WilderShares, LLC

Q3 2021 WilderHill® Quarterly Report: ECO, NEX, OCEAN, Sept. 30, 2021

The Clean Energy Index® (ECO) started 3rd Quarter around 195 and it ended Q3 around 160, down some -18%. After big +203% gains over 2020 when this decarbonization story rose 6-fold, about best performance of most any Index or Fund anywhere, a fall in 2021 was maybe due. So it wasn't surprising after ECO had fallen by ½ in 2020 to 50, a big rise afterwards to 280 - to see it again fall by ½ in 2021 to nadir so far near 150. Such volatility is partly due to the very big and pro-clean energy policies, increasingly now happening for this theme worldwide. Or since the start of 2017, when ECO Index® was at 38, it's now up +340%.

As we emphasize, ECO, global NEX, and OCEAN passively capture risky themes, so can & will at times 'drop like a rock'. Big gains & bigger drops too may happen here. And such volatility can well go on, as solar becomes the *least-priced electric power anywhere, anytime in history*. Potentially that might mean vast new clean demand from the US, Europe, and Asia. Should infrastructure & jobs, equity & social justice overlap climate solutions – there may be more volatility ahead. Perhaps not only in solar but also in wind power onshore & offshore, in electric vehicles, batteries, energy storage, hydrogen, fuel cells, thinking informed by ESG, and the deep decarbonization of everything – unlike anything seen before.

For last 5 years this Benchmark ECO Index® live since 2004, and the 1st to capture climate solutions is up +300% to Q3. This over a period when most any big energy gains will stand out. For the same 5 years CO_2-laden oil & gas are *down* some -50%, while those fossils are down by -80% last 10 years. That's in stark contrast to decarbonization as one major organizing theme here in ECO, NEX, & OCEAN, showing the strongest 5 year returns in energy.

The first-ever *global* clean energy Index is New Energy Global Innovation Index (NEX) live since 2006. The NEX is up +160% last 5 years to Q3 also starkly beating fossil fuels: there's now a tracker in Europe (GCLE; London). Global NEX has also outperformed vs. a major, younger independent global clean energy Index most every sizable period: Year to Date, past 1, 5, 10 years, since inception etc; equal weights here & greater purity help explain that divergence. In sum the WilderHill themes are firsts and benchmarks. And energy long taken from deep underground and burned – increasingly is captured in disruptive & sustainable ways – coming to us cleanly, freely, and renewably from up towards Heavens.

The Clean Energy Index® (ECO) is the first for clean energy & climate solutions. Live since 2004, the ECO Index® is a benchmark with the longest record & has often outperformed coal, oil & gas. ECO along with the NEX which is the first global clean energy Index, and Cool Climate™ OCEAN - best capture solar, wind, EVs, batteries, hydrogen, fuel cells, and decarbonizing everything. The WilderHill® Indexes provide volatile performances and useful non-correlation to fossil fuels. They're innovative, transparent, naturally informed by sustainability & ESG thinking, and can help build a diversified portfolio.

Source: NYSE.com

Recent Q3 and all 2021 Year to Date (YTD):
A growing climate solutions & stocks theme is best seen in ECO, NEX, & Cool Climate OCEAN baskets. Here's first 3-Quarters 2021, January to mid-September:
2021 to mid-September:

Source: finance.yahoo.com

Interestingly, above, a new situation presented itself YTD. Unlike last 5, or 10 years, here clean / green ECO and NEX *are now clearly at bottom, down* some -15% to -21% for Q1-Q3. In middle above are Dow, S&P500, and ACWI world Index clumping +15% to +20%. Farthest at top now are fossil fuels: oil up +50% and natural gas up +90%: oh my what a reversal!

As we'll see ahead, when stepping back, this happened only after a prior very long steep fall among all 'fossils' (fossil fuels). So that probably should be taken into account. Yet whether there's maybe some regression to mean (like last 5, 10 years) ahead – fossils falling again, and clean rising – is to be seen. That, will doubtless be reviewed in coming Reports.

Q1-Q3 2021 clean themes fell hard – so passively reflected in our 3 Indexes. Start of 2021 the 3 WilderHill themes initially rose January; ECO, NEX, OCEAN were up by +22%, +10%, +10%. But after January peaks, they fell to be +5%, -3%, +2% YTD by end of Feb. (OCEAN isn't shown as no tracker for it yet). March/April that drop deepened, Cool Climate OCEAN theme was 'least down' amongst these 3. Mid-May hit 2021 YTD nadir-so-far, ECO down -30% YTD. Next months, were sideways, bouncing a bit off the nadir all 3 down. For instance month of August was bit of stasis: -2%, nil, +2% - and for YTD they were at -20%, -14%, +3%. OCEAN here at +3% YTD was 'best' of the 3. The major Indexes were up YTD by small, like amounts. The S&P500 was up +2.9%, and NASDAQ +4% for August. And then September was a mixed bag.

