs. Take solar. If US, Europe, and Japan are to wrestle back PV manufacturing leadership that had shifted away 2010s to China (we recall 20 years ago Japan, US & Europe had dominated PV manufacturing, China was near zero) – then big changes are needed, fast. To contain rises, for 2021 Europe wholesale solar panel prices rose +19% which took it back to prices seen 2018. Yes still -33% below where they'd been late 2016. But panel prices 2021 were up some 50% in euro cents per kilowatt, from where they'd been in 2020. Polysilicon prices went up 4x in 2020 to 2021.

So if US wants to go from solar as a meager 2-3% of its power in 2021 - to 50% next 30 years to 2050, then the hurdles to expansion loom large. Think then of basic materials used in solar. Polysilicon is discussed ahead, but there's other key materials in manufacturing solar.

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

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

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

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

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

For why natural gas storage is still crucial, consider a say, cold Winter-day 2022 in Europe. An issue had begun mid-2021 when Russia suddenly exported far less gas to Europe, than its typical 80 million cubic meters (mcm)/day. Russia at first lowered gas exports to Europe in July to 49 mcm/day. Then in August, it dropped the rate to just 20 mcm/day. Gas levels were already low in Europe/UK, globally. Why? Prior months, Covid-driven supply shortages plus weather volatility had dropped supplies worldwide. US hurricanes compounded that, dropping fossil output. Net/net on sharp loss of gas supply, low storage - natural gas prices jumped. Europe lacks big domestic gas supplies, so has long had to rely on importing gas for its electrical power. So as natural gas & electric power wholesale both skyrocketed in 2021, with Asia hungry for gas too, in no time that gave way to bedeviling shortages. And therefore, eye-wateringly high electricity costs - especially in Europe. Unusual cold could create a crisis.

Russian gas profits thus grew. But another rationale may have been at play too. It's been suggested perhaps this export gas shortfall in 2021 by Russia, was to help it win a needed OK by Europe for Russia's Nord Stream 2 pipeline into Germany. Europeans for their part, still obviously needed cheap Russian gas. Two other routes might be getting lots more gas from Norway (likely in decline) – or import lots more liquified gas (LNG) from overseas via ship. But that means competing with a voracious Asia, so high prices for a Europe that needed all gas it could get 2021. Possibly it may get colder than usual in 2022 or 2023. On sparse winds so less wind power, nukes down for maintenance, coal shuttered by emissions permits - while Germany is now aggressively targeting 80% renewable power by 2030 – it can get very tight.

Sparse winds 2021 hurt UK/Europe wind output – nukes were down for maintenance, drought hit hydro limiting electricity supply: despite diverse sources of natural gas, we note UK's gas storage capability had been greatly reduced – all before possible Winter spikes in heating demand. Thus, in Fall 2021, unhappy records were set. Europe's natural gas benchmark spiked up +300% YTD. Gas futures in a key Netherlands basket rose past equivalent of $150/ barrel for oil. This all had made natural gas late in 2021, the dearest fossil fuel by far.

Ireland's electricity cost jumped briefly 10x in a 7 hours period on gas shortages. Gas was so tight in Spain & Portugal, electricity hit $165/MWh, worst since 2002. Spain had an emergency price cut. UK electricity prices briefly spiked more than 2x, near 7x just one year prior; next day UK power jumped to $395/MWh. The UK imports 7.5% of its power from France so when a key undersea cable was lost due to fire, it knocked out 2 GWs of firm power from France maybe until Spring. China too had an energy crunch. With abundant breezes, in good times UK electricity costs may drop to near zero! But sparse breezes, a wind drought of UK full wind power capacity at 24 GW - instead can fall to 1 GW. Hence in 2021, Europe's natural gas power / and its nukes – were both still needed – along with better natural gas storage.

Long-held European fears of over-relying on Russia gas were pushed somewhat aside too. Nord Stream 2 gained a bit in need; if that were an intent behind Russia's reduced flows to Europe, to build support for their pipeline, then it certainly had some effect. But German elections results 2021 also helped to green it's aims for a "massive expansion offensive for renewables". Meanwhile China, Japan, S. Korea all had been buying up LNG since Summer. So latter 2021 LNG prices had spiked over $15/per million BTUs. Hence American gas rose too (all connected) from a recent just $2 or $3 mm/BTUs - to over $5.0 – unheard of in a shale gas era. If European Market Winter gas demand competes say in 2022 vs JKM (Japan-Korea Market) demand, potentially all lose on higher prices. So, gas still vitally needed. Not only for electricity, but home heating too. That, may get scary, if there's unusually cold temperatures ahead.

Clearly, Europe in 2022 needed GWs *more* solar/wind, plus long-term battery storage for firm power. Lacking gas supply & storage vexes – most because clean hasn't yet grown big enough. In particular as Europe tries to wean itself from coal, and to reduce gas ahead - wind & solar in early 2020s are at an awkward stage. Growing yes, but not yet enough to be a Hero. In 2021, renewables had made up just 20% of Europe's electricity. Not enough to take on gas' failures. Especially not until there's great solar/wind + far more green storage ahead. These can make intermittent but clean resources, be viable, dispatchable, a real substitute.

Yet solar saw price inflation worldwide in 2021, after years of relentless price declines. Solar prices *rose* first Quarter over Quarter, year over year, residential, commercial, utility-scale - which hadn't been seen since analysts had started measuring this in 2014. Inflation wasn't just seen in solar of course, but it had been lately 'unheard of' here. Causes included: fast-rising costs for aluminum & steel in solar frames, & mounts. High silver costs in cells as noted. Pricier special panel glass. Freight costs up for shipping PV product. Labor higher for assembly high, despite mechanized operations. Polysilicon from sand is a basic building block, yet it too saw cost increases of late. Globally, solar panel prices in 2021 had risen by about 16% over 2020. Increasing input costs over 2021 reverberating ahead. They'll be felt in 2022 and at a same time that clean energy demand *may* be also be going higher then as well.

In the US, a huge growth in solar manufacturing & deployment will be needed to hit 45% solar use by 2045. From a scientific standpoint, that growth is simply Required on climate concerns – yet such ramp would be unprecedented. The US in 2014 had gotten <1% of power from solar. By 2021, it was near 3%, for just 15 gigawatts (GW) deployed that year. To ramp from there, fast enough for 45% means solar needs to double each and every year. 30 GW more installed in US each year 2022 to 2025. Then rising 4-fold/year, over what had been seen back in 2020. A fresh new 60 GW installed in each and every new year, from 2025 through 2030.

Thus by 2035 the US needs on climate, 1,000 GW renewable power on grid. By 2050, 1,600 GW of solar integral to US zero-carbon grid. That's more solar power than was generated by all sources, including by fossils/nukes, in 2021. To further Decarbonize for heat too means 3,000 GW of clean energy by 2050. Green transportation, buildings, manufacturing, industry: using zero-carbon power for each GW of needed electricity, and each BTU of needed heat.

In 2022, a new 30 GW US renewable power is needed. For comparison each GW can power 750,000 US homes, roughly a smallish nuclear plant. With proper support, solar & wind alone could grow to supply that, and new battery/storage is critical for renewables. Or, it may all stumble and fall. Especially if big future bills like BBB fail to pass. That's a distinct possibility. Partly too why there's been such huge volatility seen here. Another approach seen across the Atlantic may be small modular reactors (SMRs) looked at in UK, where its 7 big nuclear plants are being cut back, though they'd made sizable 17% of UK power in 2021. Some small nukes given a more standardized design (as may be applied in China). But can they also be made 100% safe? Less costly? Less risky? On state of the art in 2022 the answer has so far been No. Hence problems remain and swirl all around current-generation nukes in 2022. Even so, China, US, UK and others are searching for answers here for needed baseload power.

Next let's consider solar/wind/storage/EVs themes. The ECO & NEX are longtime benchmarks, so we begin here. With the innovation and volatility ever-dominating these green themes.

After big, earlier gains ECO/NEX in 2020, it was maybe 'normal' to see retrenchment in 2021. As that 2021 plummet began, in February, it was unknown of course if clean energy & so ECO would show a harsh backslash shape "\" all Q1 – and maybe Q2/Q3/Q4 too? Or perhaps an "L" shape: so down, then sideways 2021? Or given January's rise, maybe Inverted "V" like ^? For 3 reasons, that year and then into 2022 could see headwinds since: *1) there was No Clarity yet on whether a big new US 'Build Back Better' (BBB) $550B reconciliation bill might pass; 2) *China's 5-year plan might push its own coal cuts to post-2025; and 3) *Europe seeing a pause by both US & China, might refrain from hoped-for aggressive actions early 2020s.

To those 3 worries, add 2 more: *Underlying green stocks had had high P/E multiples early in 2021, plus *Inflation/Taper Risk. Perhaps Q1 2021 was a soft ceiling? Hopes for the BBB bill in was some succor if one were optimistic that the bill could pass: Billions *might* better justify rich Price targets seen in Q1 ("P" in P/Es). But still mid/to late 2021 was fated to be an interregnum. A pause between Q1's hopes - & clarity on BBB's fate for more insight into "E", Earnings. Plus, inflation could mean big falls cumulative years, with a Fed willing to let things run hot with over >2% inflation targets – or to Taper faster due to it. Thus, tech stock earnings suddenly went to worth less in 2021 on Inflation's discounted future values. Capital unsurprisingly, moved reflexively in 2021 from growth - to value. Yet it was ironic. Longer term, volatile green stories *might* re-attract capital. Traders could get re-accustomed to what (possibly) is a much higher, yet historically more typical interest rate band range.

In that case valuations above a 25x EBITDA (Earnings Before Interest, Taxes etc) might be again seen. But 2021, in a risky theme, few dividends, little positive "E" earnings – matters swung bearishly hard. Global NEX, like ECO with US listings fell hard that year – rather as one might expect on such macro-picture. Such classic sell-off was maybe overdue: NEX & ECO had already spiked up 4 fold & by 6 fold in Q1 2020 to Q1 2021 – after gaining 2019.

Recalling how in Q1 2020, ECO had crashed -50%, to see it plummet -50% in 2021 was maybe not surprising. From intraday 286 in Feb. 2021 down ½ to 145 mid-May – and near 140 in December. Given rapid 2020 gains, this took it to levels seen not so long ago: ECO was 140s as recently as Nov. 2020. And NEX, if down by say half, it was 315 as recently as Sept. 2020. Bigger drops may be envisioned. ECO in 2020 had earlier seen a -50% fall from some 90 to 45. Down -50% was a resistance level then; it next rebounded from 2020 bottom. Somewhat interestingly, a similar-sized fall again of -50% in 2021 led it to May resistance of 145 and bounce for ECO. (Though it would fall to near 140 in December). Thus after Q1 peak near 286 on Feb. 10th, ECO touched a 2021 May low of 145, then in December near 140. *Coincidentally* again near a -50% decline. That was its (at least for) 2021 nadir.

Much of 2021 unsurprisingly, then was interregnum. A rough patch rife with uncertainty. Clean energy's theme had spiked January 2021 on Presidential race results, and a surprise 2 seat gain by his Party in Senate. Following as rather expected, by Q2 – Q4 pause. Weighted down by high P/Es, fast-growing inflations fears, uncertainty on whether reconciliation could pass in 2021 – then certainty it had failed. That was empty air pocket in Q2 - Q4. With little to support P/E valuations twixt election outcomes – and more clarity ahead. Frankly skepticism & hope too on whether pieces of BBB climate reconciliation might reappear in 2022.

Without a doubt ECO may yet fall more on uncertainty. Or just perhaps, rise. If P/Es are a metric (useful) and early 2021 Price targets had been very high, then prospects that revived bits of BBB might again justify such rich P/Es, should be impactful ahead – Down or up.

Inflation worries heightened mid-2021 for clean energy. To help explain, we except here from a Raymond James piece, 'Amid Input Cost Inflation, PV Module Pricing Rises to an 18-Month High - But What Goes Up Must Come Down', from Molchanov & Price, from May 12, 2021:

Amid Input Cost Inflation, PV Module Pricing Rises to an 18-Month High - But What Goes Up Must Come Down

Not that any of us need reminders about commodity inflation these days, but here is a textbook case study from a core clean tech vertical. Benchmark PV module pricing jumped up $0.013/watt (or 7%) this past week, as reported today by the PVinsights tracker. In dollar terms, this marked the steepest weekly increase since August 2016, and the current price of $0.195/watt is at the highest level since November 2019. This is part of the broader cost escalation across the solar value chain - a rare event by historical standards, bearing in mind the decade-long trend of cost reduction.

Will this uptick in module pricing hinder underlying demand? The impact will be less than you might think...

With the spot price of polysilicon having approximately doubled year-to-date, from $10-15/kg to $20-30/kg, and also factoring in increases in glass, other raw materials, and freight costs (as, for example, Maxeon talked about in April), it is readily apparent that module manufacturers are passing through the input cost increases via higher pricing. And yet, we are **not** worried about a loss of underlying PV demand. The reason, simply put, is that the module represents a smaller portion of the all-in, fully installed system cost that might be assumed at first glance. As shown in the adjacent table, using the U.S. as a case study, the module comprises 11% of a typical commercial system cost and 7% of a typical residential system cost. (To clarify, we are doing this math on an ex-tariffs basis.) Of course, the cost structure always varies site-by- site. For utility-scale projects, the analysis is even more site-specific, so it is difficult to come up with a rule of thumb. Directionally, utility-scale is the market segment where the impact will be felt the most, though even here we doubt that it will materially change the near-term demand picture.

... and, as the supply chain normalizes, price declines will resume - even if the timeframe remains uncertain.

When we started covering clean tech all the way back in 2006, module prices were close to $3.00/watt, so even after the recent uptick they are down nearly 95% since then. Can you think of anything else in energy that is 95% cheaper than it was 15 years ago? We certainly cannot. This reflects massive economies of scale, relentless commoditization across the solar value chain, and the shift of manufacturing away from Europe and Japan to China and (even more recently) Southeast Asia. None of these trends are about to disappear. To state the obvious, the recent burst of commodity inflation is a macro phenomenon, reflecting the progress in global economic reopening, notwithstanding widespread lockdowns still in place, especially in South Asia. Because of the broad-based nature of this phenomenon, encompassing numerous supply chains, the timing of stabilization remains uncertain. But we have no doubt that price declines will ultimately resume - it is only a matter of time.

The above nicely reflected mid-2021 fears in clean energy sector. And a useful May 11th piece from Roth also highlighted supply-side constraints & inflation risk in sustainability mid-2021. It stated *"Most of our universe is down ~15-50% YTD. Lots of reasons have been given including rising rates, NEM 3.0 [new net energy metering rules], component shortages, among others. The primary driver we see is the steady & unrelenting increase in prices of raw materials and components."* They pointed eg to: polysilicon supply tightness, rising costs for steel, for freight, & labor; margin challenges, potential demand destruction. Both were very useful analyses and they helpfully pointed out challenges for 2022. Indeed that NEM 3.0 proposed decision in California would later turn out even worse than feared for residential solar without storage in 2022 (though maybe helpful for storage on grid).

Much happened in clean energy & climate in 2021. Some of it was hopeful. Like the US President's aim to cut US carbon dioxide (CO_2) emissions near 50% by 2030, needed & doable. Renewables grew some in 2021. But the thorny matter is it's at a rate still nowhere near yet swift enough, to reach 50% cuts in CO_2 by 2030. Solar & wind potentially alone are readily capable of it - but on current trends, we won't hit 50% cuts in CO_2 emissions until 20 years later, in 2050. Broadly this is due to 2 factors: renewables aren't yet being grown at fast enough pace to displace coal, oil & gas. And conversely huge global inertia behind all fossils isn't yet even slowing, let alone are they being shuttered quickly enough.

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

So, no surprise they're now expanding! Solar power growth was +39%/year last decade, when It roughly doubled in capacity every 2 years. Wind growth was 17%/year, but both onshore /offshore wind booms might soon raise wind's growth much higher ahead in the 2020s.

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

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

In Western Europe, wind & solar has been growing, and coal was cut – except 2021 on a power crunch. Natural gas too can come down there - but not quite yet! Instead, gas shortages made Europe's power prices jump 2021. Yet things do change. Sold as a transition fuel, gas may become last pariah fossil, as socially unacceptable one day as coal or cigarettes. Europe's Climate Law may mean a border tax on imported CO_2-laden products. Renewables are winners now, the EVs on a cusp, but keen need to *heat* buildings etc had no immediate green fix 2022. Replacing gas boilers in UK & Europe with heat pumps, is too costly. Renewable natural gas (RNG) blended with green hydrogen (H_2) is years away. As is running ships & aircraft on green H_2, or on ammonia (toxic, so carefully) - or green liquids, gases, solids ahead. So clean is vital – but is only one-side of a climate coin. Other side, must be real moves especially in China to cut coal. With less CO_2/methane/all greenhouse gases. The world's clean gains are for naught, if those don't drop to near nothing. Yet huge populations in China, India & Africa all have much economic & energy development ahead, that will very likely be driven by coal.

So falls seen in 2020 in coal in Western Europe & in a US (with regrettably unrelenting gas) - are outliers. Elsewhere, like China, India, Eastern Europe, even Japan, coal sees terrifying growth. China yes is growing its renewables and small EVs: great! – yet it's also expanding too its thermal and 'met' coal use at least in 5 years 2021-2025. Notably China first half 2020 had added 11 Gigawatts (GW) more coal, another 53 GW of coal maybe to come. Of all world coal power added in 2020, China had made up 90% of that. Plus, in latter 2021, many more parts of the world too also sped up their coal-use, like India did, given spiking natural gas.

Not only China is at issue: 33 of world's 60 largest Banks grew their fossil fuels funding 2020. So 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 looks worse yet. Instead of a big drawdown needed immediately according to best science to decarbonize - big cuts in methane too – fossils eg coal are still expanding globally these next 5 years.

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

There's a Huge Gap between big, just *promised* cuts to 2030, 'blah, blah, blah' - vs. actual data. These data show fast-*growing* CO_2 & GHG emissions worldwide now, 2022/2023/2024 etc led by coal. No real action. Meanwhile cuts are pledged 'round the world' that all fail spectacularly to meet, and themselves are 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 were met, there'd be still unprecedented, historic levels of emissions driving climate change. And it's to say nothing (as we still do) of that uncounted methane now forcing heating too.

A Paris Agreement saw fanfare due to its 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). Assuming science is to be believed, then CO_2 emissions would need be cut now, within *this decade far more* enormously: by near half, or 45% to 2030. Given ambitions & real actions worldwide are nowhere close to 45% required reductions, Paris arguably is already well out of date. Far more bold dramatic action now by all 3 of the greatest emitters, China, US, and Europe, are essential.

So, to be clear-eyed, fanfare over a 1.5 C target wasn't deserved. Not as a Paris Agreement 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 (oft meaningless) Agreements will head off maybe, quite likely(?!) catastrophe. Against needed 45% cuts this decade – vs. a lack of action - 'net zero' greenhouse gas in 2050 targets aren't worth discussing.

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

Overall world electricity production pie is growing, and a thing of it is, coal's growing too. While coal vexes from its mining to waste disposal, more's getting built along with financing. Thus, even as renewables' share of electricity is growing overall, the total greenhouse gas emissions have continue growing as well. Worthy of note, there hasn't been one single year, yet, of *falling* global coal capacity… ever! This says nothing of coals' uses for other high heat industrial processes like in making steel, aluminum, cement. That adds more embedded CO_2 to products often exported from China etc out to the US, to Europe, and worldwide.

Greenwashing abounds. Ill-defined terms 'net zero', or 'climate neutral' are bandied about. And emissions 'offset' in a shell game, counting disingenuously trees, forests, oceans as natural uptake. Coupled with a far distant target year 2050, words can become meaningless. 'Carbon neutral' is proclaimed – yet not the same as truer zero-carbon. Zero-carbon – should stand well apart from 'net-zero'. So, words are important. They can inspire – or forestall stronger actions. What's clearly needed is to *decarbonize now,* in tandem with action cutting diverse greenhouse gases: methane, black carbon, hydrofluorcarbons etc. The latter less-noted super-pollutants are more climate-forcing than is CO_2. Shorter-lived they are also more potent at trapping heat so nearer-term drivers of global heating within this century.

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

Instead, we hear words that dissemble. Much, as Greta says is 'blah, blah, blah', 'end coal' [later]; it follows no nations' leaders yet merit praise. Void 'twixt words & action huge. Gains in clean so far are necessary, yes; but not sufficient. In short actions are needed, to move from CO_2 – enlist capital to decarbonize as blood in veins worldwide. Arguably market forces shape energy choices - and markets deeply matter. Along with government policy choices. Once markets & policies together made coal the King of energy. Later on, they made oil near exclusive global choice to fuel transport. After, they made abundant natural gas so common in the last century that it came to dominate both for making electric power - and heat.

Lately yes, market forces are helping, a sensible choice. Good. But according to science, this transition isn't yet happening near fast enough. Shifts like from coal – to oil & gas – once took half-a-century. We don't have a half-century now given what science tells us. And this transition isn't just flopping one new kind of energy – on top of lingering old ones. Instead, it's flipping over to entirely new energy. Policies can hasten that if governments so choose. Especially now, given clean is getting cheaper, it's better and it will always be healthier. In sum capital markets along with policy and action, matter. They'll shape our future. Time & pace of change in these 2020s are of the essence. It's simple. Listening to what science, and to what seas in a fast decline now are shouting – perhaps matters like never before.

We turn now back to clean energy, climate, & broad financial markets.

Stepping back broadly let's include 2020 in looking at ECO/NEX. And given both Indexes/ETFs stood out as very top performers then worldwide, with ECO up +203%, why did these 2 do so very well in 2020? Several factors enumerated next, may help to add a bit of colour. They also mean that in down years – these 2 Indexes should drop harder/faster than most!

One factor may be that our use of true *decarbonization* as an organizing principle stood out. Another may be *Market Inefficiencies: our Indexes hold smaller & mid-caps not so well known to mainstream analysts; fewer analysts in cutting-edge innovations 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 there's scope for gains. A 3rd factor maybe all-too human: *Disbelief! Difference of opinion is what makes a market; deep skepticism - even shorting - vs say, +12,000% gains in an equity are impactful. 4th many 'clean' baskets are still steeped in greenwash; for example they have natural gas! Our thematic focus on clean energy has been unique & consistent for 15+ years; that it's come into favor maybe is good fortune.

We'd seen a bit similar at ECO in 2004–2007 as green energy, long unknown, first grabbed a spotlight – for 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 often heard in 2004 had included that: electric cars could *never* be as fast as 'real cars'; nor see 200 miles range, nor ever be pretty, nor fun to drive. Views were oft stated that solar & wind 'weren't real' - vs. 'always cheaper' coal & gas. Future earnings estimates, on short-term valuations resisted penciling anew. Importantly, valuations were based *on only future promise in 2007. Clean energy back then, was itself much too costly*. And all crashed on overcapacity, high relative costs, and clean being still just 'promise only' back over 2007-2014.

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

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

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

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

The Good

Digging deeper, for fun let's call factors behind change, or the 'delta' here: the Good, the Bad, and the Ugly. A Good factor has been ***Huge Cost Reductions** in clean energy. Solar becoming **least-cost electricity* in much of the world; wind power good too. Solar will soon be the *cheapest electricity in history!* Unimaginable to so many only a decade ago. Many models had foreseen the dirty fossils, instead, as definitively lowest-cost power in 2022.

Another Good driver: ***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 was 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. China could be a 'solar superpower'.

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

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

Models by Tsinghua University have shown how China could be reaching net-zero CO_2 by 2050, all greenhouse gases 2060. It requires big, fast declines in coal power - and heat – plummeting from >70% – to <5%. To instead more slowly cut coal, from post-2025 means sharper cuts 2030. Far better would have been aggressively started Decarbonizing. Immediately on straight pathway would have been so preferable to so many, worldwide. China instead may be ramping up nuclear first, rising from 'just' 46 plants that were making 50 GW in 2021. No doubt nukes will see accidents ahead. And it is again re-ramping coal, 2022 Regardless, China's new energy costs may well top $15 trillion! So a greater spend than is contemplated by Europe, or a US: re-allocations to its economy. The most ambitious Plan the world has seen. There may yet be 10+fold increases in solar, 7+fold in wind. Maybe 10x-100x more solar manufacturing capacity. Tremendous ramps in storage – with energy technologies like say green hydrogen for zero-CO_2 high heat for steel and cement. Hence the changes shall still be colossal.

Consider batteries: both in electric vehicles & energy storage. Apart from Tesla to 2021, China had clearly most seized opportunities. As well, Japan, South Korea, Taiwan. About 1 million EVs were sold in China 2019: 54% of world total, 3 times the US. And it's been growing fast: EV growth in China could surpass 25%/year, for 4+ million EVs in 2025. Maybe again a reason for the big volatile moves in ECO/NEX/OCEAN! Such demand had helped push battery costs down 80% in 8 years. Maybe well below <$100/kWh as demand grows 5-fold+ plus.

America's battery leader in 2020 had been Tesla, with its 35 GWh of lithium-ion capacity, aiming to rise to 3,000 GWh (3 TWh) by 2030. 3 TWh give or take, was about all the world's battery making capacity in 2020, so change is happening! Ford, GM announced big goals, all reasons for valuation deltas. Making all vehicles electric, may mean >10,000 GWh new battery manufacturing/year. 2x plus for energy storage to replace fossils. In EVs maybe lithium metal at anode rather than graphite, a step to solid state. Beyond lithium-ion, much more is ahead. Nickel/zinc, or iron is heavier, deeply discharging on less thermal management, good longevity. Cooled EV charging cords, to faster charge. Vanadium/iron flow batteries maybe for grid storage that's cheaper, better resisting degrading over time, etc etc.

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

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

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

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

There's ample news coverage of what the US may do. Includes whole government approaches on a strong unitary executive, green jobs in areas hard hit by coal, oil & gas losses. Tougher so yet ahead, maybe a carbon tax, or National Renewables Standard. Ending fossil tax breaks - although watch for maybe work on clean power, alternative fuels, energy efficiency. Upstream, thinner-margin solar & battery manufacturing may linger as Asia-based for now, Europe growing. But low-cost PV could electrify US. Better yet is to make PV with little or no embedded coal/carbon. Incentives for jobs in grid, transmission weatherization, distribution, EV charging etc maybe seen in new energy policy packages 2022 and after. While the 2021 loss of BBB meant political appetite was for split up, smaller legislative bills.

The Bad

Perhaps 'bad' factors too had helped in 2020's rise. Bad in a sense, drivers to some didn't yet warrant such exuberance; Hydrogen (H_2) & fuel cells in 2020 come to mind. Not that these can't one day possibly sooner than expected - be vital. It's more in 2020, they maybe hadn't yet justified hype, not until breakthroughs occur. But then this is a passive Index – not active managed – so not actively trying to predict rises or falls. Notably hydrogen & fuel cells seen in all 3 basket/s outperformed in 2020. H_2 is still burdened by its sparse CO_2 avoided and low efficiencies. But H_2 may become increasingly green/relevant. Made from 'rock gas' (natural gas drilling) so inextricably tied to fossils, it's not a worthy solution. Such 'blue' H_2 from fossil fuels & sequestration could only pass a very low bar, and is polluting. Big Oil may embrace a chimera of blue H_2 – yet it may compete with green H_2 in this decade only (if green scales up big). For neither ugly blue H_2 with 'sequestration', nor ugly brown/grey H_2 made from traditional rock fossils coal or gas - are made in clean green, renewable scalable ways.

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

Green H_2 by contrast *could be* hugely scalable, growing speculation is it far more plausible than before. Demand for green H_2 *could* - *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 'green ammonia' (H_2+Nitrogen=NH_3) easier to handle than H_2, say made on site by offshore wind. (Blue ammonia undesirably, uses rock gas). Visuals of wind or solar making green H_2 – or then a 'green-ish NH_3' - in place of oil might be painted.

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

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

The Ugly

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

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

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

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

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

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

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

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

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

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

Not so on climate. Singularly, researchers are now shouting. Perhaps it's conservative then to heed science – unwise to reject it. This may one day hit us not in a spirit of gladly looking towards smart solutions, nor boldly advancing our better natures. Instead, it may mean hastily saving what may be saved: remember Summers lasting only 3 months? Winters? Cool nights? Farther out, Coral Reefs? Sandy Beaches? How better to prevent that as a future we needlessly bequeath. Especially when sustainable, no regrets paths make us healthier, happier, richer, safer, more secure. Save us from spiraling blood & treasure, diseases, and despair. This sea change might mean our intentionally embracing ahead: Prevention Rather than Cure.

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

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

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

So 2019 & 2020 saw big gains in these Index themes, followed unsurprisingly by big falls in ECO/NEX in 2021. During 2021, ECO touched recent lows near 140; NEX fell to near 400; OCEAN dropped to near 350. Should future energy/climate bills fail like was seen in 2021 – or equities fall generally as on taper fears or inflation, or on the pandemic, etc etc - then all 3 Index themes could plummet farther, swiftly. And should an outlier happen: US Debt default, terrorism, act of war, or a market crash, high-fliers could be much more seriously hit.

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

There's 'defense' too on climate. Smaller steps, extant infrastructure. Capturing methane – if otherwise indifferently released to air like a sewer. 'Renewable natural gas' is far less than ideal; it only renders methane as CO_2 - combusted as less potent greenhouse gas. Lower CO_2 or bit better negative-CO_2 liquids from renewables like as aviation fuel, gasoline, diesel.

Past gains like 2019/2020 no way foreshadow gains ahead. Indeed, such big rises may auger sharper falls in 2022 and later. Regression to mean, nothing is certain. Or, they *may* point towards better paths. Once upon a time, fossils magnified human power many-fold. Yet we can't let a past dominance by once-magic fossils now waning - mean what's bad for fading coal, oil, gas - is bad for humanity. We're wiser to set out for a once-more-stable climate. Towards broad sunlit uplands with carbon back again near 280 ppm: this choice is seminal.

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

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

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

Perhaps foreshadowing, a deadly disaster had hit Texas in 2021 when a freeze took down its electrical grid. That US blackout showcased too battles going on in messaging. What will it take to build a stronger, more reliable grid going forward? Fossil fuels including natural gas once so dominant – lately are finding themselves at times on their back heels.

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

Was that really so? Let's start with that frozen wind turbine photo shown by 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 a powerful & fictional 2021 false narrative. That meme shared widely by a publicist, website, & others was memorable, but clearly not true. Yet it definitely had stoked misinformation and was seized on by wind's opponents as 'proof' of wind power 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 being mainly powered (yet) by renewables; but instead, natural gas. 52% of grid power was natural gas in 2020 – vs. about 39% gas in grids on gas nationwide. What's key, is how well Forecasts of energy Supply – match Demand. In that week, the Electricity Reliability Council of Texas (or ERCOT) had expected 82 gigawatts (GW) of power would be available, in Winter. Greatest expected supply percentage of all, was expected to be natural gas. A huge projected 50 GW availability.

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

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

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

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

Core 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 hot place; much equipment was thus left unweatherized, as tanks that divert oil, water, and gas, became solidly blocked off.

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

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

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

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

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

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

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

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

Consider too, Texas' disaster, bad as it was, was minutes away from maybe being far worse - were frequency stability lost. Had grid transformers caught fire, high voltage lines destroyed, it could have been Months, not days of no power. We don't realize how dependent we all are on electric power 'til it's gone'. Poor infrastructure resilience is a big deal. (As next seen in Louisiana in Fall 2021, or a gas crunch in Europe early 2022; each one is another story).

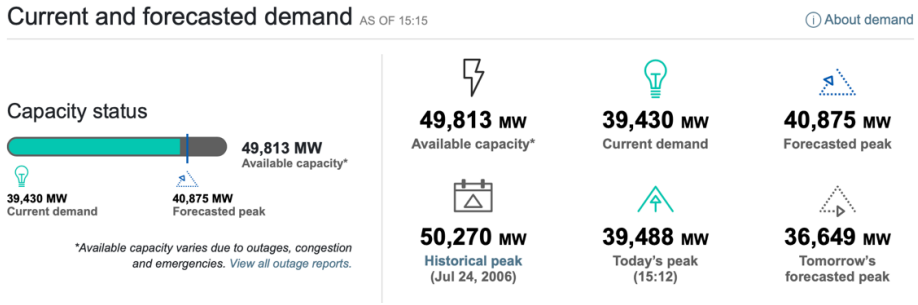
It boils down to: How ready are we for a changing climate? Honestly, not at all. A sole key oil fuel pipeline from Texas to US East Coast if shut – could paralyze Southeastern US. Glance at a weather app like Ventusky; it shows swirling arctic polar vortex each Winter. Bitter arctic air drops at times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

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

A slowing Gulf Stream *could* paradoxically mean bitter cold. Trace a finger on a globe from lovely Britain/Northern Europe, either westward or eastward. Quickly it becomes frozen and barren away from a North Atlantic warmed by the 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 unlikely is no change at all!

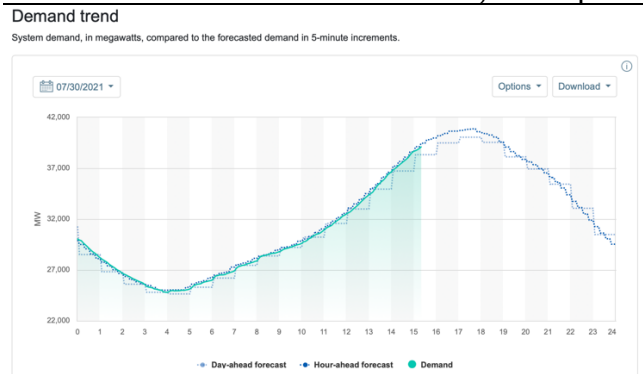
Texas, Winter 2021, gas was weakest link; nukes & coal were vulnerable too to cold – as they are to heat, floods & drought. For solar & wind, instead, new Storage for abundant clean electricity is what's now needed. Together making electricity cheaper too on renewables. Storing that clean power, is where we'll need to focus and grow. It can & will be done in myriad ways, but it's clear that ***Storage*** is where attention ought to now be turning.

To illustrate, let's consider for example Summer day heat, say end of July 2021 in California. On a typical expected hot day – here July 30, 2021 shown below, the situation in 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 is forecast to peak soon that afternoon at 40,000 MW:



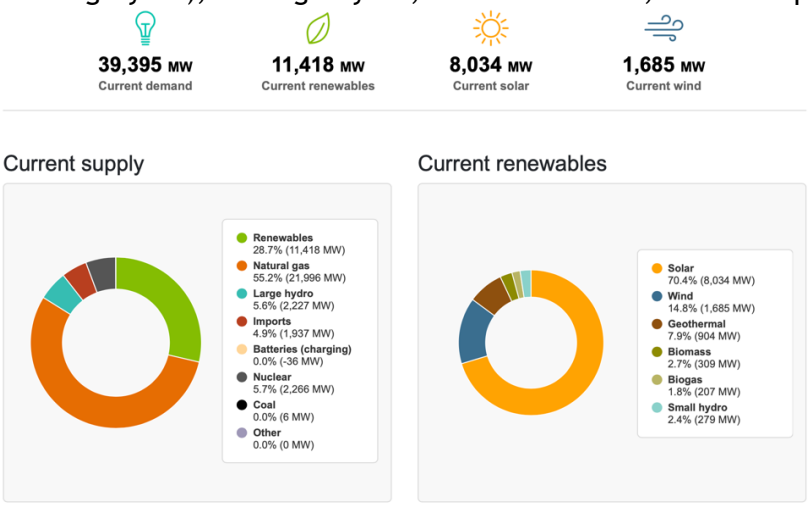
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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



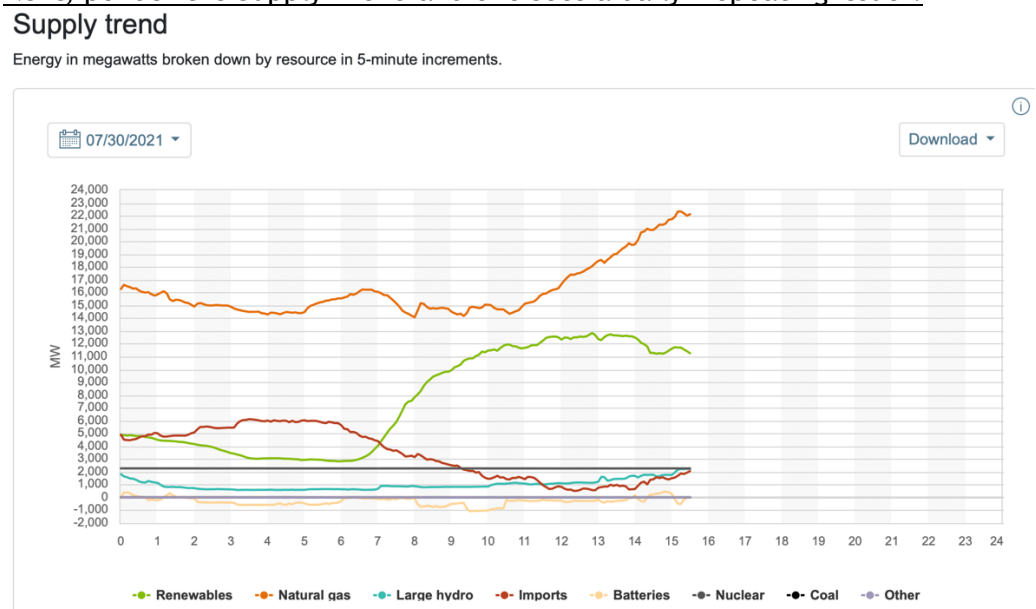
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

<u>To meet that readily-forecastable 3 pm Demand, all Supply sources were producing as follows:</u>
a huge 55% of electric power was 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.