Notably then, fossils *gained* strongly over Q1-Q3 2021, after their prior deep lows. Previous years our green themes usually did far better than fossil fuels. That changed 2021, when oil & gas - admittedly coming off their own dismal deep lows, clearly instead jumped.

For fossils once down so dramatically, 2021 was quite a reversal. Oil recently had hit historic lows 2020 on Demand Collapse due to pandemic. The world's oil industry needs oil prices at least in $60s. Nearer to 'just' $50 per barrel punishes indebted shale producers. Oil under $40 foretells misery ahead for producers, even countries. Equities are inherently forward-looking so oil's vexed theme back in 2020 hadn't seemed an attractive destination for capital. But following big OPEC supply cuts, discussed ahead, oil & gas gained strongly 2021 followed by a cautious supply growth. Yet big 2021 natural gas jumps, in time may make clean energy again relatively attractive, vs. competing natural gas for power production.

A key point, to be repeated, is the *Costs for solar/wind electricity by contrast, can go very low at times, naturally*. This variability is a characteristic, indeed a core trait of renewables. Oil instead faces 'make or break' price floors, beneath which industries suffer. Past oil busts have meant lost capacity, job losses, non-producing wells shut in. Like in 2020 when oil hadn't had a firm floor, which dramatically changed 2021. **Demand destruction** was key 2020. In 2021 that changed *since the cure for cheap oil, is cheap oil* - while renewables fell.

Oil's rebounding in 2021 to $60s+ WTI oil came after big supply cuts by Saudi Arabia, renewed demand & hopes of more inflationary growth. Otherwise, were prior 100m+ barrels/day still supplied early 2021, that could have prolonged market collapse. Coal (no longer tracked by ETF fund) lagged badly in 2020; no US coal plants being built regardless of whom is President. Coal's dismal US economics have swamped all political will, so US miners now look overseas to where coal is still widely burned, and Asia had the world appetite 2021. Yet the fact that America's own domestic coal supply had once been the last century's cheapest, dirtiest, and most stable source of electricity, suddenly is no longer much in its favor.

Discussed too ahead so just touched on here, is potent ongoing greenwashing by some fossil interests still wedded to promoting gas. 'Blue hydrogen' hype – even though methane leaks render H_2 (hydrogen) from gas as awful as burning fossils directly. Clearly, electricity from gas in the US & China will still be huge 2030. From standpoint of climate risk & global heating – that's a big worry. China goes on using both coal & gas all this decade (though China also is wisely-building smallest EVs - a smart path resisted so far by Europe & US). By contrast, Western Europe may have then reduced its gas somewhat, its nukes & coal more so, but with big hiccups like acute gas shortages discussed ahead. A result is Europe alone may reach 50% of electricity from non-hydro renewables 2030. Conversely: 2 of world's 3 biggest blocs still mostly powered from dirty, non-renewables end of this crucial decade, looms large.

Another issue also discussed ahead, has been a possibility of forced labor in China. Horrid to contemplate, it led eg in 2021 to a Withhold Release Order (WRO) by US Customs. Any solar products even possibly made by forced-labor-tainted sources, wholly unwanted. Thus panel makers will need to very carefully manage supply chains. Tracing supply-chains can be done, but in practice takes a year or more. Hence some solar panel makers may choose to use non-China sourced polysilicon when manufacturing their products – even in China.

One possibility 2022 may be to look towards German (or Vietnam, Malaysia) polysilicon supply. European poly sent to PV plants in China, will mean costs of distance + shipping. That said, European plants can be/are run on greener power. All PV manufacturing globally must be managed more-carefully for diverse extant issues. Supply chains more attuned to sources of materials. And sourced from green renewable power, like first seen in Europe. Clean should become more desirable ahead, than an industry that relies still on burning dirty coal.

Change is afoot. Some may happen sooner than expected. A major EVs+batteries+solar maker is developing software, Autobidder that may allow it to harness deployed solar+batteries to sell power directly – competing with Utilities. Maybe electric aircraft at last better challenge a past hegemony of fossil fuels for better efficiency in air transportation. Perhaps too, making new batteries ahead on lower-cost zero-carbon lithium, wind, hydro, renewable power. Possibly: recycling li-ion battery materials, improving anodes/cathodes, domestic lithium sources with lower-water use. But based on the fact that CO_2 levels already are >400 ppm, thus no real possibility of holding global heating to 1.5/2 degrees C so climate emergency a foregone certainty - all that may be welcome & necessary – yet not fast enough.