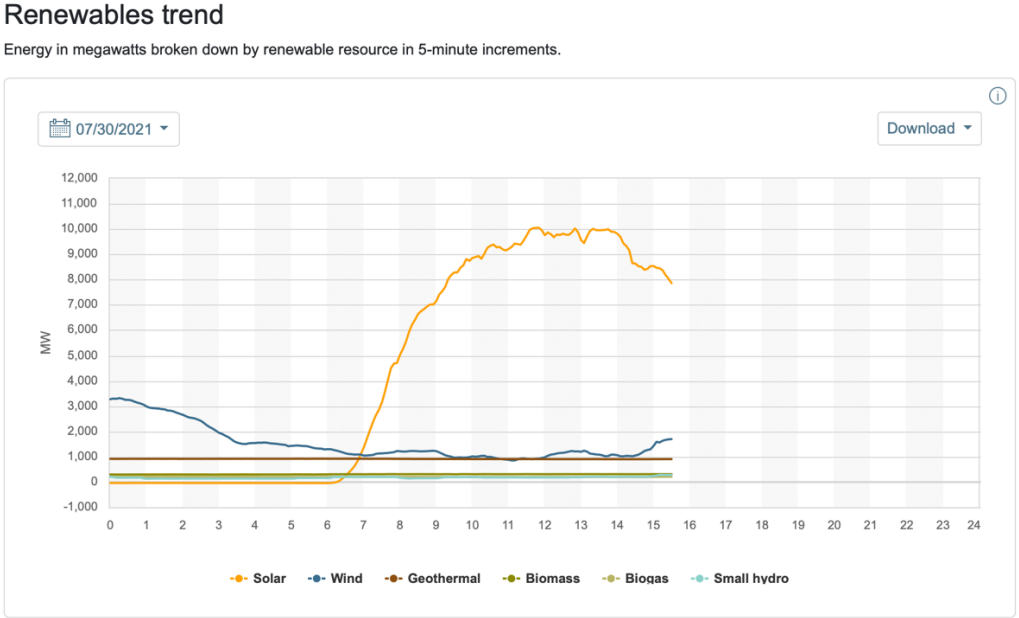
Next, ponder the Supply Trend and one sees a daily 'repeating issue':



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

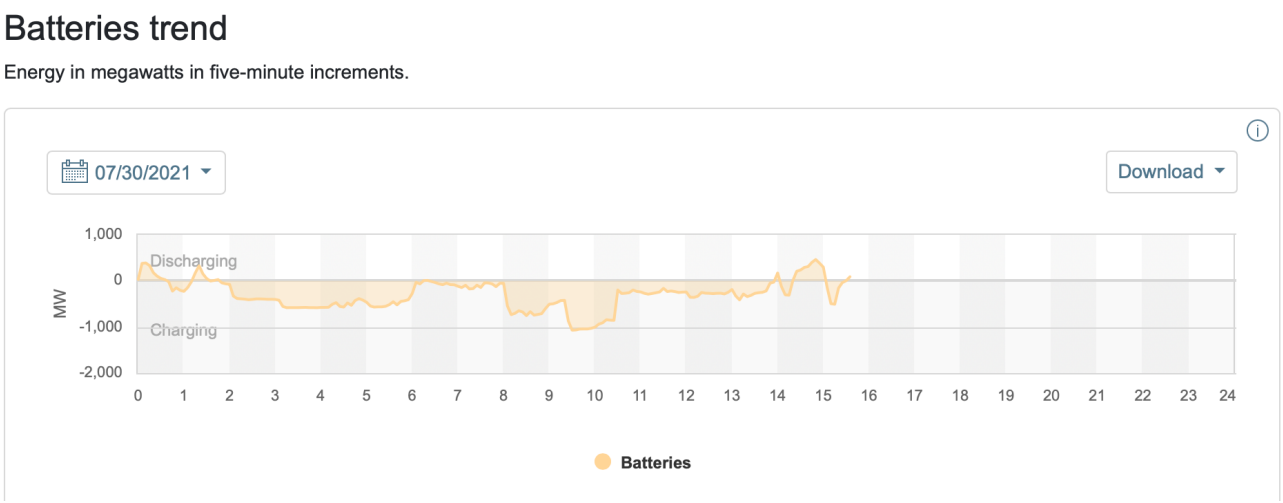
Solar power that makes up most of the renewables' contribution in green above, is about to drop hard, as sun begins to set. Of course, eminently forecastable! So, this 11,000 MW from solar at 3 pm above to help meet 40,000 MW of demand – will fall very hard. Firm dispatchable natural gas is generating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



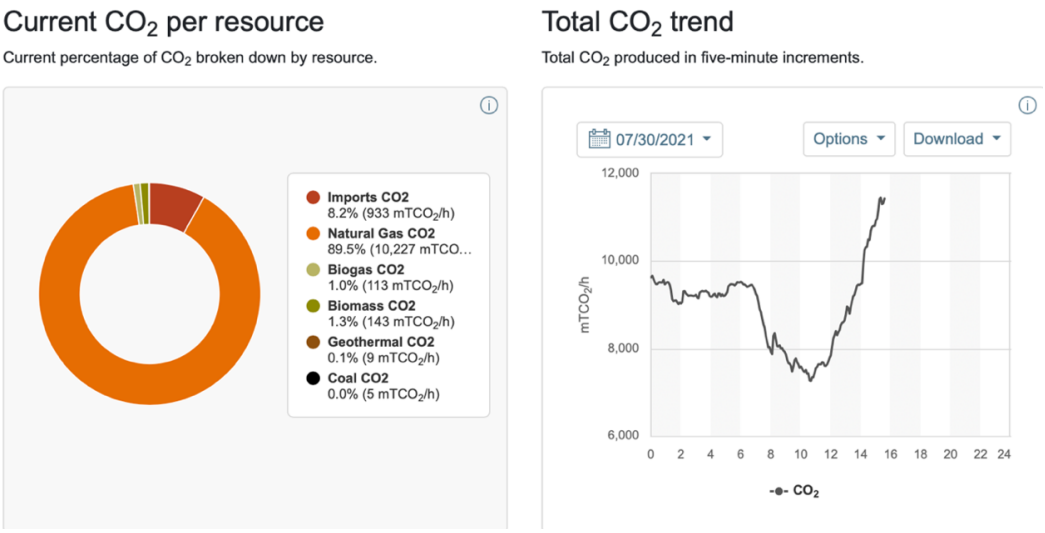
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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

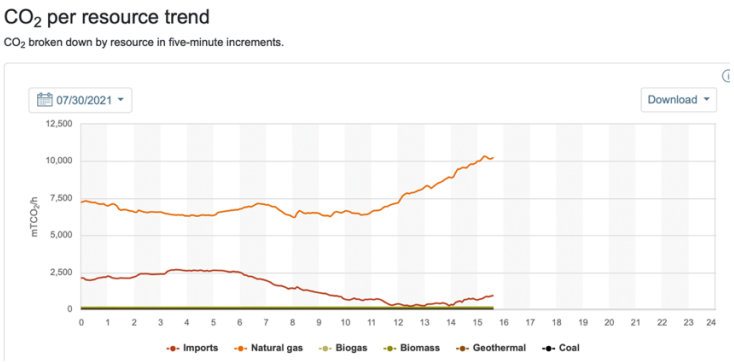


Source: CAISO.com Today's Outlook – On July 30, 2021 at approximately 3:30 p.m.

Hence on insufficient storage in early 2020's, we all suffer from an ongoing dependence on fossils. Mainly on natural gas in California (like Texas, much of US, Europe etc) – producing huge carbon emissions. Big hydro can't be scaled up any more; indeed big reservoirs like Lake Powell, Lake Mead may soon be 'dead pools'. Natural gas might not be as odious as the CO_2 coming from coal per ton, but methane leaks badly vex Earth and climate nonetheless. About 90% of this *measured gas* CO_2 (and leaks make it worse) is but one GHG. 8% from Imports:



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

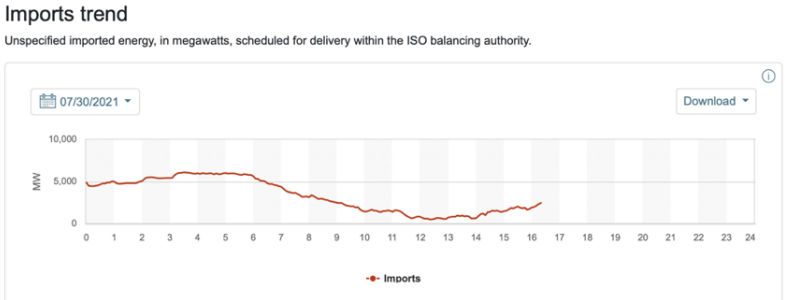


Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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

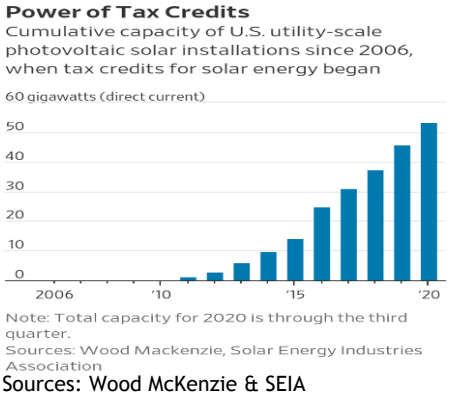
It gets worse. Practical Issues in California's grid early 2020s included in a Flex Alert, the CO_2 Emissions could spike to get Supply as high as possible, over >50,000 MW to meet demand. Natural gas+peaker plants could get maxed 100%, no maintenance, much power imported from out of State. Demand for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

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



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

So what to do 2022/2023/2024 etc? Changing tack recall past possibilities of Tax incentives for energy storage. Back in 2020 proposed pro-storage tax changes had passed in the House – but failed in Senate and weren't supported by a President who opposed green. Next, 2021 saw a new President. But a reconciliation BBB failed in the Senate. But 2022 it's just possible that such text might be attached to broader bills, or tax extenders, or simply narrower stand-alone legislation. Tax credits, once so crucial to starting solar – could again, possibly, grow vital to storage, batteries, grid. A big 'omnibus' BBB bill had failed 2021. But piecemeal tax-credit language carried over from BBB was maybe possible in new spending or tax extenders say 2022 and onwards. It's a chicken & egg problem. Solar had needed both cheaper panels – & favorable (tax) policies to light a fuse, prime a pump. Both were needed. This chart shows how fast solar then grew after partly on pro-solar tax credits post-2006. Solar stands strongly on its own now – but like all else in energy, earlier tax policies had mattered:



Sources: Wood McKenzie & SEIA

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

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

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

Last Few Years … and Indexes

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

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

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

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

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

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

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

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

Source: finance.yahoo.com

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

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

One key problem had been in 2021 the US lags so badly in producing lithium, nickel etc for batteries. Also, in producing enough rare earths minerals, which in fact are not very rare, yet needed for motors & strategic uses. As Sen. Manchin observed 2021, "We don't produce any of the rare earth minerals, or very, very, very little of any rare earth minerals that it takes to make a battery. We depend on other sources of the world … that we seem to want to be out of sight, out of mind, and we just say, 'Well, we have an electric vehicle." Nickel, for instance, is in critical demand for manufacturing batteries, for electric cars, and grid.

This 'ain't our first Rodeo' in seeing a US fall badly behind when it needn't have done so. We saw solar manufacturing decamp from Japan, US, Germany - to China 2 decades ago - then to Vietnam, Malaysia, Thailand, etc. By 2020 the 3 biggest PV makers were based in China. (Whether a shift happens ahead may depend partly on if US tariffs are put on exported PV). A problem is, this may be happening again for crucial batteries. Such needn't occur. But the US in 2021 had only 3 big battery factories. Tesla's Gigafactories could point the way, yet we may see only 10 in total big US battery factories in 2030. We should be seeing many more. Here, 'US' factories include the S. Korean etc owned factories merely built in the US.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Given 2016 declines, last 5 years to end 2021 by mathematical coincidence could have improved – even if ECO had been flat-ish 2021. That was a mathematical fluke without much significance; just please do be aware of it given steep slope up in 2020 – then sharp decline. And 2021 was about drops. At any rate 5 years captures a small sliver of time. Corrections happen, trees don't grow to the sky. Clean once long *down* past 5 years in prior Reports in the 2010s, had shifted. And a once more monolithic early 2010s with 'All of energy far down' (clean too) - lately has been changing in the early 2020s, by a lot.

In a 5-year Chart below clean ECO/NEX has left a down 2014-2016 period. It also reflects 3 positive up years 2017, 2019, and 2020. So, gains in ECO, NEX, OCEAN were big absolute ways – plus more so relative to major Indexes too. With clean ECO up by +300% below, it left dirty fuels, and major Indexes 'in the dust' even with 2021 jumps in dirty energy. Past 5 years to Oct. 2021, ECO's tracker is strongest of all, up +370%; and global new energy NEX is up +200%. Performance by a best major Index 'bogey', NASDAQ is comparable to NEX and tied at +200%; while Dow and S&P500 are near 'just' +100%. Normally anything up +100% in 5 years is a 'Win'. So, in an absolute sense, all 3 major bogeys did well. Just relative to clean themes of ECO/NEX/OCEAN, did major Dow and S&P500, flail – only NASDAQ is near NEX. Far at bottom are the two fossils: oil and natural gas themes, each far *down* dropping some -40%!

ECO/NEX trackers vs. fossil fuels themes and major Indexes, Past 5 years Oct. 2016 to Oct. 2021. Once, the last 5 years was 'tough' for all of energy; here it's now Differentiated – Clean ECO/NEX at top have far outpaced Dirty energy – and most major Indexes:

Source: finance.yahoo.com

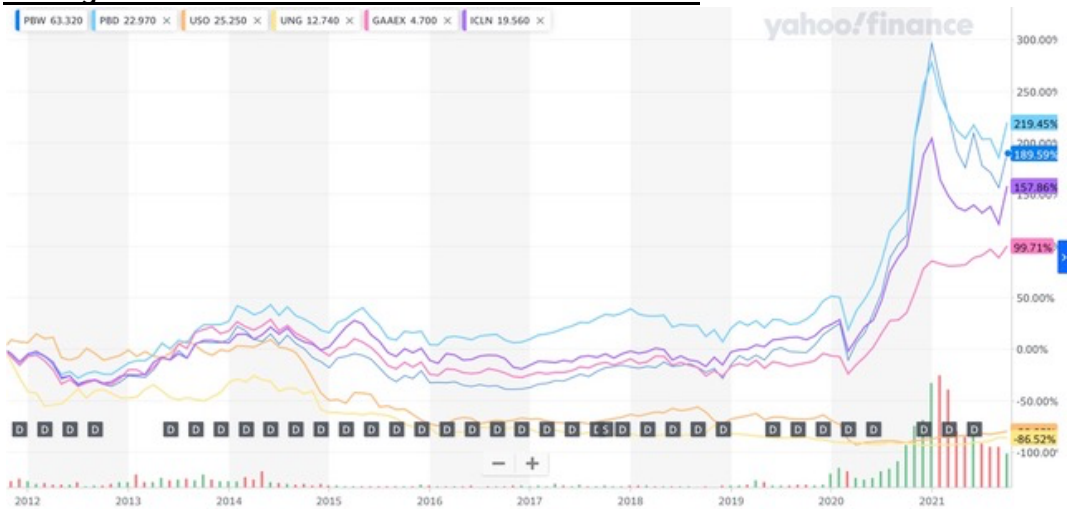
A separate major, independent, younger global clean energy Index, not ours and not shown - trailed Global NEX here; that global clean energy theme underperformed NEX most all sizable periods, the last 1, 5, 10, 12 years, since inception etc. It, and a couple other relevant themes: an excellent solar-only story, and an active alternative energy fund, are seen next in the charts ahead for stories of past 10 years, 12+ years, plus. These three replace a Dow, S&P500, and all country world ACWI theme, for better visual clarity in the Charts.

Clean can also clearly can & does plunge at times. So, after tremendous gains for 2020, a big drop 2021 wasn't so surprising. On the other hand, clean's gains may at times outpace broad Indexes, going up more. Consider August 2020: the Dow had gained +7% for its 7th best August since 1984. S&P500 was up +7% in its 8th best August since 1986. Meanwhile same month, ECO was up that August by +20%, NEX was up +15%, & OCEAN was up +12% (nor was it their greatest monthly gains in that year: November and then December 2020 next saw larger gains).

Next page is past 10 years rolling, here well positive for clean. Until recently, clean's story last 10 years was a relative 'dog' (our apologies to all dogs). What had changed? From a strict charting sense, it's partly due to leaving steep declines seen long ago, late 2000s and early 2010s. They were near final legs of a steep renewables plunge. So including in any bit of those years had bent performance downwards. Clean energy has relatively outperformed vs. dirty at times since. Still, clean also plunged back then too, which warrants attention. Thus, seen next is a rolling chart for the rough past 10 years, Oct. 2011 - to Oct 2021.

Here in the past 10 years, *Global* NEX tracker is up most +220%, while ECO is up 2nd best by +190%. This period leaves behind a Great Recession that thunderously dropped all 2008-2012. That had put in bottoms for many *non-energy* stories, many moved very well up afterwards. But not so for energy, which got hit harder, stayed down longer. Seen especially in dirty themes, much in energy went on falling farther 2010s, no immediate rebounding up.

Rolling Past 10 Years from Oct. 2011 to Oct. 2021:



Source: yahoofinance.com

That 2010s decade was rough for clean energy too – just less tough. This story is well captured by ECO/NEX. Note ECO tracker at start of 2010 was at 55: it ended 2019 at 34 - so down. Global NEX tracker in 2010 was 16: it ended 2019 at 14 – so down. Yet clean vs. dirty has diverged - lately happily, by a lot! ECO's clean energy history was live in that decade, as China's manufacturing scaled up fast, and drove down costs. That accelerated solar & wind installations; it also meant lots of (over)supply and crushed solar/wind margins.

Solar has moved somewhat past that overcapacity & commoditization, thin margins. Globally, NEX is most positive last 10 years as noted. ECO is positive too for 10 years. Then next is a large gap vs. a separate global clean energy Index (not ours) telling a not-so-clean and more concentrated story; it's up but 'only' +160%. An active-managed alternative energy fund is up +60%. Just below that an excellent, focused solar-story is up +100%. Meanwhile oil & gas are plumbing depths, far down -85% even after recent gains. A tale of two cities: Big Declines in Dirty energy – vs Clean all Well-Up to varied degrees. That was trending for some time. Until 2021's gains for oil & gas, and that *might, possibly* begin to create a new narrative.

Perhaps ahead this decade, solar + electric cars increasingly converge. We wrote about this 10 years ago, 'Solarsense: The Economic Case for Dumping Gasoline Car and Powering Your Car by the Sun' (2011) and 'Driving on Sunshine' on vehicle to grid, and much more.

So very highest here Global NEX and ECO - far outperformed vs. other energy themes here – and showed yet again it's very tough for active funds to beat the Indexes. Yet even clean, had trailed broader Indexes not seen here like S&P500. On other hand, clean ECO & NEX clearly did 'best' last 10 years in energy stories. As time rolls on past earlier tough years, green Indexes like NEX *may* begin telling a new story. As shown next how NEX captures global new energy, the theme definition is no backroom matter; it's very consequential.

NEX as the first for Global Clean Energy – vs. a differing younger theme:

Consider major differences as between our Global NEX with its trackers in US and Europe – vs. a differing and younger 'global clean energy' Index also with trackers in US and in Europe. That other global Index has several characteristics which do set it far apart from NEX. One, was that other Index was maybe a better choice if one sought a highly concentrated basket made of big caps only, excluding exposure to energy storage, electric vehicles, fuel cells, H_2 and more. Because that other basket has been very concentrated, not-so-clean - it has differed from clean NEX for global clean energy diversely in solar, wind, EVs, energy storage, hydrogen, decarbonization etc. There's been numerous contrasting differences.

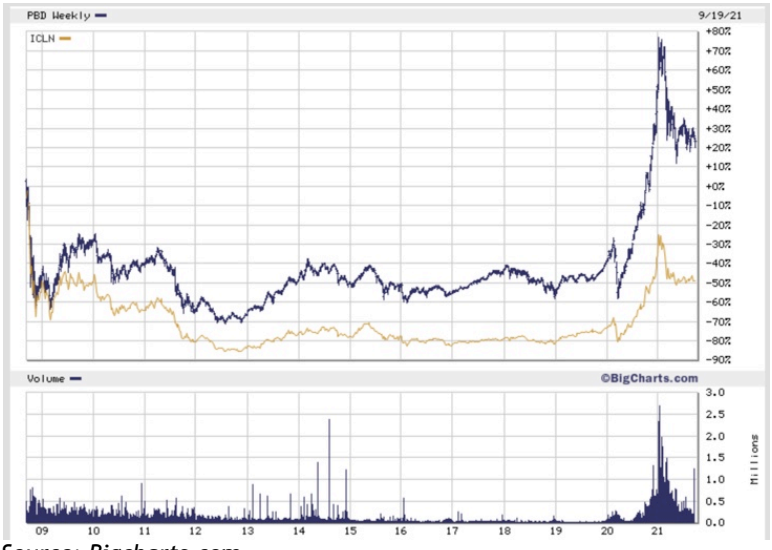
For example in late 2021, much cleaner NEX's 'carbon intensity rating was a good low 151.45 (tons CO_2e/$M Sales) - vs. a dirty 732.57 for that other Index that's wrapped around electric Utilities and Renewables equipment – for nearly 3/4s of it! An NEX steeped in innovation is also unlike old classification by GICS (Global Industry Classification System) nomenclature from 1999. One result has been that other global basket falls heavily into GICS "Utilities". If aiming for only not-so-clean, narrow concentration with a few biggest names, less themes or none in energy storage or EVs – then that other basket was maybe a better choice.

Consider too their Biggest divergence, is Performance. In briefer periods, NEX vs. other Index trade leadership back & forth a bit. On shorter-time-horizons, one Index might lag the other, either way. So, in briefer time frames only, it was mostly a wash, no clear leader.

But for most longer periods, this key fact stands out: **Global NEX (seen in bold)** has mainly well Outperformed that other Index that's also for global clean energy **(seen in brown).** This stands for most lengthy periods: the past 1, 5, 10, 12+ years, since their inception etc.

Here's a Chart below for global clean energy as captured by both Indexes via live trackers for the past 12+ years, Sept. 2008 - to Sept. 2021. It's interesting to see how divergent their performances are for these two Indexes/ tracker funds. *In sum the **global NEX tracker (bold)** has clearly shown far better performance over time capturing global clean energy:*

NEX (bold) which is the first Global Clean Energy theme is Up +25% – vs the separate Index in this global clean energy theme **that's Down -50%** (for Sept. 2008 – Sept. 2021):



Source: Bigcharts.com

Seen above for many years, clean NEX has Outperformed significantly, by well over +50%. Why might that be? 4 factors help explain why that other global theme has trailed so far behind the **NEX** for global clean energy. Perhaps it's because that other, non-NEX basket was:

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

Nothing wrong with that other *per se*. Also it means good contrast between 2 ideas of clean energy Indexes. For other differences, between global NEX – vs. other global energy basket, the NEX had launched/went live first in 2006 – well before that other Index. At start of say, Q2 2021 the NEX had 125 components. That other global basket instead for years since its inception, had held just 30 components to 2021. Just 30 has meant less clean energy scope. It isn't possible to well capture many stories across EVs, hydrogen, fuel cells etc etc.

Weighting styles matter greatly. That other basket based on market cap, was modified by a 4.5% cap, at times far exceeded. Generally at any rate, just 10 names in that other tracker might have reached nearly half (or more) of its total Index weight! In truth global clean energy must be far more than 10 dominant names. Concentrating that way meant a big few might push it up if momentum there narrowly did well - or it might pull that down.

As seen in performances last 1 year, 5 years, 10 years, since inception etc, while the 2 Indexes at times trade leadership back & forth in shorter periods - over most longer periods, the NEX is doing significantly better. Equal weighted NEX say, in Q2 2021 had much greater 125 names and may grow for far wider reach. And helpfully its equal weight style lets more & smaller names be included and heard: each has a voice. Given a big difference in performance, it seems equal weights *may* allow passive NEX (& tracker) to better capture more - especially smaller/mid cap stocks and inherently clean, purer plays. *Please note, Neither one approach is 'right': they're simply 2 differing methodologies.* 2 varied ways for clean stories to be captured. One very concentrated/biased to big – the other clean and wider-ranging.

The other as a practical matter does have moderately lower expense ratios in its trackers (although swamped by performance difference). And its heavy-trading helpfully means liquidity. Overall then, 2 takes on a fast growing theme. An Equal weighted cleaner, better-performing NEX - vs. Market cap less-clean other that skews to Top few. Probably its quite useful in real world ways having 2 such differing benchmarks for a fast-emerging global story. And that other Index has faced vexed issues given how it was designed/constituted. One was arguably very excessive concentration. Another, its tracker faced liquidity risks, given design. As increasing sums flowed in, only a few names in its tracker/s, that could overwhelm the shares in even mid-cap stocks. It in turn might *distort share price, and also *take inordinate number of days for a tracker to 'fill' given such far above average volumes.

After conducting useful public consultation early 2021, the other Index made numerous understandable changes in Q2 2021 and forward. Long having had a fixed 30 components, it was then adding 52 more – and could go towards 100+, total unlimited. (With newly unlimited ceiling it was again growing more like NEX; which makes sense as new energy story grows ahead and this better allows the other Index to reflect an evolving story over time).

However very problematically there could be & were *Non-Pure-plays* added - outside of clean energy. That *might* mean less closely adhering to a clean energy theme, instead for just 'a kind of global clean energy' basket, *less pure*. Big differences between it in 2021 and after – vs. clean, purer NEX. That other Index was before closer to clean energy theme. Generally, for example, it had before had little fossil fuels exposure like in natural gas or diesel.

But with changes, it has held - and still has 2021 – many non-clean names. For just 3 examples, 1) that other Index added with big 5% weighting late 2021 a utility that was getting only 8% of its earnings from renewables: it is instead based on fracked natural gas and already has enough gas pipelines to go from New York to Paris and almost back again: it will not be clean nor sustainable for decades at soonest. 2) It also added another dirty energy name, again another that can't be in NEX as it's heavily in natural gas plus has long deeply in nuclear too: both those are excluded from NEX which is purer as being for clean energy. Moreover 3) that other Index added another electric utility also ineligible for clean energy NEX since it's generating electricity by burning oil & even burning diesel (among last US Utilities to do so)! In 2020 only 35% of that dirty utility's power was from renewables, though it is in a region blessed by abundant sun & wind. Now that other Index 2021 did another market consultation to allow more changes, notably explicitly still allowing much gas(!), just weighted a bit less. And it has kept unfortunately to 'carbon intensity' as a metric. That metric allows dirtiest fossil fuels by use of a distorting false numeracy. Clearly fossils don't belong in an ESG basket; nor should they be in a genuine Global "Clean Energy" theme. Hence, that other theme had moved further away post-2021 to arguably become now only 'kinda clean energy'.

We recall how years back, as small caps grew popular, big inflows made it hard for active funds in general to hold smaller equities. Even those <$1 billion(!) market cap. There was a liquidity risk from inflows. So 'small cap' inched up, maybe to be >$5 billion market cap or more(!) to accommodate growth. Some definitions got thinned out or were diluted out of target concept – no longer pure. A ramification of fast-rising popularity of 'small caps' then was it got harder to hold small equities as inflows grew. Whether active Funds – or passive Indexes. Consider now, newer ESG thinking; green goals seeing tremendous interest. There's been an upswing of activity. Of 'net creations' especially in ETFs in ESG themes. One result may be as investors 'open up to see their ESG holdings', what's in ESG funds, they may be very surprised by what's inside. Confoundingly, many ESG funds today might even hold some oil & gas companies, perhaps even some coal-based names(!). That can be & should be addressed. A greater understanding of ESG arguably ought to prohibit such inclusion.

Arguably with growth, a priority should be staying true to clean. Not be pushed out, to brown energy. Otherwise, a prior focus on good targets (like robustly green, zero-carbon) might get pushed somewhat off-theme. How in the world could oil & gas be included in any ESG basket? Or, make claims to be green or ESG leaders? They can't. But, one unfortunate way is via a 'carbon-intensity' metric. That allows a big fossil fuel producer say with revenues of 70% oil & 30% natural gas – to massively just ramp its gas production so it's say 60% natural gas, 30% oil, 10% biofuels – and claim it's now 'clean'! Because CH_4 /natural gas spews somewhat less CO_2 - vs. oil or coal – on more revenue/profits – it may misleadingly claim a green hue. Nothing of the sort is true. But 'carbon-intensity' lends false numeracy, seeming quantitative rigor - when it's the opposite. Left side of the equation is correct: carbon footprint is measured in tons CO_2 - Scope 1, 2, 3. But right side of equation, via 'intensity' grafts on 'value' or revenue Dollars, Renminbi, Euros. The air cares not a whit 'how *profitably*' a CO_2 molecule is made, whether it's more *profitable*, or less so. But the upshot, is fossils are given a pass.

What 'carbon intensity' can & wickedly does do, is to lend fossils a fig leaf. Seems to be quantitative, yet lets polluting firms claim green mantle going oil or coal – to gas. Clever for marketing it enables fossil firms to even go into a few 'clean' baskets – or ESG funds. By other-conceived notions like 'profits per ton/CO_2', that slippery 'intensity' is facile indeed.

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

As to how a green fund or passive Index performs, return to Weighting Methodologies. Interestingly, we've seen that Equal-weighted NEX oft outperforms last 1, 5, 10, 12+ years – vs. a Market cap weighted Index. Note, NEX has smaller pure plays, is inherently purer, with room to grow. For how that may be relevant to outperformance; consider a Chart below.

Here much better results are real-world, is seen in the equal-weighted NEX vs a market-cap weighted Index over long periods; this concurs with the literature. *The Economist* in 2021 wrote about their own notional clean energy Index in portfolio modeling. They constructed a Green Index as seen at right: when it was straight Equal-weighted it very nicely doubled and so went up swiftly from 100 to over 200 in 2020, thus up over +100% … vs a market cap weight version that instead had gone up by less, from 100 to about 160 or 'just' +60%. In their 'Climate Finance: The Green Meme' (May 22, 2021) they report:

Source: The Economist (2021)

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

Describing too how inflows have been increasing into green & ESG themes, they also state:

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

The Economist makes a good relevant point: that it's both surprising and dismaying to find any 'brown' fossil fuel names in ESG funds. Likewise same in global clean energy funds.

Of minor note the sharp thematic volatility seen here isn't necessarily due to *Global* aspects. Consider the *global* NEX - vs a *US-listings only* in ECO. These 2 have industry's longest track records (15+ years, 13+ years) - so put aside for a moment that other, separate global clean energy Index. Glance at just NEX/ECO and a few thoughts come to mind. One, is US-listings-only ECO basket *can* also be hugely volatile too. Seen head-to-head, day to day in eg first 6 weeks of 2021, NEX tracker sizably saw 14 days of 3% or more change/day to March 15. Yet US listings-only ECO tracker, had even more: 24 days of sizably 3%+ change/day.

Hence being *global,* itself, probably doesn't confer volatility. But this clean/new energy innovation, may somewhat. NEX has eg risky areas, say H_2 & fuel cells like other clean energy baskets. And fast moving Europe *may* seek more H_2. Continental Europe lacks gas reserves (it's no Texas) so has been importing gas from uncertain suppliers. It may seek domestic green H_2 on climate risk too. Says nothing of how such equities may perform (maybe down like 2021 or up like 2019/2020). Just reflects a risky theme. Both Index themes clearly remain as always hugely risky, volatile, uncertain: whether clean (US) - or global new energy innovation.

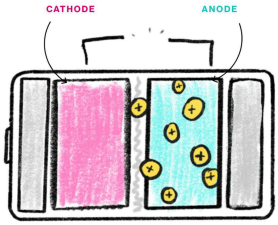
Potential infusions of investment ahead – can both contribute to volatility down, maybe up. In 2021 the International Renewable Energy Agency noted a startling $131 *Trillion* may be needed for clean energy by 2050, to avoid heating >1.5 degrees C. Coal use *may* drop in Europe. Reversing sharp gas gains 2021, gas *could yet* peak there within this decade. Global electrolyzer capacity *may* go from puny 0.3 GW – to 5,000 GW. Green H_2 may be a feedstock for 'green ammonia' - or methanol/CH_3OH, - but neither is green if coming from fossils; that is instead greenwash. Europe, potentially, *might* soon become a green world leader. China may ramp nuclear – while regrettably only slowly reducing (if at all) its coal use to 2025.

So great uncertainties about all this abounds, giving rise to huge volatility and great risk here. Myriad sub-themes may see advances, some incremental, others maybe non-incremental. Possibly, disruptive jumps. New energy storage & batteries plainly have some focus here – ECO & NEX have had significant aspects here since 2004. Other competing baskets may be arriving for storage as well. (That other Index for 'global clean energy' though less-pure may add ahead themes we've long had in NEX like energy storage, smart grid, alternative energy vehicles allowing it to grow perhaps as a truer clean theme better reflecting the story; and help it resolve liquidity risk while skewing away from overweight a few top components).

Energy storage as noted is a big deal in a world needing far better, cheaper, more batteries. An excellent piece in Bloomberg Businessweek helps illuminate ('The Hidden Science Making Batteries Better, Cheaper and Everywhere.' April 27, 2021; we side note that Bloomberg New Energy Finance had been an early partner here for years in the global NEX Index). Excerpting from their useful and nicely-visual piece, we post several good illustrations below.

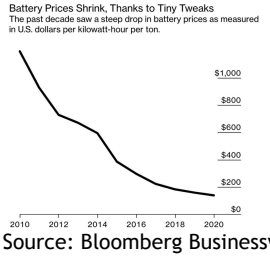
First off what's-called 'lithium ion' includes a constellation of battery materials besides just lithium, such as Iron, Nickel, Manganese. There's much effort now at using little to no, cobalt. While differing chemistries will favor diverse characteristics, all basically consist of *Cathode, *Anode, *Separator, *Electrolyte. The anode is partly settled for now: graphite & some silicon - maybe eg nickel niobate (NiNb2O6) ahead. A few chemistries have dominated at Cathode, each has particular traits where certain strengths are favored – batteries are named for these materials at cathode. Traits balanced include: cost, energy density, weight, calendar longevity, cycle life, fast charging ability, temperature range. Favoring one trait, like seeking a better energy density, may come at the cost or trade-off of a reduced cycles life.

a) 4 basic battery parts:



Source: Bloomberg Businessweek

Battery prices are falling hard:

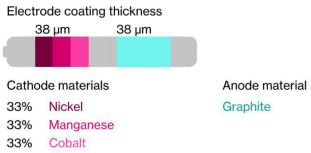


Source: Bloomberg Businessweek

b) Nickel Manganese Cobalt (NMC) in Zoe:

Source: Bloomberg Businessweek

NMC Composition back in 2012:

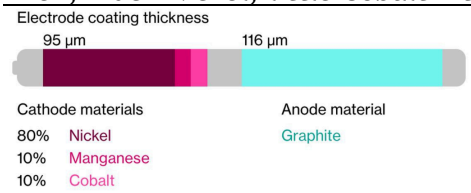


Source: Bloomberg Businessweek

c) NMC as seen recently in a Nio:

Source: Bloomberg Businessweek

Then, much Nickel, little Cobalt = thicker:

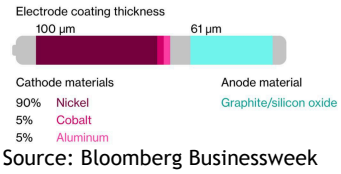


Source: Bloomberg Businessweek

d) Tesla 3 has used NCA:

Source: Bloomberg Businessweek

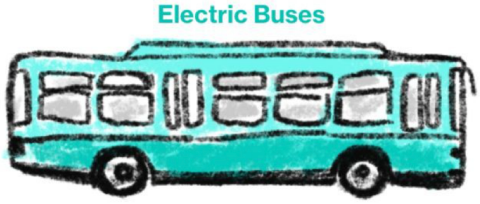
NCA, light strong battery, no manganese:



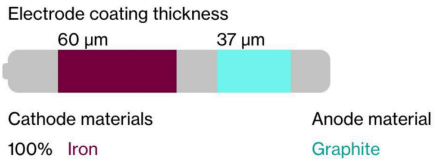
Source: Bloomberg Businessweek

Popular has been NCA, or NCM with say 8:1:1 ratio of nickel, cobalt, manganese. LFP uses cheaper iron, phosphate – freed from vexed cobalt and costly nickel. So LFP is gaining in use and it improves profit margins, while (heavier) sodium-ion is being looked at too. Uses may favor say cost - vs. weight. Heavy LFP on iron hasn't had quite the same performance of say, NCA, but it's safer and improving fast. (We'd had an early electric bike here 2001 with LFP chemistry). LFP may be seen in a bus as less range and weight's a non-issue and may have gone <$100kWh(!) in 2021 in China – or be used in a price-conscious ever-faster EV sedan:

e) Electric Buses using LFP lower-cost iron:



Source: Bloomberg Businessweek



Source: Bloomberg Businessweek

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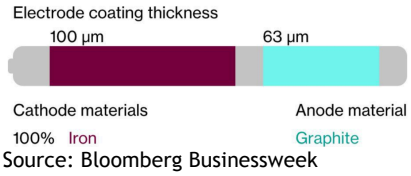
f) Modern LFP, a bit less-energy dense:

Source: Bloomberg Businessweek

Thicker Electrode, is less costly using iron:



Source: Bloomberg Businessweek

So efforts go on for better cathodes, varied chemistries in uses like cell phones vs. ebikes vs. EVs etc etc. Much depends say if energy density - or lower cost is desired. It's certain cathodes will keep on evolving, improvements ahead. For example nickel is costly and relatively scarce. Plus on desires to get to no cobalt, attention is being paid to improving energy densities as noted via iron/phosphate (LFP) batteries. At one world-class top EV maker, iron has let that manufacturer improve its profit margins – over spiffy/costly NCA (nickel, cobalt aluminum) performance cells. A huge LFP supplier in China (where else?) seeing new LFP competition, has been giving leverage to EV makers to consider yet more lower-cost, good LFP options.