2021 was wracked by record heat, drought, storms, floods. Yet in decades, maybe a few years hence, people may look back at 2021 with all its miserable temperatures, floods, bitter Winter cold snaps, hurricanes, rapid disappearing sea ice and gradually rising seas - as part of a much cooler, more stable, far more desirable past. One that can never be recovered.

Data latter 2021 have made clear too that there's been No hoped-for 'green recovery'. No 'post-pandemic' moves from fossil fuels. CO_2 emissions first half 2021 had already exceeded pre-pandemic, by more than 5%. So from strictly climate perspectives, we're still losing badly. Such facts are no cause for great optimism about our coming decade, nor our century.

September 2021 brought the debate to a head over proposed US legislation. Broad outlines of this 2021 Gordian knot are well-known: two legislative bills were in play. One, a 'classic' small Infrastructure Bill with support by some conservatives so making it bipartisan. However, it would do near '*nothing*' for climate solutions. Lower-cost it had understood 'pay-for' revenue sources - especially relative to big-ticket past spending & tax cuts by both parties.

A 2nd big reconciliation bill, needed No votes from conservative party. It only could pass, if voted-for unanimously by more liberal party. As a wish-list of liberal aims it was far more climate-focused, text being shaped end Q3. It included eg Federal Grants (carrots) for utilities & electricity suppliers to grow new clean power plans; conversely those who didn't clean up would pay a Fee (sticks). There were many varied clean energy tax credits etc.

To incentivize, utilities growing clean energy by 4%/year could in its draft form receive $150 per megawatt/hour. Clean energy was defined as under 0.10 tons CO_2 per MW/hr, so coal that spews 10x would be kept out of incentives. Nuclear though was included. As was solar, wind and hydro power that could each benefit being zero-carbon in this proposed legislation.

As for political process, a moderate Senator from fossils-focused state couldn't support this reconciliation bill as first conceived. Both on substance saying transition from fossil to clean was 'already happening' so why spend any taxpayer dollars to speed it up – and on draft bill's initial $3.5 Trillion price tag, stating it was both too high and too inflationary. They felt it had to 'additive' (including fossils) and not exclusionary keeping them out – despite climate. But that 1 Senator and moderates in House supported & wanted action of a traditional sort on roads & bridges. $$ for infrastructure of a more classic kind. Plus so-called 'carbon sequestration' to add years to dirty fossils by pretending they're cleaner. That could throw all fossils coal, oil & gas a life line on pretense their CO_2 is somehow cheaply avoided.

Progressives meanwhile, weren't as concerned about 'pay-fors' in $3.5 Trillion reconciliation. For them taxes on wealthiest made sense and/or deficit spending long used by conservatives for their causes (tax cuts). They noted US spends far more on military, blood & treasure, without the climate and job benefits seen here. They feared their party's moderates were too concerned over costs (offset pay-fors) and not concerned enough on climate – so might go for a small bipartisan bill only. Because moderates had secured a late-September deadline on the small bill's vote, there was real tension last days of Q3 to agree on a big bill – to win both. Liberals aimed for $3.5 Trillion – not a $1.5 Trillion hinted by that coal state Senator – who resisted naming a $ figure. End of September however a US Debt default also grew possible – a shutdown, while less than $3.5 Trillion grew self-evident. So it was choc-a-bloc uncertainty. And prior linkage between the two bills began to weaken those last days…

Were an 'unhelpfully' small bipartisan bill only to pass – that would be worse than nothing to progressives. Early in Q3 they'd deny such a bill. Progressives' leverage was to link the two: they knew several (silent so far) moderates sought spending on roads & bridges – plus ideas like 'carbon sequestration' and nuclear power. Thus progressives were very willing to deny that small bill, to get reconciliation done. A main progressive leader felt $6 Trillion was appropriate given scale of this problem, taxes and/or deficits could readily pay for all, and $3.5 was already a compromise. But at end of Q3, that leverage was challenged.

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

Given that moderate's failing state infrastructure; they'd vote for small spends – but later on by late 2022. Right now, finding a sweet spot on $$ size – was mandatory for both bills. But end of Q3, there was pressure for the bipartisan vote first. Infrastructure = jobs. That Senator as Committee Chair had helped sculpt the weak bipartisan bill, so desired it. Goodies in it can make much possible (remember Robert Byrd?) bringing moderates off fence. But would a big reconciliation then even get done? Or would internal dissension within the liberal party in Q4 sink both bills/all!?? Progressives were arguably correct to hold to all or nothing, given 'nothing' for climate was in a small bipartisan roads and bridges bill. But this infra-party dissension could kill both! Last day of September, it was at last coming to a head.