Or adding bit of silicon at anode, without anode swelling, may show promise. Farther ahead exciting metallic lithium batteries could be – should be - very impressive. Fire risk was untenable still in 2021, as 'dendrites' could penetrate electrolyte. But new-generation solid-state batteries ahead this decade may be tantalizing. A drumbeat of wistful hope, that ever-on horizon solid-state batteries that in past are so-elusive, *may* be getting closer. Possibilities of non-incremental advances in solid-state batteries later this decade make one hopeful.

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

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

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

So iron is quite literally, everywhere! We see it in Mars' red-tint that's due to iron. Iron's to thank for Earth's vital magnetic core. That molten iron makes a magnetic shield protecting life from intense solar radiation that otherwise kills. Miners already, are starting to look at making 'green' iron ore for steel. In a 'two-fer' they could maybe use it for batteries too. Maybe gigawatts of new green electrolyzer capacity, with Europe & Asia leading.

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

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

Lest that disappoint, consider gaslighting, greenwashing, or dissembling are oft last gasps of a waning industry. Fossil interests may/do see writing on the walls. Solar & Wind vs old coal – like Electric Vehicles vs old gassers, arguably are already regarded as superior technology. They've 'won' in a sense already. Next decade+ is an important but more granular way filling in the blanks. Mid-term incumbent natural gas likely faces stiff competition by batteries/ storage, especially with gas price spikes along a way enabling new firm power. Longer-term, much riskier, just maybe: green H_2 *might* be viable for heat in buildings and industry. And all very risky as baskets here capture dynamic evolving themes. Looking ahead, we're at start of an innovative new decade+, future entirely uncertain. Yet let's briefly look back now at a past decade+ in Indexing, for brief elucidation on time frames and Charts.

A little point about Charts. An issue with **rolling** Charts, the past 1, 5, 10 years is that in a few years, these *may* show very strong returns ahead for ECO & NEX. Once charts leave huge falls in 2008-2012, after tough energy times 2014-2016, then with relative drops removed both ECO/NEX *may* show far greater relative gains. For that reason, a view is needed too with the greatest so far ECO declines 2008/2009 preserved: hence this Chart below. From a fixed (not rolling) 2008, looking onwards. Long-running ECO + tracker might have begun from 2005, yet other trackers didn't commence until later – so earliest feasible start was mid-2008.

Over now 14+ years & growing, this *non-rolling* chart shows Very Big declines. Unsurprisingly, all fossils lag green sizably. But relative to rolling 10 years that may grow quite rosy, a vibrant difference here is the global crash in 2009 has been highlighted and forever preserved.

Farther back we'd note an ECO predecessor in the WilderHill Hydrogen Fuel Cell Index had informally calculated 1999-2007. Given this ECO chart below picks up from 2008, we've uniquely thus been capturing hydrogen & fuel cells for over 20 years now since 1999! For H_2 FCs, one can visit our 20+ year-old 'predecessor site', the Hydrogen Fuel Institute, http://h2fuelcells.org So, this chart below preserves as in amber, big 2008/2009 drops after rising in early-2000s. From 2008 as some trackers commenced, near peaks, all soon plunged. That 2008/2009 crisis 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 here, we can see fossil fuels oil and gas are far down here some -95%(!). 'Above' them is that independent other global clean energy basket off -50%, that theme which fell hard long had just 30 components and differs greatly vs. clean NEX. Then, solar-only is well off -50%. An active managed alternative energy fund nearby, -50%. Well 'above', steeply rising yet down by -22% given big falls 2008 is ECO. Clearly 'highest' energy basket here is the global NEX though near nil as up a negligible 6%. Broader major Indexes (not seen here) did *far* 'better' – yet they differ sizably for energy is but a sliver there. Plus, in 2017-2020, clean energy showed quite some up volatility too; that *may* yet change things ahead:

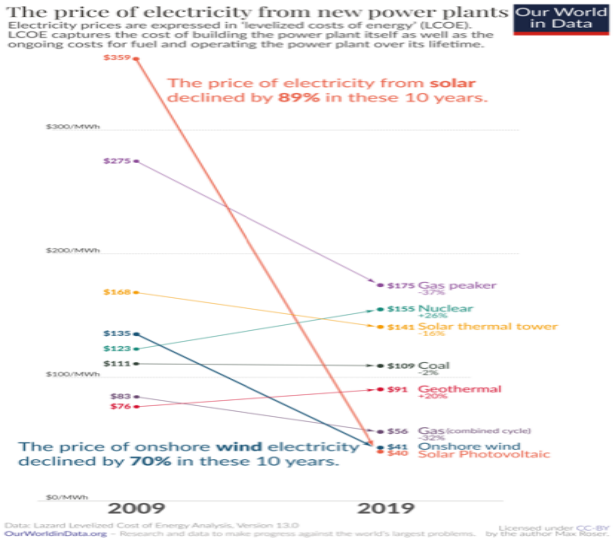
<u>Roughly Last 13+ Years starting from a Fixed June 1, 2008 to October 2021:</u>

Source: yahoofinance.com

So that's looking back, a decade or more in past, to when clean energy looked very different. A flip side to America having had nearly-zero-green power back in 2010 - is despite growth - where we stand on renewables in 2022, is *Awful*. In 2022 US offshore wind 'should' already be hundreds of GWs, instead its near-non-existent. US had total 7 offshore wind turbines in 2021; Europe had 5,400. Solar in 2021 made only 3%, and wind 8% of America's electricity. At a time when solar & wind *'should'* be meeting 100% of US electricity demand. Instead, electrification of cars, trucks, ships, planes still was but a tiny rounding error start of 2022. So, it may feel like we've come some ways – *but only given where we were in 2010*. World Economic Forum noted from Our World in Data that fossils made 79% of energy production worldwide in 2019. Unsurprising as fossils for years were cheapest option. Low-cost meant all – they alone were uniquely emphasized in past as dispatchable power. But not much longer.

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

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



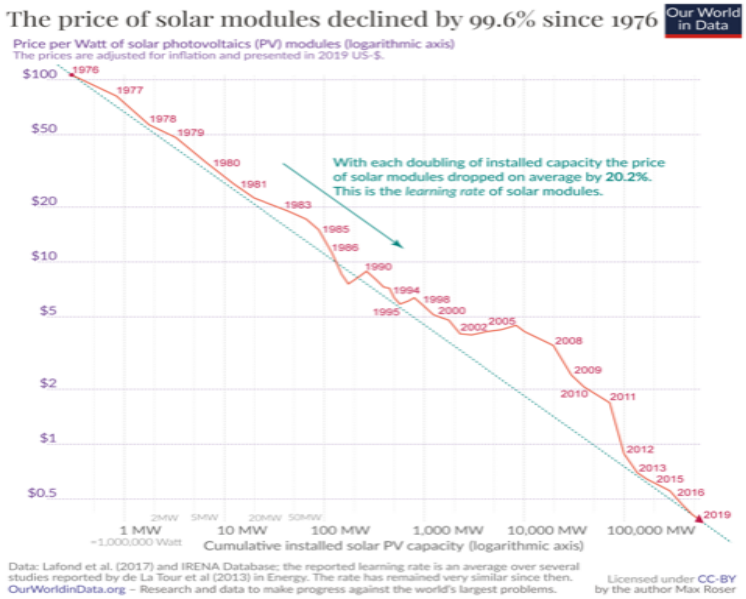
Source: Roser, Why Did Renewables Become So Cheap So Fast? Our World in Data (Dec. 2020).

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

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

Renewables solar, wind geothermal - instead 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 in already-built coal, gas & nuke, can they hope to reduce costs significantly until extant plants age-out. Comparing like for like, new solar/ and wind simply are much more affordable on levelized costs/LCOE – than dirty.

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



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

Solar prices fell enormously -99.6% since 1976(!) on technology. If US tariffs on PV from China etc are removed, so PV enters US freely, it's cheaper still. Fossils – by contrast - are Not all about technology; they may be doomed 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 power and are deploying it all. No doubt they will Not go gently into that good night. Natural gas & nukes may have notable roles yet in this 2020s decadal energy transition period. In sum, it's no wonder solar & wind power make up most power plants built today – with growing storage. Here in a clean energy Index, storage is crucial. How an Index is constructed, and where it aims as we'll next address – is significant.

Very meaningful are initial choices within an Index. They shape it and that vision impacts later performance mightily. Even passive baskets are formed in a theme's creation. Let's look at a well-known 'FTSE 100'. Based in UK, often called the 'Footsie', this Financial Times Stock Exchange Index is made up of the 100 largest blue-chip firms on London Stock Exchange. A 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 the firms domiciled there, are doing.

Consider then when market value of just 1 US company, Apple, overtook that entire market cap weighted FTSE 100 Index 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 the 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 1999 earlier at 6,930. Later it passed that 2016, next in 2018 at 7,877. But Jan. 2021 at 6,400 it stood out as being only +11% higher than where it had been some 15 years prior.

Much stronger growth rate was seen from 1984 to 2005 when it had had a much better return compound average growth +12.5% (real terms +8.5%). But 2005 through 2020 annual growth rate had become much slower. Only 2% ahead of an inflation that then was at +4.7%.

That over a period of late when US technology & innovation equities positively boomed.

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

As a market cap weighted Index, it can auto-adjust for awful returns in CO_2 heavy oil. As its once-biggest firms declined, lost prominence, it should have allowed faster-growing smaller firms to instead take leadership positions. But a problem has been, the rest of that Index remember is literally 100 largest firms; they've similarly been in slower areas like mining (8 in 2021, but had been 12), in retail and 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.

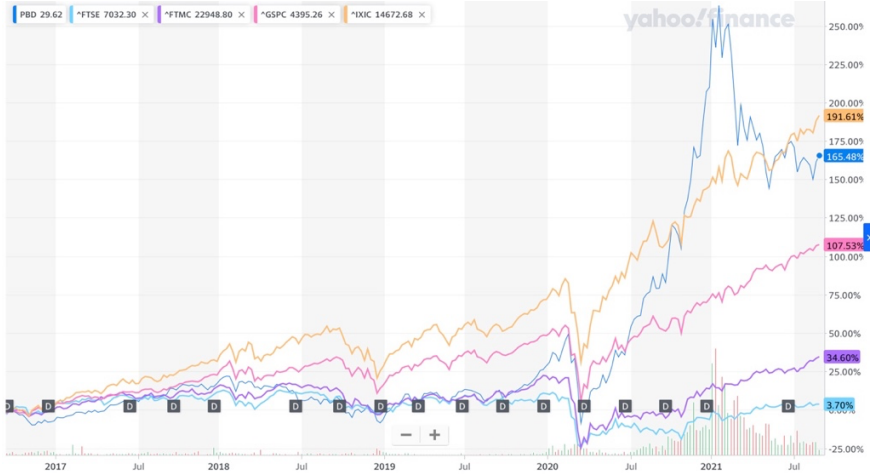
What's was in FTSE 100 in 2021? Royal Dutch Shell was near top. Of 277 past components in FTSE 100, many were retail like Boots (health beauty retail), in old energy like BOC (now part of Linde). Banks, once UK giants in FTSE have faded. British American Tobacco and Imperial both in tobacco – do not 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 in the past 5 years to 2021 by our own two trackers, the global new energy innovation NEX Index, and ECO Index.

As pointed out, a part of FTSE 100's issue is an absence of organic growth in its components. Sage plc has its 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 2020/2021, innovative-equities, than FTSE 100.

In a 2021 chart below, clearly the bottom performance past 5 years is a FTSE 100, light blue. It was up relatively little this 5 years period to Sept 2021, a very puny +4%. Next up mid-cap FTSE 250 in purple did better, +35%. But tech-rich S&P500 in pink has doubled here up +110%. And **NEX in blue** is up +165%; A tech innovation **Nasdaq composite, in gold** is most up +192%. 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':

Past 5 years to Sept. 2021; FTSE 100 & FTSE 250 at bottom - vs. the NASDAQ & **NEX** at top:



Source:YahooFinance.com

In some ways FTSE 250 is similar to 100 – other ways different. As name implies it's 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 by 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 may do better down years). In the FTSE 100 those big older energy firms 2021 were 9% of it, plus mining/materials 13% - for 22%. By contrast, those 2 older themes were just 5% of US market; 10% of Europe. In US, technology was 28% and healthcare 14% of S&P500; in a Europe-wide Index (ex-UK) they were 10% & 16%. By contrast those 2 were just 1.3% & 10% in UK. To quote The Economist from Nov. 27, 2021, "The London Stock Exchange (LSE) increasingly looks like a care home for old-economy companies, rather than a cradle for new-economy ones. Less than 2% of the FTSE 100's value is accounted for by tech firms, compared with 40% of the S&P500's." In sum, Index rules & construction are definitions that can vitally shape a theme. They matter. Next, let's look at a few possibilities for clean new energy ahead here in a world that's fast changing.

Recent Change – perhaps possibilities ahead:

Bills proposed in 2021 were just a start: there'll be much more climate legislation over this decade. What happens *may be* historic for clean energy. *Just possibly* impactful across 2020s. 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 is seen in a 500 page Select House Committee on the Climate Crisis Report from Summer 2020 and increasingly 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 accomplished – but some will. Work shall unfold over years; the most aggressive aims dashed on rocks of reality. Yet any steps begun in this decade, towards real decarbonization, would be a big change.

The Plan is no small beer; far more ambitious & aggressive than ever contemplated before. On a new Oval Office, House + Senate, this decade **may** unfold unlike 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 and spike as sole fault of renewables - expectations may shatter. Great change requires much support, legislation, and a US Senate home to compromise, inertia, realpolitik.

Consider as well, how little was done for US clean energy in say 2020. That Summer 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 in 2021 clearly 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, big 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 all 2019. This had tripled the world figure 1H 2019. Major offshore wind array decisions in 2020 had included to green light a 1.5 GW Vattenfall project off The Netherlands and largest to date at $3.9 billion; a 1.1 GW SSE Seagreen offshore farm in UK for about $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 for this appetite were huge declines in offshore wind costs – plus looming subsidy cliffs. Unlike solar based strongly in semiconductors (cramming ever more capacity in chips), wind is more about advances like in heavy fabrication, ever-bigger blade designs. From 2012 to 2021 levelized offshore wind costs had thus dropped 67%. Unlike onshore-wind that rubs up against limited space, oceans are immense windy places for massive turbines far from view. Big wind farms provide desirable, reliable, returns on capital. Renewable investments rose 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.

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

One maybe, was BP with big money was a bit late to the party. Their bid with German partner Energie Baden-Wuerttemberg was well outside norms for bids in wind. It meant they'd pay 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 the £89,000 MW/year & £76,000 MW/year in 2 bids in 2021 won by the 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 may feel 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 tough target anytime, especially aiming for no-risk. Too, oil & gas had earlier shown poor returns, years prior to 2021. US behemoths like ExxonMobil had been hit considerably. Even with 2021's gains, past times were hard to match. A 23-year-old oil rig roughneck once earned $100K+ working part-time: that bubble is largely gone. Hard to think of a 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 and training may make good salary around $80Ks/year. Geothermal with drilling, $80Ks. Solar with some years of experience, $70Ks. Unionization rates have dipped everywhere including fossil production. But in areas like pipefitters, unionization rates are relatively higher and it comes with sizably better Wages and Benefits. Here 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 to be enjoyed by first-mover risk-takers. Otherwise, lumbering fossil fuel giants like a BP or 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 oil supermajors – who have instead made clear they do *Not* wish to venture into renewables. For a contrast, take Orsted, of Denmark. It divested out of old oil & gas - to now focus on true green energy. A leader like Orsted, even slow-changing BP, Shell, or TotalEnergies of Europe – all contrast sharply with America's Big Oil. US oil may cling to 'sequestrating carbon', blue H_2 marketing ideas – soldiering on in fossil-centered business models. All those probably non-starters, as was reflected in market caps even 2021.

Consider 2020 Raymond James data on the renewable clean tech investments at the big cap oil & gas firms, showed that of 7 Big Oil firms committing to net-zero emissions 2040 to 2050 - fully 6 were based in Europe. Of the top 7 with all Big Oil, their name/country and the 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%).

A 4% cap ex spend at BP for new renewables & clean tech, might not be terribly inspiring. However, ExxonMobil in the US spent much less at 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 shows biofuels, biomass, wind, solar, and 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 with only modest moves back up as demand rebounded, oil/gas/coal leapt up in 2021. But look back further, and Big Oil stock valuations have Declined a bigger 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 Sept. 2021. Here is **BP in dark blue** as a Big Oil example, at bottom, down -27%; hardly different also negative is carbon-heavy **ExxonMobil, in yellow**. In sharp contrast is Orsted, in light blue, highest at +266% (once in oil & gas, but sold that & instead is in clean renewables like offshore wind). Close is a tracker for decarbonization seen in **global new energy innovation Index (NEX) in orange**, 2nd from top and up some +170%:

Source: GoogleFinance

Denmark's Orsted rather is posterchild for a once oil & gas firm, fully transitioning to clean new energy – successfully so. Growing more profitable to boot! No half steps, nor dithering 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 a green transition (like Orsted) to sustainable energy will satisfy this measure. Even if US Big Oil is determined to stay in dirty energy on facile CO_2 accounting. Or by claiming 'offsets' an oil company may pretend rock gas is clean, or 'green'. Or it may make dubious marketing claims – yet Scope 3 nonetheless grows ever-tougher.

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

Lessons learned by UK offshore can also assist US on infrastructure like undersea cables. Facilitate offtake of power in a first-place. In this and more, the US has badly trailed behind UK in offshore wind. By 2021, there was just 10 GW in UK – yet it ranked it a world-leader. The UK now aims to quadruple this decade for 40+ GW offshore wind - enough to power much. They could do more. The US by contrast in recent 2021 pathetically had near-zero offshore wind power, despite being a vast country with bigger 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 has 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, equivalent to just 2 turbines! That figure ought to be growing yesterday – but it's happening much too slowly.

Breaking down a US Pipeline there's 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 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 mostly early development stages. As slices of pie, already-installed US wind was 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 wind was advancing towards permit offtake, or 22%. It's a big ocean; some 60% of that 28 GW pipeline, or 17 GW was in lease/site control steps. There are many years to go yet in just this decade - but progress is 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 the 11 US States in a wind pipeline in 2021, were on the East Coast. Despite Pacific Ocean/Gulf wind resources! One might've guessed there'd already be tens of gigawatts off Texas/Louisiana coasts - yet only California & Hawaii in 2021 then had potential projects. Merely 1 GW in planning – with much needed like submerged cabling. That said BNEF raised estimated US offshore wind projections by +70%, from 11 GW by 2030 estimated 2018 – to 19 GW estimated by 2030 later projected in 2019. It's been growing since.

Possibly, big changes ahead in offshore wind are relevant to all 3 themes, ECO, NEX, OCEAN. In the US - and worldwide too. For scope of potential changes, consider how puny offshore wind was just recently. Then, imagine what *may* come in this decade – escalating quickly near 2030 and after. Up until 2019, the global cumulative offshore wind capacity had only reached but 27 GW. And it 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 to boom; it had swiftly added nearly half (47%) of all new global capacity in the one year, 2019.