It boiled down to: could reconciliation with some teeth, some climate action but costly $3.5 Trillion (or less) – win unanimous support needed. Progressives felt it had to be all, or nothing at all. They'd observed that weak bipartisan bill was wedded-to a fossil thinking, baby steps that were no answer at all. But, would they vote against it, if just it alone was on the plate? Could moderates+progressives relent on a slimmer, say $1.5 or $2 trillion big bill? Progressives didn't want to go to $2 trillion. But they simply might be forced to. And then maybe return to the well later on. Further compromise – or it all falling apart - thus lay ahead for Q4.

If it was $3.5 Trillion, an analysis had shown 7.7 million new American jobs could be created by clean energy programs growing US economy by $1 trillion to 2031. Jobs to improve the electrical grid, add more solar and wind power, grow EVs and chargers, better efficiency etc. It could mean good new green jobs with diversity, equity & inclusion. Meanwhile, as will be discussed ahead, cleaner electric power could actually come to *cost less* in the future.

That was *politics* 2021. Now, as for the *work* of growing clean energy fast, a worrisome factor lately was new price inflation. Input materials soaring in cost. As clean energy supply chains were stretched on renewed demand post-2020, inflation looked far stickier than a very brief case laid out by the Fed. Clearly, this began to feel worrisome across all clean/energy.

Take solar. If the US, Europe and Japan are to wrestle back a PV manufacturing that had shifted to China (we recall 20 years ago when Japan, US, and Europe once dominated PV manufacturing – and China was then near zero) – then many big changes would be needed. If US wanted to go from solar being a meager 3% of its power in 2021 - to near 50% mid-century, then any roadblocks to rapid expansion loom large. Think then of materials to make solar PV. Polysilicon is discussed ahead. But there's other materials needed in manufacturing panels.

Silver, always costly when making solar panels, is ripe for change.

To fast ramp solar, one good start will be a hard look at reducing its costliest inputs. Take silver used as conductor in PV cells. How better to reduce, or better yet replace silver with far cheaper, plentiful copper. Solar panels in 2021 were devouring 20% of global industrial silver supplies/year. Inflationary times like lately (maybe with unprecedented inflation or stagflation ahead), very costly silver can account for 15%+ of total costs of a solar cell. Thus to grow solar more swiftly, limits of silver's supply might become a thorny constraint.

For comparison, silver in 2021 had cost $750,000/ton - vs. copper at $9,000/ton, even after recent increases. But obstacles to a switch included copper oxidizing, and it's not easily used in PV cells. Note then a recent advance may make copper better at replacing silver here. Testing done in 2021 on a new kind of solar cell using 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 a great many diverse sorts of greener changes lay ahead.

For instance, buses will likely see much change this decade. Especially if a big bill passes. A typically dirty smelly diesel, or loud propane school bus costs $150,000. A quiet clean electric school bus, by contrast, in 2021 cost a dear $350,000. So only 1,000 buses (as pilot projects on grants) have so far been electric, of a total national fleet of 480,000 school buses.

It was impossible to know end of Q3 if a big infrastructure bill will pass – & if so, how much funding in it for clean school buses. But consider: an earlier draft had $5 Billion to help schools buy electric/low-emission buses. Half clean electrics, could mean schools buying some 24,000 new electric buses. Driving their costs down sharply too, for future buses to boot.

One big school bus manufacturer is Blue Bird. Half of its 11,000/year buses 2021 were dirtiest diesel. Other half burn alternatives propane, gasoline, or compressed gas, also polluting & awful for kids and climate. So far then, it's only sold a tiny number of clean electric buses. 775 in the 3 years to 2021, given they've had much higher upfront purchase costs.

Now if a big infrastructure bill passes – clean, quiet vastly more maintenance-free electric school buses *may* be afoot. Moreover, with great battery storage capacity, whole fleets of EV buses could be excellent backup to grid. Made cheaper by mass production. Maybe used some days Vehicle to Grid (V2G) too selling back power and earning schools money - or as emergency community backup power. Hence rather than kids/parents paying for bus fare, instead new pure battery electric buses *might* become another new profit-maker for schools!

Yes, there'll be many obstacles to becoming cleaner, now & ahead. Bricks and arrows doubtless thrown at green energy. Clean will also see genuine bumps as it gains in size. Much will be contrived. By renewables' opponents seeking to blame clean (wrongly) for power outages. Like Texas 2021, as blackouts first were blamed on wind power(!) – described ahead. And there'll be cases where renewables can be correctly criticized this decade. But as coal declines gas falters at times – solar/wind without yet much storage arguably aren't to blame. But that's because there aren't *yet enough* renewables + storage. Wind/solar/storage are starting to displace dirty fuels to make a difference – but there's not enough clean - yet.