A decade prior, steady UK growth had built the most installed offshore wind: 8 GW. Germany started later, grew faster. China even more recently then 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 27 GW operating 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 by start of 2022.

More granular, it gets interesting from 2024 as the US may be a big player in *floating* offshore wind. It opens immense tracts of available space. Offshore wind as fixed to seabed, has been mainly seen on America's East/Gulf Coast; trailing edge margin keeps waters shallow. But floating opening up US West Coast, waters thousands of feet deep, would be a new ballgame. Here 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 about 1/3rd of the floating pipeline. A 25 MW test, called Float Atlantic in Europe became operational 2020 and it proved the potential. Very early days yet. And Asian leadership in floating wind isn't just China, nor just Japan; 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 and each had operating floating test units.

A startling change may be America's 2.3 GW *proposed* pipeline. Castle Wind off of California, at 1 GW may float in 900 meters' depth. 7 proposed US projects may use steel semi-submersible platforms, easiest of 3 main types of floating substructures. On a shallow draft they might be built dockside, be 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 seabed, 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 for offshore wind (WTIVs) must be built using monopiles on seafloor and jackup depths over 50 meters. New US vessels, considering America's Jones Act. Port infrastructure too must be built, from scratch, for growing both fixed & floating wind.

Of course, most crucial in wind, is pricing. Like solar, it's been falling, wind more modestly than solar – but falling nonetheless. Both renewables are growing very favorable, vs. costly current technology like nuclear, coal, oil & gas. Storage is what's needed now as well. Old 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 the world's better-priced ocean wind projects was 6.9 cents. And US tax changes 2021 made it better. Floating wind may fall to near 6 cents, then under that in later years, most everywhere.

Once *offshore wind* gets a better toe-hold 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, solar there too is fast advancing as China confounded expectations for slower solar in 2020 due to Covid. Instead, its solar manufacturing *gained* speed in pandemic. First half of 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 fossil fuels. 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 in California & Texas. And a crunch late 2021 in Europe/UK – was mainly once again due to fossils, especially to natural gas issues.

Back in 2020, in EU-27 wind, solar, hydro, bioenergy then made 40% of electricity overall. Fossil fuels were 34%. With some notable standouts: Austria then made 93% mainly using its renewable hydropower, Portugal had made 67% from its renewables, Germany 54%.

In Denmark, 2020, wind & solar made 64% of its electricity; Ireland 49%; Germany 42%. In absolute terms Germany had continued building enormous growing fleet of renewables - with pretty big moves away from coal. And its wholesale electricity prices went *down* near just 3 cents per kilowatt/hour (kWh). By contrast in neighboring more coal-dependent Poland, wholesale electricity costs burning its dirty coal were higher - more near 5 cents kWh.

So, Wind & solar are growing. From making just 13% EU electricity 2016, to 22% in 2020. Yet in a more pressing perspective, there's a long, long way to go given what's needed on CO_2. More renewables, more flexibility, ability to export excess power, transmission, batteries: all are fast needed! 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.

A surprise in 2020 was the US extended a 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 then 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 the just very few, only small solar listings possible for ECO and NEX we well recall back in 2006, even 2012. Yet in 2022 fast rising cost inflation across solar inputs – 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. Compellingly, clean energy – 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, heating. Coal too seeing knock-on rises, like oil spikes, Maybe strong inflation, 'slugflation', even stagflation. Not our Grandparent's energy world - or maybe, one simply different!

For years, coal's price had hovered near level – as renewables & natural gas got far cheaper. Thusly did renewables (and natural gas) become leaders. Especially in 2020 on demand loss, Utilities turned 1st to their lowest-cost sources. Those were renewables, and natural gas. Coal was left out. Gas is big, capable, flexible. Fracking had let gas costs fall to just $2 per million BTUs – later on spikes in 2021, it would go $6. But still, all fossils lack prospects for sustainable growth decades+ 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 cars or trucks only let them reach silly theoretical bests near 40% efficiency. More typical car heat engines sadly just 20% efficient(!). Gigantic heavy SUVs anchored further down by low-torque 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 in 2010s had under-appreciated what lithium-ion batteries - lashed to efficient (>90%) torquey AC motors, could do. Next improving on better, cheaper batteries, 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 a dottery old way to achieve electric power generation!

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

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

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

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

Yet like older Newtonian Physics, what was 'known', misled. Semiconductors at nano-scale, we've lately learned bit of quantum strangeness, and to make use of that. Smallest scales around us space/time, gravity, differ from past Newtonian suppositions. In a weirdly different Quantum theory once bizarre; it increasingly explains reality. On such greater understandings – that other worldly weirdness (the truth) usefully-gets-harnessed by new technologies.

It's already essential to cell phones, GPS, Lasers, MRI Imaging, LEDs. Ubiquitous computers rely now on quantum effects not-heretofore known prior centuries. Revolutionary ideas, superposition of objects in 2 or more states at same time. Einstein-Podoleky-Rosen paradox where 2 entangled particles though far distant from one another, seem linked real-time so appear to share information - inconceivably faster than light! (Entanglement & Copenhagen interpretation solved a latter thorny quantum puzzle). We've progressed as we learn. Space is not truly a complete vacuum; virtual particles may briefly snap in & out of existence. Photons may act in 4 possible ways, 2 are observed, other 2 options cancel each other out. Wonderful Mr. Richard Feynman's Rules of probability are weirdly, profoundly deterministic – and there is the Hong-Ou-Mandel effect. (If interested in more, see for example Quantum Centre at the UK University of Sheffield, https://www.youtube.com/watch?v=ld2r2IMt4vg).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Getting to US to zero CO_2 from 2020, means eliminating in 15 years: all 668 coal plants, most of 6,080 gas-fired plants. Fast-ramping solar/wind with a 15% faceplate capacity – that made 9% of US energy in 2019 as they're non-firm; intermittent windless days, no solar at night.

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

That's far, far too late given CO_2. So instead, consider tripling 2021's growth in renewables. Back of napkin we'd need to replace 791 gigawatts of fossil generation, to be 100% clean by 2035. For a rough $ cost estimate, a 1,500 MW (1.5 GW) of wind power built in Oklahoma in 2019 had cost then around $2 billion. That gives a figure of $1 trillion to replace US fossil power – 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 grave problem' vs firm power, and that 'solar/wind are much too costly' – we'll take some pages ahead to outline a plausible US scenario for next 15 years.

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

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

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

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

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

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

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

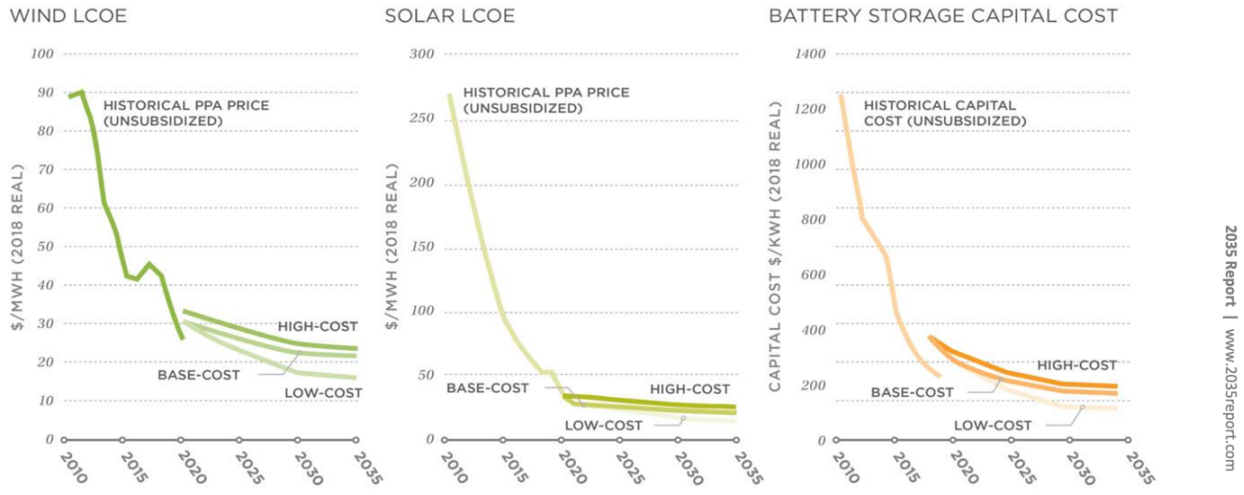
US energy generation growth had gone big before; natural gas grew by 65 GW in 2002. Now what's needed, changed: *energy storage* is 3rd leg triad to solve intermittency of renewables. Key new storage deployment needs to grow by 25% each year. Starting from a measly 523 megawatts storage in 2019, it should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

Happily, only modest new transmission or spur lines are seen necessary to interconnect expanding clean power, so less pressing need for costly slow-to-build intergenerational lines. No tough overturning of grid infrastructure, requiring long lead times. But what changes, is the composition of both generation and storage over this now fast-arriving 15 years. Texas may seek to connect to the US East and West grids for resiliency, but that's a different matter. First off, all US coal plants will need to be permanently shuttered by 2035 under this plan. Places like California, it's already done. Extant coal elsewhere mainly has been running so many years now, that 15 added years in this Plan leaves time to recoup capital investments. It is doubtful coal owners would want to burn much longer, given higher costs and liabilities vs. clean power – but recouping those costs going 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.

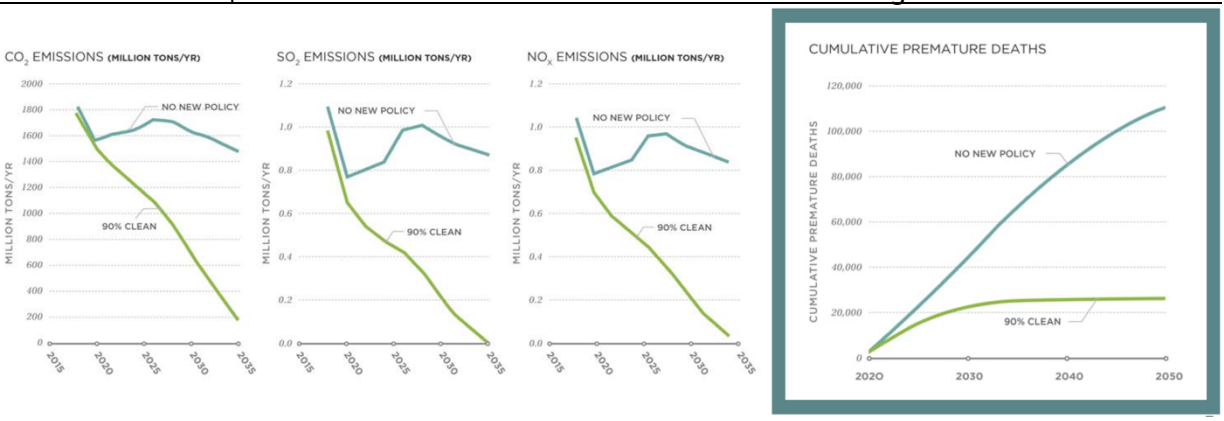
<u>Dramatic Declines in Costs Have Arrived 2020 Far Sooner than Expected:</u>



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!

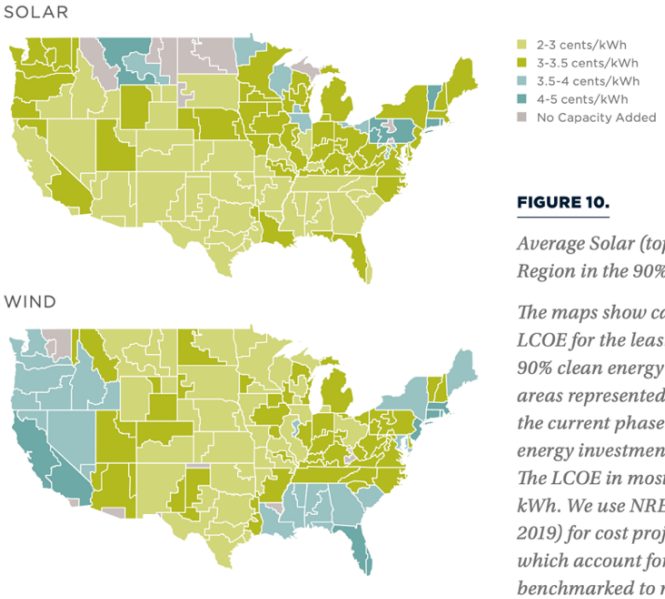


FIGURE 10.

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.

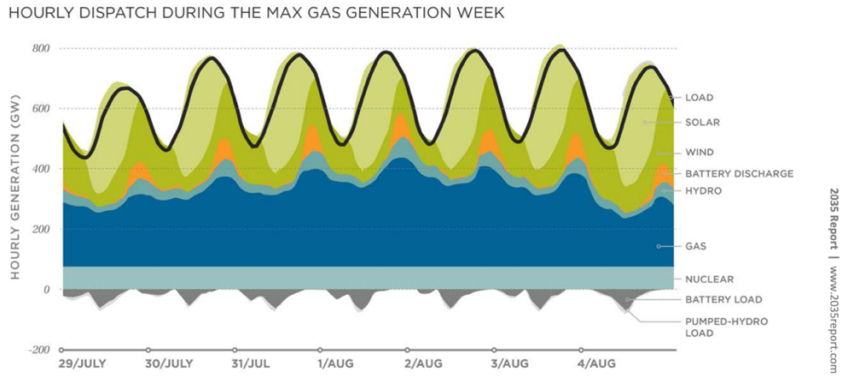
Over 7 weather years modeled, in normal conditions, wind, solar, battery storage generally, regularly provided 70% of annual generation; hydropower & nuclear provide 20%. But when there's very low generation by renewables solar/wind – and/or unusually very high demand, existing natural gas plants, hydro,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

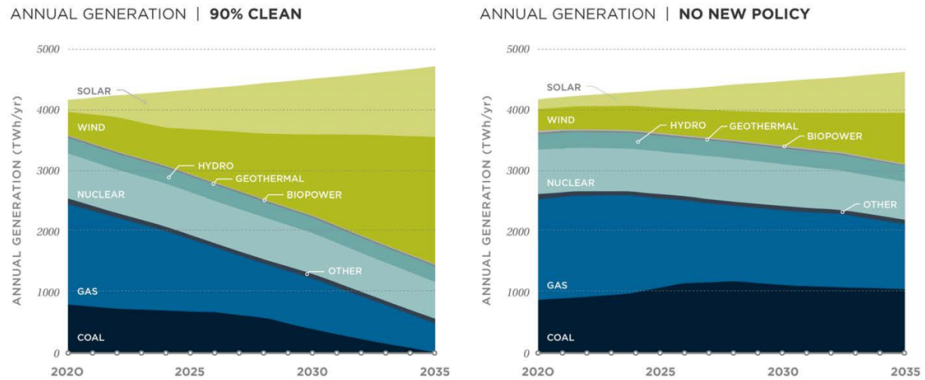
A Worst-Case Generation Period for Renewables: Still Moving Off of Fossil Fuels/Nuclear:



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).

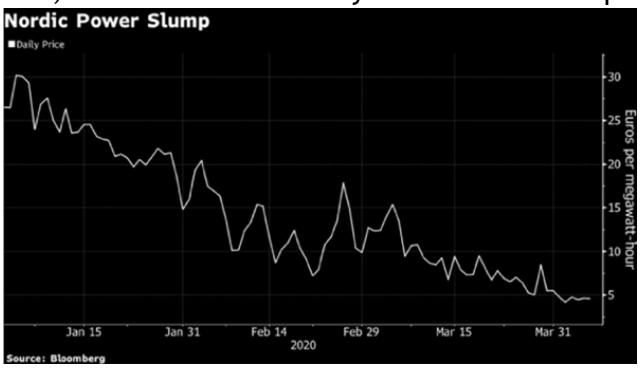
Recall some 'normal', pre-Covid, *applied* clean energy trends back early 2020. As renewable prices were falling in good & snowballing ways (unlike oil/gas). Start with Solar; costs had then hit a new record low: *only 1.35 cents per kilowatt/hour* at a big 1.5 GW solar farm going up in Abu Dhabi! True,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

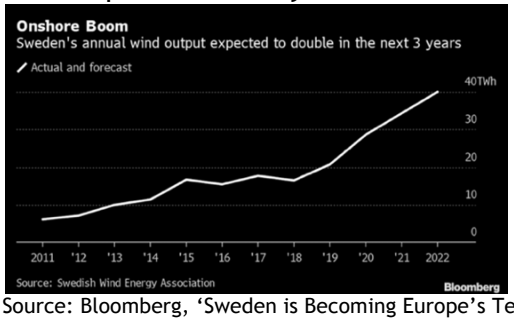
Sure, yes, renewables wind/solar are intermittent. Winds not always blowing, like no sun, or rains for hydro. Yet at such times, then other renewables too may be tapped. For instance, geothermal might possibly grow well as firm power. Especially when oil rig counts drop, geothermal may then grow attractive.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

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

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

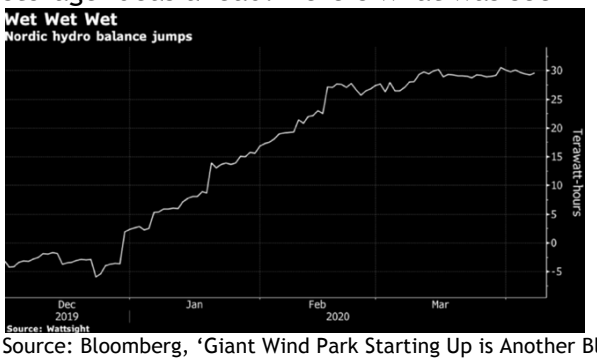
Dirty cheap northwestern China coal, had long attracted industries like PV; cheap electricity eg Liuzhou was an incentive to make EVs too. Yet Northern Nordics may potentially do it one-better ahead! If cheap/er renewable power can make green steel, aluminum - industries shall welcome that – as low embedded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

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



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

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



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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Solar manufacturing capacity worldwide, back in 2020 was 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 puny 0.250 GW in 2010!). We've seen PV manufacturing becoming a low-margin, commodity business. With a decade of consolidation, wringing out costs, growing capacity, PV growth steepening; yet 2021 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 over 30% of their power by wind 2020. Like more Liberal Colorado, New Mexico, Nevada, Vermont. Offshore wind may come to Great Lakes, US Gulf coast, Western US Coast: maybe all offshore wind powerhouses ahead.