Wind is highly intermittent. So much so a lack of wind some months can be very difficult. Yet that's so now, with close to zero clean energy storage. When natural gas intentionally, or unintentionally gets less available, then problems will soon arise given wind's making just 20% of power. Both wind/solar will be seen much differently soon - as storage grows.

For a near-term hard case, think late 2021 Winter in Europe. An issue began in Summer 2021 when Russia suddenly started exporting far less natural gas to Europe, than prior typical rates of 80 million cubic meters (mcm) per day. Russia at first lowered its gas exports to Europe in July to 49 mcm/day. Then in August it dropped that rate to just 20 mcm/day.

Levels of gas storage already low in Europe and elsewhere, tanked. Why? Months of Covid-induced supply shortages had dropped storage worldwide. US hurricanes compounded it, disrupted fossils output. Net/net it was a sharp loss in gas supplies, very low storage - and much higher natural gas prices worldwide. Europe lacking big domestic gas supplies has long had to rely on imported natural gas to make electrical power. As Europe & world natural gas & so electric power wholesale prices skyrocketed in Fall, in no time spikes were reflected in record-dear retail prices too. And therefore eye-watering electricity costs.

Russia's gas profits grew. But another rationale may have been at play. It's been suggested perhaps this export gas shortfall latter 2021 from Russia, was to help win needed OK by Europe for Russia's Nord Stream 2 pipeline into Germany. Europeans for their part, still obviously need cheap Russian gas. Two other routes were to get lots more gas from Norway (likely to decline) – and/or to import lots more liquified gas (LNG) from overseas coming by ship. But that means competing with voracious Asia so high prices. Yet Europe needed all the gas it could get latter 2021. Especially as it can get colder than expected. Plus on low winds, many nukes down for maintenance, and coal being shuttered by costly emissions permits.

Sparse winds in UK/Europe hit output – as did nukes needing maintenance. Drought had hit hydropower sources also limiting electricity supply. Despite having many potential sources of natural gas, Europe's storage Q4 was low & prices high – before Winter's spike in demand for heating. Thus in September unhappy records began to be set. Europe's natural gas benchmark spiked up nearly +300% YTD. Gas futures in The Netherlands rose to about the equivalent of $150/barrel for oil – making gas late in 2021 the dearest fossil fuel by far.

Ireland's electricity costs jumped briefly 10x, over 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 two-fold, near 7x just one year prior; next day UK power jumped to $395/MWh. UK imports 7.5% of its power from France so losing a key undersea cable in Kent to fire knocked out 2 GWs of firm power from France, maybe until Spring. China too saw an energy crunch. With abundant breezes it's possible the UK's electricity costs can instead drop to near zero! But if winds are sparse, that Us full wind power capacity of 24 GW, may instead be under 1 GW. At this point late 2021, Europe's natural gas/and its nukes – were all still sorely needed – along with gas storage.

Thusly was long-held European fear of over-relying on Russian gas pushed aside. Nord Stream 2 gained acceptability; if that was an intent behind Russia's reduced flows to Europe, to build support for their pipeline, it certainly had intended effect. But German elections late in 2021 gave new power to a Green Party that aims for "massive expansion offensive for renewables". Meanwhile, China, Japan, S. Korea all had been buying up LNG since Summer. By late 2021 LNG prices had spiked over $15/per million BTUs. So American gas thus rose too (as all is connected) from a recent $2 or $3 mm/BTUs to over $5.0 – unheard of in a shale era. If European Market Winter gas demand begins competing 2022 vs JKM (Japan-Korea Market) demand, potentially all lose on higher prices. So gas still needed. Not only for electric power, but for home heating too. That may get scary if there's freezing temperatures.

Europe thus needs GWs *more* solar/wind + plus requisite long-term clean storage for firm power. Insufficient gas supply & storage vexes - when clean isn't yet big enough. Especially as it tries to wean itself fully from coal, draw down gas ahead. That's why wind and solar early 2020s are now at an awkward stage. Growing, but not yet large enough to be real Hero. Renewables in 2021 made just 20% of Europe's electricity. Not enough to take on gas' failures. Especially not until there's more solar/wind + plus far more green storage ahead. That would make intermittent clean sources firm, viable, and dispatchable: a real substitute.

Plus, growing solar was seeing new price inflation worldwide. 2nd Quarter 2021 after years of relentless price declines, solar prices *rose* first Quarter over Quarter, year over year in residential, commercial, utility-scale. That hadn't been seen since the analysts had started measuring it in 2014. Inflation isn't just in solar, but it was rather 'unheard of' here. Causes include: fast rising costs for aluminum & steel in solar frames, mounts etc. Rising silver costs in cells as noted. Pricier panel glass. Freight costs for shipping PV product. Labor higher for assembly despite mechanized operations. Polysilicon from sand is a basic building block, yet it too has also been seeing cost increases of late. Globally solar panel prices in 2021 rose to about 16% higher than was seen 2020. Increases in input costs can reverberate ahead. They may be felt in 2022, when clean energy demand *might* then be going higher as well.