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

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

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

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

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

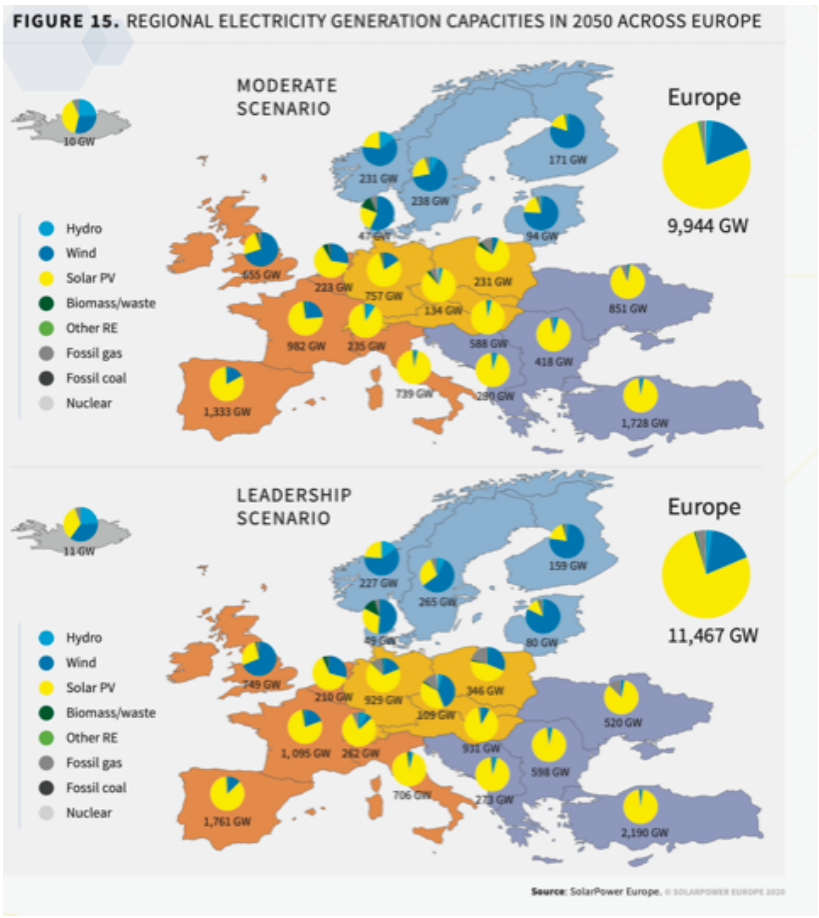
This Report recommends that policymakers should begin immediately creating a framework targeting installed 7 TW solar power – plus 1.7 TW of wind to be reached before 2040.

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

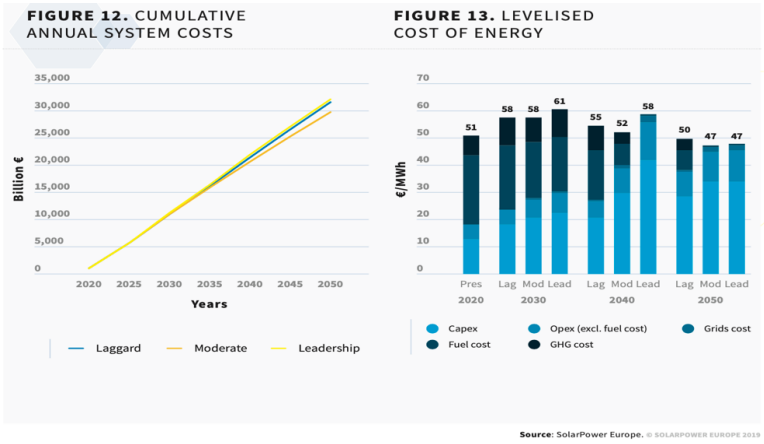
2 scenarios presented were Moderate approach – and Leadership one that's quicker. Former meets only 2 degrees C heating goal of Paris. Latter meets a more robust, better 1.5 degrees C goal. Again, it's a matter of when this ramp begins, so the angle of departure. But interestingly, the stronger and sooner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

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

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



Source: Solar Power Europe 2020.



Source: Solar Power Europe 2020.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Consider CO_2: A Topic Gaining Importance

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

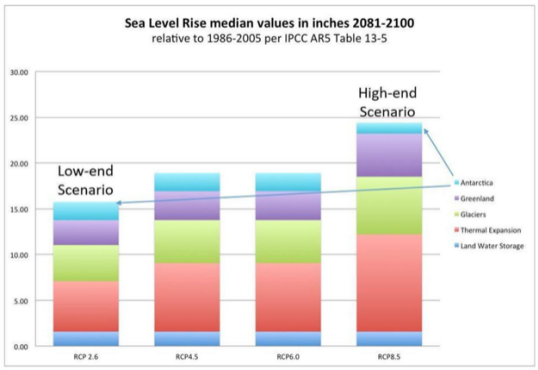
Imagine say, just 80 years hence. Note aspects of projections by an Intergovernmental Panel on Climate Change (IPCC) for sea level rise in 2100, may be a bit misleading. End of this century, rise may be unwinding at more rapidly accelerating rate, than what had seemed projected by IPCC. Getting that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

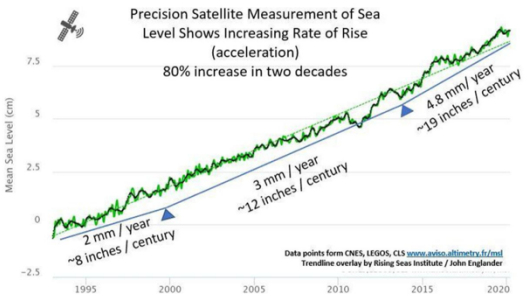
That actual sea levels seen in 2100, could be greater than IPCC projections is well laid out in 2020 piece, 'Twenty-first century sea-level rise could exceed IPCC projections for strong-warming futures' by M. Siegert et al., One Earth, 3 (Dec. 18, 2020). Their first paragraph nicely lays out cogently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

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

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

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





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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Pliocene carbon levels 3-5 million years ago over a long period, declined. After that epoch, then a couple million years of hot Earth before humans appeared, PPMs and temps fell; down off an earlier Miocene, from 2,000 ppm perhaps on extreme volcanism, eventually giving way to hospitable carbon levels and temperatures wherein we evolved, nearer 230 ppm. Key then was our planet's ability to pull CO_2 out of the atmosphere over very, very, very long periods of time by Earth's natural 'rock thermostat'. Specifically, CO_2 was absorbed for example such as by rocks over millions of years. And taken up as by calcium carbonate and oceans

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

A tiny sea level change we're accustomed to now - rising only a little over 1 inch per decade and 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 indicate 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'd once been prepared to give, the 2020s may feel like progress. Clean energy appears to 'fast' (not really) be replacing fossil fuels. But, based on CO_2 budget, even 'ambitious' action now puts us in a maybe unbearably hot future, rising seas or worse. Once, we'd got our energy from beneath our feet, underground. Being dirty wasn't viewed as a problem. Thankfully, clean energy is increasingly coming from above towards the Heavens. It renewably shines on our faces, cleanly blows across our cheeks, in ways more sustainable, desirable, economic, and arguably for a better future - if we can make it …

Conclusion:

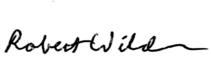
The Clean Energy Index® (ECO) started 4th Quarter near 160 and ended near 150, down for Q4 about -7%. In the year, ECO Index® began 2021 at 215 and so was down -30%. After its notable +203% gain for 2020 when this ECO decarbonization story rose hard by 6-fold, about the best performance for any Index or Fund anywhere and that followed a +58% rise for prior 2019 – a strong 2021 decline was maybe overdue. Thus it wasn't so surprising after ECO Index fell in early 2020 by ½ to 50, rising next to 280 - to see it fall again in 2021 by ½, to near 140. Volatility partly due to green policies (up) - or reconciliation bill's death (down, yet its energy portions may be resurrected). Since 2017 when volatile ECO was 38, it's up +300%.

The first *global* clean energy Index is the New Energy Global Innovation Index (NEX) live since 2006 with a tracker in Europe too: it's up about +200% for last 5 years, starkly beating fossils. NEX has often outperformed too vs. a less-pure, not so clean, independent other 'global clean energy' Index most sizable periods past 1 year, 10 years, 12 years, since their inception etc; much greater thematic purity in the NEX & equal weights here help explain that divergence. In sum WilderHill themes are clean, pure-play benchmarks. And energy long dug from down deep underground & burned – increasingly is captured now in disruptive & sustainable ways – fuel that's coming to us all freely and renewably from up towards Heavens.

10 Additions to ECO for Q1 2022 were Archer Aviation, ESS, Fluence, Hyzon, Lightning eMotors, Ree, Rivian, Sunlight, View, Wallbox – and 3 Deletions for Q1 were Ayro, GreenPower, Willdan. At Global NEX Index for Q1 2022, 13 Adds were Cadeler, China Datang Renewable, Electreon, Energiekontor, Fastned BV, Lilium, Lucid, Nexans, Nkt, Pod Point, Proterra, Rivian, Wallbox - 13 NEX Deletes were Caverion, Falck, Greencoat, Greenlane, GreenPower, Hexagon Purus, Hydrogen Refueling, Royal DSM, Ree, Sunworks, Transalta, Voltalia, and Willdan.

As always, we welcome your thoughts and suggestions.

Sincerely,



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Appendix I:

ECO Index (via independent tracker PBW) Descending Weights in latter-Q4 on 12/13/2021, or about ~2 weeks before the rebalance to start Q1 2022. 71 Stocks:

Name	Symbol	Weight
Enovix Corp	ENVX	2.32
Lithium Americas Corp	LAC	2.20
MP Materials Corp	MP	2.14
EVgo Inc	EVGO	2.10
Canoo Inc	GOEV	1.97
Tesla Inc	TSLA	1.95
Enphase Energy Inc	ENPH	1.94
Wolfspeed Inc	WOLF	1.90
Standard Lithium Ltd	SLI	1.85
XPeng Inc ADR	XPEV	1.83
Fisker Inc	FSR	1.80
Willdan Group Inc	WLDN	1.79
Ameresco Inc	AMRC	1.79
Plug Power Inc	PLUG	1.76
Bloom Energy Corp	BE	1.75
Ormat Technologies Inc	ORA	1.72
Albemarle Corp	ALB	1.70
Li-Cycle Holdings Corp	LICY	1.68
SunPower Corp	SPWR	1.66
ESCO Technologies Inc	ESE	1.62
Livent Corp	LTHM	1.61
Piedmont Lithium Inc	PLL	1.61
SolarEdge Technologies Inc	SEDG	1.56
MYR Group Inc	MYRG	1.53
Sunnova Energy International Inc	NOVA	1.53
Sociedad Quimica y Minera de Chile SA	SQM	1.52
First Solar Inc	FSLR	1.52
Sunrun Inc	RUN	1.50
Blink Charging Co	BLNK	1.49
FuelCell Energy Inc	FCEL	1.48
JinkoSolar Holding Co Ltd ADR	JKS	1.47
Gentherm Inc	THRM	1.46
QuantumScape Corp	QS	1.46
Renewable Energy Group Inc	REGI	1.44
Array Technologies Inc	ARRY	1.43

Advanced Energy Industries Inc	AEIS	1.41
NIO Inc ADR	NIO	1.38
Canadian Solar Inc	CSIQ	1.38
FTC Solar Inc	FTCI	1.37
ChargePoint Holdings Inc	CHPT	1.37
Quanta Services Inc	PWR	1.36
ReNew Energy Global PLC	RNW	1.35
GreenPower Motor Co Inc	GP	1.34
Maxeon Solar Technologies Ltd	MAXN	1.33
Woodward Inc	WWD	1.33
Azure Power Global Ltd	AZRE	1.29
Gevo Inc	GEVO	1.28
Beam Global	BEEM	1.27
ReneSola Ltd ADR	SOL	1.25
Lion Electric Co/The	LEV	1.21
Advent Technologies Holdings Inc	ADN	1.21
Ballard Power Systems Inc	BLDP	1.20
Kandi Technologies Group Inc	KNDI	1.19
Infrastructure and Energy Alternatives Inc	IEA	1.15
Romeo Power Inc	RMO	1.14
Stem Inc	STEM	1.14
Universal Display Corp	OLED	1.13
Shoals Technologies Group Inc	SHLS	1.12
American Superconductor Corp	AMSC	1.12
Arcimoto Inc	FUV	1.11
Itron Inc	ITRI	1.10
ElectraMeccanica Vehicles Corp	SOLO	1.09
Daqo New Energy Corp ADR	DQ	1.06
Workhorse Group Inc	WKHS	0.97
Joby Aviation Inc	JOBY	0.97
Lordstown Motors Corp	RIDE	0.88
Eos Energy Enterprises Inc	EOSE	0.83
TPI Composites Inc	TPIC	0.68
SPI Energy Co Ltd	SPI	0.37
Sunworks Inc	SUNW	0.31
AYRO Inc	AYRO	0.29

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

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

INDEX (ECO) SECTOR & STOCK WEIGHTS FOR START OF Q1 2022. 78 STOCKS.
Each stock freely floats according to its share price after rebalance.
*Stocks below $200 million in size at rebalance are *banded with a 0.50% weight.

Renewable Energy Harvesting - 17% weight (12 stocks @1.37% each +1 *banded)
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 panels after spinoff from Sunpower.
Ormat, ORA. Geothermal, also in areas of recovering heat energy.
Renesola, SOL. Solar, project development and operations, China & globally.
**SPI Energy,* SPI. Solar and EVs, develops solar projects, subsidiary in EVs.
Sunlight Financial, SUNL. Solar residential financing, credit provider.
TPI Composites, TPIC. Wind Blades; also light-weighting for transportation.

Energy Storage - 26% sector weight (20 stocks @1.30 each)
Albermarle, ALB. Lithium, specialty materials in batteries for energy storage.
Chemical & Mining of Chile, SQM. Lithium, large producer in energy storage.
Enovix, ENVX. Silicon-anodes, 3D for improving new lithium-ion batteries.
Eos, EOSE. Zinc grid batteries, 100% depth discharge, longer-life, is not li-ion.
ESS Tech, GWH. Iron flow batteries, longer duration and non-lithium storage.
Fluence, FLNC. Battery storage, for renewables and digital applications.
Kandi, KNDI. EVs, inexpensive small cars early-stage, battery exchange, China.
Lion Electric, LEV. Urban electric trucks, buses, vans; vehicle to grid storage.
Lithium Americas, LAC. Lithium, deposits in State of Nevada U.S. & Argentina.
Livent, LTHM. Lithium, and compounds used in batteries for energy storage.
Lordstown Motors, RIDE. Electric commercial pickup trucks, American startup.
NIO Inc, NIO. EVs, China-based startup premium vehicles, battery as a service.
Piedmont Lithium, PLL. Lithium, US domestic source battery-grade lithium.
Quantumscape, QS. Battery, solid state lithium-metal energy dense fast charge.
Rivian, RIVN. Electric vehicles, trucks and commercial fleets, charging
Romeo, RMO. Battery packs, designs & builds energy systems, snap in uses.
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 - 26% sector (20 stocks @1.30% each)
Ameresco, AMRC. Energy saving efficiencies, net zero CO_2, decarbonization.
American Superconductor, AMSC. Wind, grid conditioning; superconductors.
Archer Aviation, ACHR. Electric aircraft, cleaner, vertical takeoff & landing.
Arcimoto, FUV. EVs, smaller very low-cost 3 wheeled electric vehicles.
Blink Charging, BLNK. EV Charging, among bigger EV charging networks in U.S.
Canoo, GOEV. Electric delivery vehicles, configurable and multipurpose.

Chargepoint, CHPT. EV Charging, global including for fleets and businesses.
Electrameccanica Vehicles, SOLO. EVs, 3 wheeled and custom electric vehicles.
EVgo, EVGO. EV Charging, DC fast-charging Networks from renewable power.
Fisker, FSR. EV crossover SUV, is assembled by contract manufacturer.
Infrastructure and Energy, IEA. Renewables, power generation to delivery.
Itron, ITRI. Meters, utility energy monitoring, measurement & management.
Joby Aviation, JOBY. Electric aircraft, cleaner, more energy efficient.
MYR Group, MYRG. Grid transmission and distribution, for solar & wind farms.
Quanta Services, PWR. Infrastructure, modernizing grid & power transmission.
Ree Automotive, REE. EVs, modular propulsion and steering in wheel arch.
Shoals, SHLS. Solar, electrical balance of system (EBOS), 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 - 21% sector weight (16 stocks @1.31% each)
Advanced Energy, AEIS. Power conditioning: inverters, thin film deposition.
Advent, ADN. Fuel cells, high temperature so fuel-flexible for diverse uses.
Ballard Power, BLDP. Mid-size fuel cells; PEM FCs as in transportation.
Bloom Energy, BE. Stationary fuel cells, not-yet cleanest/renewable fuels.
Enphase, ENPH. Microinverters, also energy storage systems and software.
ESCO Technologies, ESE. Power management, shielding, controls, testing.
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.
Plug Power, PLUG. Small fuel cells, for eg forklifts; drop in replacements.
SolarEdge Technologies, SEDG. Inverters, solar optimizers, inverters.
Wolfspeed, WOLF. Electrifying power, Silicon Carbide SiC, converters.
Woodward, WWD. Converters, controls for wind power, energy storage.

Greener Utilities – 8% sector weight (5 stocks @1.40% each + 2 *banded)
**Beam,* BEEM. EV Charging, rapidly deployable portable PV power platform.
ReNew Power, 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, lease, PPA or purchase rooftop PV.
**Sunworks*, SUNW. Solar provider, a 1-stop for commercial and residential.

Cleaner Fuels – 2% sector weight (2 stocks @1.00% each)
Gevo, GEVO. Biofuels, lower carbon liquid fuels from renewable sources.
Renewable Energy Group, REGI. Biodiesel, natural fats, grease to biofuels.

Appendix III: **WilderHill New Energy Global Innovation (NEX)** descending weights late-Q4 via independent tracker (PBD) 12/13/21, ~2 weeks before Rebalance to start Q1 2022. 125 stocks:

Name	Symbol	Weight
EVgo Inc	EVGO	1.30
Iljin Materials Co Ltd	020150 KS	1.18
Enphase Energy Inc	ENPH	1.13
Lithium Americas Corp	LAC	1.12
Canoo Inc	GOEV	1.12
Li-Cycle Holdings Corp	LICY	1.11
Fisker Inc	FSR	1.11
Plug Power Inc	PLUG	1.11
MP Materials Corp	MP	1.10
Wolfspeed Inc	WOLF	1.09
Motech Industries Inc	6244 TT	1.06
FREYR Battery SA	FREY	1.05
XPeng Inc ADR	XPEV	1.01
Bloom Energy Corp	BE	1.00
Willdan Group Inc	WLDN	1.00
Enlight Renewable Energy Ltd	ENLT	1.00
Falck Renewables SpA	FKR	0.98
Sino-American Silicon Products	5483 TT	0.98
NEL ASA	NEL	0.98
McPhy Energy SA	MCPHY FP	0.97
Ameresco Inc	AMRC	0.95
VERBIO Vereinigte BioEnergie AG	VBK	0.95
QuantumScape Corp	QS	0.95
Ecopro BM Co Ltd	247540 KS	0.95
United Renewable Energy Co Ltd/Taiwan	3576 TT	0.94
Ormat Technologies Inc	ORA	0.93
FuelCell Energy Inc	FCEL	0.93
BYD Co Ltd	1211 HK	0.92
PowerCell Sweden AB	PCELL SS	0.92
2G Energy AG	2GB	0.91
Arcosa Inc	ACA	0.91
SolarEdge Technologies Inc	SEDG	0.91
SunPower Corp	SPWR	0.88
Livent Corp	LTHM	0.87
Solaria Energia y Medio Ambiente SA	SLR	0.87
Novozymes A/S	NZYMB DC	0.86

CropEnergies AG	CE2	0.85
Acciona SA	ANA	0.85
Koninklijke DSM NV	DSM	0.84
Piedmont Lithium Inc	PLL	0.84
Corp ACCIONA Energias Renovables SA	ANE	0.84
Kingspan Group PLC	KSP	0.84
Hannon Armstrong Sustainable Infrastructure	HASI	0.83
Gencell Ltd	GNCL	0.83
Greencoat UK Wind PLC/Funds	UKW LN	0.82
Sociedad Quimica y Minera de Chile SA ADR	SQM	0.82
Nibe Industrier AB	NIBEB SS	0.82
SMA Solar Technology AG	S92	0.82
Terna - Rete Elettrica Nazionale	TRN	0.81
Verbund AG	VER AV	0.81
Encavis AG	ECV	0.81
Sunrun Inc	RUN	0.81
ChargePoint Holdings Inc	CHPT	0.80
Neoen SA	NEOEN FP	0.80
Prysmian SpA	PRY	0.80
West Holdings Corp	1407 JP	0.80
Aker Offshore Wind AS	AOW	0.79
GreenPower Motor Co Inc	GP	0.79
Xinjiang Goldwind Science & Technology Co Ltd	2208 HK	0.79
Array Technologies Inc	ARRY	0.78
EDP Renovaveis SA	EDPR	0.77
Nordex SE	NDX1	0.77
Xinyi Energy Holdings Ltd	3868 HK	0.77
Flat Glass Group Co Ltd	6865 HK	0.77
JinkoSolar Holding Co Ltd ADR	JKS	0.77
Samsung SDI Co Ltd	006400 KS	0.77
TransAlta Renewables Inc	RNW	0.77
Sunnova Energy International Inc	NOVA	0.77
First Solar Inc	FSLR	0.76
Doosan Fuel Cell Co Ltd	336260 KS	0.76
Hydrogen Refueling Solutions	ALHRS FP	0.76
SolTech Energy Sweden AB	SOLT SS	0.76
ITM Power PLC	ITM LN	0.76
Renewable Energy Group Inc	REGI	0.76
GS Yuasa Corp	6674 JP	0.75
Landis+Gyr Group AG	LAND SW	0.74

Maxeon Solar Technologies Ltd	MAXN	0.74
Mercury NZ Ltd	MCY	0.74
Siemens Gamesa Renewable Energy SA	SGRE	0.74
NIO Inc ADR	NIO	0.74
Signify NV	LIGHT	0.73
Ganfeng Lithium Co Ltd	1772 HK	0.73
Orsted AS	ORSTED DC	0.73
SFC Energy AG	F3C	0.72
Meridian Energy Ltd	MEL	0.72
AFC Energy PLC	AFC LN	0.72
Grenergy Renovables SA	GRE	0.71
Ballard Power Systems Inc	BLDP	0.71
Xebec Adsorption Inc	XBC	0.71
Canadian Solar Inc	CSIQ	0.71
Innergex Renewable Energy Inc	INE	0.71
Boralex Inc	BLX	0.71
FTC Solar Inc	FTCI	0.71
American Superconductor Corp	AMSC	0.70
Lion Electric Co/The	LEV	0.70
Caverion Oyj	CAV1V FH	0.70
Azure Power Global Ltd	AZRE	0.69
Greenlane Renewables Inc	GRN	0.69
Scatec ASA	SCATC	0.68
Stem Inc	STEM	0.68
Joby Aviation Inc	JOBY	0.68
Alfen Beheer BV	ALFEN	0.67
Ceres Power Holdings PLC	CWR LN	0.67
Gurit Holding AG	GUR SW	0.66
Universal Display Corp	OLED	0.66
Xinyi Solar Holdings Ltd	968 HK	0.66
Shoals Technologies Group Inc	SHLS	0.65
ReneSola Ltd ADR	SOL	0.65
Voltalia SA	VLTSA FP	0.65
Hexagon Purus ASA	HPUR	0.65
Itron Inc	ITRI	0.65
Gevo Inc	GEVO	0.65
CS Wind Corp	112610 KS	0.64
Vestas Wind Systems A/S	VWS DC	0.64
RENOVA Inc	9519 JP	0.64
REE Automotive Ltd	REE	0.62

SK IE Technology Co Ltd	361610 KS	0.61
Daqo New Energy Corp ADR	DQ	0.57
Cell Impact AB	CIB SS	0.51
Eos Energy Enterprises Inc	EOSE	0.50
Lordstown Motors Corp	RIDE	0.50
Abalance Corp	3856 JP	0.49
Eolus Vind AB	EOLUB SS	0.49
Sunworks Inc	SUNW	0.44
TPI Composites Inc	TPIC	0.36

There's strong representation above from *Lithium & Battery Materials, *EV Charging, and *EVs.

Appendix IV:
WilderHill New Energy Global Innovation (NEX) - for start of Q1 2022. 125 Stocks.

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

Name	Description	Sector	Currency	Activity
2G Energy AG	Hydrogen, biogas, and combined heat and power.	ECV	EUR	GERMANY
Abalance	Solar, from planning to operations; also PV products.	RSR	JPY	JAPAN
Acciona SA	Sustainable infrastructure, has separate renewables.	RWD	EUR	SPAIN
AFC Energy	Fuel cells, alkaline has greater H2 fuels tolerance.	ECV	GBP	UK
Aker Offshore Wind	Offshore wind, new floating deepwater technolgies.	RWD	NOK	NORWAY
Alfen NV	Electric Vehicle charging, smart grid, energy storage.	EEF	EUR	NETHERLANDS
Ameresco	Energy savings, performance contracts, renewables.	EEF	USD	US
American Superconductor	Wind turbines, and grid power transmission.	RWD	USD	US
Arcosa	Wind tower structures, grid power and infrastructure.	RWD	USD	US
Array Technologies	Solar, ground-mounted axis sun trackers.	RSR	USD	US
Azure Power Global	Solar, India, aims to offer lowest-cost electricity.	RSR	USD	INDIA
Ballard Power Systems	Fuel cells, PEMs used in transportation and more.	ECV	CAD	CANADA
Bloom Energy	Stationary fuel cells, distributed but non-renewable.	ECV	USD	US
Boralex	Renewables generation, operates wind, hydro, solar.	RWD	CAD	CANADA
BYD Co.	Electric vehicles, batteries, rail, and more.	ENS	HKD	CHINA
Cadeler A/S	Offshore windfarm installation vessels, specialized.	RWD	NOK	DENMARK
Canadian Solar	Solar, vertically integrated solar manufacturer, China.	RSR	USD	CANADA
Canoo	Electric delivery vehicles, configurable, multipurpose.	EEF	USD	US
Cell Impact AB	Fuel Cells, stamped bipolar, PEM flow field plates.	ECV	SEK	SWEDEN
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
Corp. Acciona Energias	Renewables, one of world's biggest: wind, solar etc.	RWD	EUR	SPAIN

CropEnergies AG	Bioethanol, from cereals and sugarbeet, Germany.	RBB	EUR	GERMANY
CS Wind	Wind power, both onshore, and also offshore.	RWD	KRW	S. KOREA
Daqo New Energy	Solar, high-purity polysilicon for solar wafers, China.	RSR	USD	CHINA
Doosan Fuel Cell	Fuel cells, high temperature and hydrogen, S. Korea.	ECV	KRW	S. KOREA
Ecopro BM	Battery materials, cathode and precursor for Li-ion.	ENS	KRW	S. KOREA
EDP Renovaveis SA	Wind power, among largest producers in world, Iberia.	RWD	EUR	SPAIN
Electreon Wireless	Wireless road charging, for EVs while driving.	EEF	ILS	ISRAEL
Encavis AG	Solar, large solar park operator, also wind, Germany.	RSR	EUR	GERMANY
Energiekontor AG	Wind farms, also solar parks in Germany.	RWD	EUR	GERMANY
Enlight Renewable	Solar & wind power, clean energy storage infrastructure.	RSR	ILS	ISRAEL
Enphase	Inverters, micro-products for solar panels, storage.	RSR	USD	US
Eolus Vind	Wind power, also consulting services for wind.	RWD	SEK	SWEDEN
Eos Energy	Batteries, zinc chemistry for stationary grid storage.	ENS	USD	US
Evgo	EV charging, an early leader in fast charging.	EEF	USD	US
Fastned BV	EV charging, uses wind and solar power, Europe.	EEF	EUR	NETHERLANDS
First Solar	Thin film solar, CdTe low-cost alternate to polysilicon.	RSR	USD	US
Fisker	Electric cars, electric SUVs, with contract manufacturer.	ENS	USD	US
Flat Glass Group	PV panel glass, solar plants engineering & construction	RSR	HKD	CHINA
Freyr Battery SA	Batteries, decarbonization in cell manufacturing.	ENS	USD	NORWAY
FTC Solar	Solar, ground mounted trackers; also PV software.	RSR	USD	US
FuelCell Energy	Fuel cells, high temperature and hydrogen.	ECV	USD	US
Ganfeng Lithium	Lithium, production of compounds, metals, for batteries.	ENS	HKD	CHINA
GenCell Ltd.	Fuel cells, hydrogen from ammonia, remote power.	ECV	ILS	ISRAEL
Gevo	Biofuels, lower carbon liquid fuels, renewable sources.	RBB	USD	US
Grenergy Renovables SA	Solar projects, and wind, batteries, Spain, Latin America.	RSR	EUR	SPAIN
GS Yuasa	Battery technologies, also lithium for EVs, Japan.	ENS	JPY	JAPAN
Gurit Holding AG	Composite Materials in wind, lightens cars, planes.	RWD	CHF	SWITZERLAND
Hannon Armstrong	Energy efficiency, capital & finance for infrastructure.	EEF	USD	US
Iljin Materials	Rechargeable battery materials, elecfoils for batteries..	ENS	KRW	S. KOREA
Innergex Renewable	Renewable power, run-of-river hydro, wind, solar.	ROH	CAD	CANADA
ITM Power plc	Fuel cells, uses PEM technology; also hydrogen.	ECV	GBP	UK
Itron	Meters, Utility energy monitor, measuring & manage.	EEF	USD	US
JinkoSolar	Solar, wafers through solar modules, China OEM.	RSR	USD	CHINA
Joby Aviation	Electric Aircraft, more efficient transportation.	EEF	USD	US
Kingspan Group plc	Efficient Buildings, insulation for conservation, Ireland.	EEF	EUR	IRELAND
Landis+Gyr Group AG	Advanced meters, modernizing grid, Switzerland.	EEF	CHF	SWITZERLAND
Li-Cycle	Recycling lithium-ion batteries, recover raw material.	ENS	USD	US
Lilium NV	Electric Aircraft, vertical takeoff and landing.	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
Meridian Energy	Hydroelectric power stations, some wind, New Zealand.	ROH	NZD	NEW ZEALAND
Motech	Solar, cells and modules manufacturing.	RSR	TWD	TAIWAN
MP Materials	Rare Earths, US sourced strategic Neodymium, NdPr.	ECV	USD	US
Nel ASA	Hydrogen, in fuel cell vehicles, renewably, Norway.	ECV	NOK	NORWAY
Neoen SA	Renewable energy, mainly in solar, some wind.	RSR	EUR	FRANCE
Nexans SA	Cables, for grid power infrastructure.	EEF	EUR	FRANCE
Nibe Industrier AB	Heating & cooling, sustainable technologies, Sweden.	EEF	SEK	SWEDEN
Nio	Electric Vehicles, design, manufacture, premium EVs.	ENS	USD	CHINA
NKT A/S	AC/DC cables, grid infrastructure improvements.	EEF	DKK	DENMARK
Nordex SE	Wind turbines, based in Germany/Europe, worldwide.	RWD	EUR	GERMANY
Novozymes A/S	Biofuels, enzymes used in partnerships, Denmark.	RBB	DKK	DENMARK
Ormat	Geothermal, works too in recovered heat energy.	ROH	USD	US
Orsted A/S	Sustainable wind, also biomass, thermal, Denmark.	RWD	DKK	DENMARK
Piedmont Lithium	Lithium, US-based source for battery-grade lithium.	ENS	USD	US
Plug Power	Small fuel cells, e.g. in forklifts; drop in replacements.	ECV	USD	US
Pod Point	EV Charging, UK, Norway, home and business.	EEF	GBP	UK
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
Renewable Energy Group	Biodiesel, natural fats, oils, grease to biofuels.	RBB	USD	US
Renova	Wind, Solar, Biomass, power generation in Asia.	RWD	JPY	JAPAN
Rivian	Electric trucks and vehicles, fast charging network.	ENS	USD	US
Samsung SDI	Batteries, innovative energy storage, EVs, South Korea.	ENS	KRW	S. KOREA
Scatec ASA	Solar power, develops, owns and operates worldwide.	RSR	NOK	NORWAY
SFC Energy AG	Fuel cells, direct methanol (DMFC) technology.	ECV	EUR	GERMANY
Shoals Technologies	Solar, electric balance of system, wiring, combiners.	RSR	USD	US
Siemens Gamesa	Wind, onshore & offshore, turbines, gearboxes, Spain	RWD	EUR	SPAIN
Signify NV	Lighting, systems increasing efficiency, Netherlands.	EEF	EUR	NETHERLANDS
Sino-American Silicon	Solar, semi-conductor silicon wafer materials, Taiwan.	RSR	TWD	TAIWAN
SK IE Technology	Battery materials, separators and ceramic coated.	ENS	KRW	S. KOREA
SMA Solar Technologies	Inverters for solar, industrial scale storage, Germany.	RSR	EUR	GERMANY
Sociedad Quimica Chile	Lithium, a key element in advanced batteries, Chile.	ENS	USD	CHILE

SolarEdge	Inverters, panel-level solar optimizers, micro-inverters.	RSR	USD	US
Solaria Energia	Solar, renewable power generation, Iberia.	RSR	EUR	SPAIN
SolTech Energy Sweden	Building-integrated solar, also solar leasing in China.	RSR	SEK	SWEDEN
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
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	Wind, wind turbine manufacturing & services, Denmark.	RWD	DKK	DENMARK
Wallbox NV	EV charging, can be bidirectional for vehicle to home.	EEF	USD	SPAIN
West Holdings	Solar, Japan-focused residential and commercial PV.	RSR	JPY	JAPAN
Wolfspeed	Electrifying high power systems, SiC, GaN.	EEF	USD	US
Xebec Adsorption	Gases for new renewable energies, hydrogen.	RBB	CAD	CANADA
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

125 stocks/100 = Individual Weights for Q1 2022 **WEIGHT EACH COMPONENT = 0.800000**

13 Additions: 1798.HK, CADLR.OL, ELWS.TA, EKTG.DE, FASTN.AS, LILM, LCID, NEXS.PA, NKT.CO, PODP.L, PTRA, RIVN, WBX

13 Deletions: CAV1V.HE, FKR.MI, UKWG.L, GRN.TO, GP, HPUR.OL, ALHRS.PA, REE, DSMN.AS, RNW.TO, SUNW, VLTSA.PA, WLDN

NEX SECTOR WEIGHTS:	SECTOR	#	Approx. Weight
Energy Conversion	**ECV**	**16**	**13%**
Energy Efficiency	**EEF**	**25**	**20%**
Energy Storage	**ENS**	**22**	**18%**
Renewables - Biofuels & Biomass	**RBB**	**6**	**5%**
Renewables - Other	**ROH**	**5**	**4%**
Renewable - Solar	**RSR**	**31**	**25%**
Renewable - Wind	**RWD**	**20**	**16%**
		125	**100%**

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

NEX Historical Sector Weight Information

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

Q1 2011	1.50%	26.95%	6.99%	10.50%	9.46%	24.59%	20.00%
Q4 2010	1.79%	24.32%	8.80%	11.21%	6.02%	24.16%	23.71%
Q3 2010	1.97%	20.31%	8.86%	11.70%	6.59%	24.42%	26.16%
Q2 2010	1.90%	17.29%	8.53%	12.36%	6.58%	24.29%	29.05%
Q1 2010	2.04%	16.93%	8.65%	12.25%	6.73%	25.03%	28.36%
Q4 2009	2.25%	15.20%	7.10%[1]	11.26%	7.10%	27.51%	29.58%
Q3 2009	2.59%	13.77%	5.38%	10.76%	6.81%	29.24%	31.45%
Q2 2009	2.42%	12.89%	4.79%	12.21%	6.49%	30.57%	30.63%
Q1 2009	2.77%	15.14%	5.29%	14.19%	8.25%	25.70%	28.68%
Q4 2008	2.25% [2]	23.93%	3.57%	12.09%	6.48%	26.63%	25.05%
Q3 2008	3.31%	20.03%	3.33%	13.14%	6.54%	27.27%	26.39%
Q2 2008	3.81%	17.85%	2.81%	14.32%	6.47%	27.03%	27.71%
Q1 2008	3.93%	13.56%	2.94%	14.26%	6.99%	30.00%	28.34%

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

Appendix VII, Cool Climate™ Clean Solutions Index (OCEAN) for latter Q4 2021, 108 components:

Components: Cool Climate (OCEAN)	Theme	Activity	Sector
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 Offshore Wind	Offshore wind, deep water, floating, Norway.	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 Superconductor	Wind power, better power grid.	USA	PP
American Water Works	Water and Wastewater Systems.	USA	WT
Azure Power	Solar power, India focus.	India	CE
Badger Meter	Water Metering.	USA	PP
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 SA	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
Cell Impact AB	Fuel cells, bipolar flow plate forming.	Sweden	PP

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
Eos Energy	Zinc battery chemistry, alternative to Li-ion.	USA	PP
ESS Tech	Batteries, long-duration flow liquid electrolyte.	USA	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
Grenergy Renovables SA	Solar power parks, wind power.	Spain	CE
Grieg Seafood ASA	Seafood, aquaculture with high ESG scores.	Norway	SF
Gurit Holding AG	Wind, composites, also in transportation.	Switzerland	CE
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
Lilium	Electric jets, vertical takeoff and landing.	Germany	GT
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
Meridian Energy	Power generation 100% from renewables.	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
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 Prod.	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
Xebec Adsorption	Hydrogen, generation and purification.	Canada	PP
Xinjiang Goldwind Science	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

Equal Weight = 108/100 = 0.925925% each for start of latter Q4 2021.

Cool Climate Clean Solutions (OCEAN)

SECTOR	#	Approx %
GREENER TRANSPORT (GT) =	14	13%
CLEAN ENERGY (CE) =	36	33%
WATER (WT) =	22	20%
SUSTAINABLE FOODS (SF) =	7	6%
POLLUTION PREVENTION (PP) =	29	27%
TOTAL CONSTITUENTS =	**108**	

Deletes: ADN.OQ, NETI.N, GNCL.TA, GREENH.CO, GP.OQ, HPUR.OL, DSMN.AS, PPS.L, SUNW.OQ, VLTSA.PA, VOW.OL

Additions: EKTG.DE, GWH.N, FELE.OQ, FREY.N, LILM.OQ, MSEX.OQ, MWA.N, PTRA.OQ, STN.N

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

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

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