Huge growth in solar manufacturing & deployment is needed if US is to hit 45% solar power by 2045. From a scientific standpoint, it's necessary, on climate concerns – yet the ramp rate this size would be unprecedented. The US in 2014 got <1% of its power from solar. In 2021, it was around 3% for some 15 gigawatts (GW) deployed in that year. To ramp up next from there fast enough, means solar power would need to double ahead each/every year. 30 GW more installed US each year 2022 to 2025. Then to rise another 4-fold over that seen back in 2020 – a fresh new 60 GW more installed in each and every year from 2025 through 2030.

Just by 2035 the US needs 1,000 GW of renewable power to grid. By 2050, 1,600 GW, and here solar power delivered to US zero-carbon grid. That would be more power than was generated by all sources, including fossils/nukes, in 2021. Plus to Decarbonize widely may mean 3,000 GW solar by 2050. To green transportation, buildings, manufacturing, industry: all then using clean sources in each GW of needed power, and each BTU of needed heat.

So in 2022 at least 30 GW of new US renewable power needed. For comparison, one GW powers 750,000 US homes, or roughly size of a smallish nuclear plant. With proper support, solar & wind could rapidly grow to supply that. New storage *may* leap to fore, as also needed for renewables. Or, they may all stumble and fall. Especially if a big 2021 Infrastructure bill fails to pass. That's a distinct possibility. And partly why there's been as often seen here, huge volatility. Another approach from across the Atlantic: small modular reactors (SMRs) were given new attention in the UK. It's 7 big nuclear plants are to fall in number soon yet provided sizably 17% of UK power 2021. For certain SMRs can have a standardized design (in China too). But, can they also be made safe? Be less costly? Less risky with truly waste storage? On current state of art 2022, the answer has been No. So, problems remain and swirl around nukes in 2022, even as China, the UK and many others search there too for answers.

Let's next consider stock Indexes for green themes, solar/wind/EVs etc. ECO & global NEX are originals, benchmarks, so we'll begin here. They reflect innovation – so volatility and immense downs / ups that can and often do dominate this greener theme.

After huge gains in ECO/NEX in 2020, it was perhaps 'normal' to see retrenchment in 2021. When 2021's plummet started in February it was unknown of course if clean energy & so ECO might show a harsh backslash shaped "\" over all Q1 – maybe for all Q2/Q3/Q4 too? Or perhaps an "L" shape: down, then just sideways? Or given January's rise maybe an Inverted "V" as ^? For 3 reasons, 2021 and even going into 2022 could see ongoing headwinds here because of: *1) No Clarity Yet on a big US Infrastructure Climate Bill passing Q4; 2) *China's newest 5-year plan could push big coal cuts post-2025; and 3) *If Europe sees a pause both by the US & by China, it too might refrain from hoped-for aggressive green actions early 2020s.

To those 3 worries, add 2 more: *Underlying green stocks had hit High P/E multiples Q1 2021; plus an *Inflation/Taper Risk. Perhaps Q1 was thus a soft ceiling? Hopes for reconciliation bill in 2021 was succor, if one is optimistic, Infrastructure bill's $3 Trillion *could* better justify rich Price targets Q1 ("P" in P/Es) - but Q2/Q3 fated to be a long interregnum. A pause between Q1's hopes - & clarity maybe in Q4 on a Bill needed to increase "E", Earnings. Plus Inflation fears could mean big falls over cumulative years, on a Fed willing to let things run hot over >2% inflation targets – or need to Taper due to it. Thus, tech stock earnings suddenly were worth less 2021 on discounted future values. Capital unsurprisingly, moved reflexively Spring 2021 from growth - to value. Yet it's ironic. Long term, volatile green stories *may* again re-attract capital. Traders can get re-accustomed to seeing what (possibly) may become a much higher, yet historically rather a more typical interest rate range.

In that case valuations above 25x EBITDA (Earnings Before Interest, Taxes etc) might be again more seen. But 2021 in a risky growth theme, few dividends, little positive "E" earnings – matters swung bearish. Global NEX, like an 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 upwards 4 fold & by 6 fold from late Q1 2020 to late Q1 2021.

Recall that Q1 2020 ECO had crashed -50%. Seeing it down again -50% in 2021, was maybe not so surprising. From intraday 286 in Feb. 2021, down by ½ to 145 mid-May. Given rapid 2020 gains, this only took it to levels seen not long ago: ECO was @145 recent as Nov. 2020. And NEX if down say half, was @315 as recent as Sept. 2020. Bigger drops may be envisioned.

ECO Q1 2020 earlier saw -50% fall from around 90 to 45. That -50% was resistance level then; ECO next rebounded up from 2020 bottom. Somewhat interestingly, a similar-sized fall again in -50% in 2021 led to a (so-far) May resistance level of 145 and bounce for ECO. Thus after a Q1 peak over 286 on Feb. 10th, ECO touched a 1H low near 145 on May 13th, *coincidentally* again it falling -50%. That in retrospect has been a (so far) recent 2021 nadir.

So Q2 & Q3 2021 not surprisingly an interregnum. A rough patch, filled with uncertainty. Clean energy's theme had just spiked Q4 2020 & January 2021, on Presidential race results and a surprising 2 seat gain by his Party for the Senate in January. Following that, as rather expected was Q2 & Q3's pause. Weighted down by high P/Es, fast-growing inflations fears – and by uncertainty over whether key Infrastructure reconciliation could pass Q4 - there was 'empty air' Q2 & Q3. Little to support high valuations twixt election outcomes – and clarity ahead. Frankly even on whether Infrastructure/Climate reconciliation might pass in Q4 2021.

Without doubt ECO late 2021 or 2022 may fall quite more on uncertainty. Or, perhaps, rise. If high P/Es are a metric (useful) & Price targets early 2021 were high, then prospects for a big Infrastructure spend to soon justify those P/Es should be sizably impactful.

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 across a clean energy sector. And a useful May 11th piece from Roth has highlighted too supply-side constraints & inflation risks in sustainability's theme. It stated, *"Most of our universe is down ~15-50% YTD. Lots of reasons have been given including rising rates, NEM 3.0 [net energy metering rules] and component shortages, among others. The primary driver we see is the steady & unrelenting increase in prices of raw materials and components."* They pointed to eg polysilicon supply tightness, rising costs for steel, for freight, & labor; margin challenges and potential demand destruction. Both are good analyses, and they both helpfully pointed to some challenges for 2022.

Much happened in clean energy & climate globally in 2021.

Some was hopeful. A US President's aim to cut US carbon dioxide (CO_2) emissions 50% by 2030 is needed & very doable. Yes, renewables grew in 2021. But a thorny matter is, at a rate of growth still nowhere near swift enough for 50% cuts in CO_2 by 2030. Solar & wind 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. This is broadly due to two things: the renewables aren't yet growing at fast enough rate to displace natural gas, oil, and coal. And conversely the global inertia in fossil fuels isn't yet slowing, let alone are they being shuttered nearly quickly enough.

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

So no surprise they're expanding! Solar power growth was about +39%/year in the last decade. It roughly doubled in capacity every 2 years. Wind growth was 17%/year; a possible onshore & now offshore wind boom might raise wind's growth much higher ahead in the 2020s.

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

Despite Covid, US residential solar grew by +30% YoY 1H 2021. US offshore wind starting from 'zero' will see sizeable gains this decade. But for 50% CO_2 cuts in this decade to avoid crisis – all still falls far short. That ought Not dissuade. New energy *can* deliver abundant, affordable clean change right away. Electric cars *may* go from tiny 2% US new car sales 2021, to 50% this decade, yet that still lags China & Europe badly. In Germany, pure EVs (up +79%) hit 15% of new sales August 2021, with all plugin cars (also hybrids) 31%. Norway's new EVs hit 83%(!) in 1H where gasser cars are outliers. China's 15% is rising very fast. Global EV sales likely to be 10% early 2022 – overshadowing US. China sold 1.1 million EVs 1H 2021, Europe sold 1 million – both were far better than US. So, like clean power generation, Europe leads the way in EVs too. China is rising now very fast from near nil. And the US is lagging.

Western Europe growing wind & solar, is slashing coal. Its natural gas can be brought down ahead too - but not yet! In 2021 gas shortages caused Europe's power prices to jump. But things change. Long marketed as a transition fuel, it one day may be last pariah fossil, as socially unacceptable as coal or cigarettes. Europe's Climate Law may mean a border tax on imported CO_2-laden products. And while renewables are clear winners now, EVs on cusp, the need for *heat* in buildings etc has no immediate clean fix early 2020s. Replacing gas boilers in UK & Europe with heat pumps, would be too costly. Renewable natural gas blended with green hydrogen (H_2), years away. As is running ships & aircraft on green H_2, or ammonia (toxic, so carefully) - or green liquids, gases, solids ahead. Clean is necessary – but it's only one-side of the climate coin. Other side must be real moves especially by China to cut coal, alongside less CO_2/GHGs in 2020s. All the world clean energy gains are for naught, if fossils use doesn't drop to near nothing. Yet huge populations in China, India, & Africa, have much economic / energy development ahead that will very likely be driven by coal.

Coal fell hard in Western Europe and US on clean energy (& regrettably too on more gas use) - but those are outliers. Elsewhere, like China, Eastern Europe, India, even in Japan, coal is seeing terrifying growth. China is fast growing renewables and very small new EVs: great! – yet it is expanding too coal burning for at least the 5 years 2021-2025. Notably China in the first half of 2020 added 11 Gigawatts (GW) more coal, and another 53 GW more coal maybe to come. Of all the world's coal power added in 2020, China had made up 90% of that.

Not only China is at issue: 33 of world's 60 largest Banks grew fossil fuels funding 2020. Any & all hopes to decarbonize the world in the 2020s are now blown apart by coal alone. In 2021, world carbon emissions spiked some 1.5 billion tons(!) mostly on coal. 2022 looks worse yet. Instead of drawdown needed immediately according to best science to decarbonize (with big reductions in methane too) – coal is still expanding globally these next 5 years.

There's happier words. A US 'commitment' to cut emissions by 50% from 2005 levels by 2030. A COP 26 Scotland for 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 1990 – not later in 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 oceans as 'carbon sinks' that reduce emissions, offsets can make a mockery of reductions. Some words inspire, others mislead. With all air traffic & shipping kept out of emissions tallies(!), methane too(!), facts are worse yet. Aircraft, ships, methane; each seriously forces greenhouse impacts and ought not to be so pretended away because they're just 'too hard to reduce'.

So there's a Huge Gap between even big, *promised* cuts to 2030, vs. actual data. These data are showing fast-*growing* CO_2 & GHG emissions worldwide across 2022/2023/2024 etc led by coal. Meanwhile, cuts pledged 'round the world' that all are failing spectacularly to meet are themselves nowhere 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 even fulfilling the 75 commitments – would only reduce global emissions by 1% from 2010 levels to 2030. So even if the NDC targets from so many countries were met, there'd still be unprecedented, historic levels of emissions driving climate change. To say nothing (as we now do) about the methane forcing heating.

Paris Agreement saw fanfare due to its supposed agreement that the heating would be held to 2 degrees C (3.6 degrees F), or better to 1.5 C (2.7 degrees F). Assuming science is to be believed, then CO_2 emissions will need be cut *this decade far more* enormously: by near half, or 45% to 2030. Given ambitions & real actions worldwide are nowhere close to 45% required reductions, the Paris view arguably is already out of date. Far more bold dramatic moves now by all 3 of the greatest emitters, China, US, and Europe, are essential.

So to be clear-eyed, that fanfare over a 1.5 C target wasn't deserved. Not as Paris Agreement lacks mechanisms to enforce necessary cuts to achieve it. Not when there's no real Plan to meet the 1.5 C target in this decade. Not when leaders talk like (oft meaningless) Agreements will head off a maybe, or likely(??) catastrophe. Against needed 45% cuts this decade – vs. a lack of action - 'net zero' greenhouse gases 2050 isn't yet worth discussing.

Or we can squint, for hope. In 2020 plainly superior economics of renewables had meant 80% of new generating projects worldwide were clean energy. It's just dollars & cents/ sense. That led to a 10.3% rise of carbon-free electric generation, globally. Also nice to see, 91% of new renewables were in wind & solar. Wind rose to 58 gigawatts (GW) in 2019; that doubled in 2020 on to 111 GW. As a percentage of total global electricity production, clean sustainable energy grew by 2 percentage points - from a 34.6% 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 when we're nearing the precipice of perhaps irreversible changes.

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

Greenwashing abounds. Ill-defined terms like 'net zero', 'climate neutral' bandied about. And actual emissions 'offset' in bit of a shell game, counting disingenuously trees, forests, oceans, as natural uptake. Coupled with far distant target year 2050, words are meaningless. 'Carbon neutral' is proclaimed – yet it's Not same as truer zero-carbon. Robust zero-carbon – stands well apart from 'net-zero'. So words are important. They can inspire – or forestall stronger actions. What's clearly needed is to truly *decarbonize now,* in tandem with action cutting diverse greenhouse gases: methane, black carbon, hydrofluorcarbons etc. Those latter super-pollutants are far more climate-forcing than CO_2. Shorter-lived they are 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 GHGs, more broadly, if the science is believed.

Instead, we hear words & words that dissemble. Some may call for 'ending coal' – yet the gap between those words vs. reality is vexed. Gains in renewables necessary, yes; but not sufficient. Alone it won't do the trick. A shift is needed from CO_2 – also necessarily enlisting capital to decarbonize. Equities, are like blood in veins worldwide. Arguably market forces can/do shape energy choices so matter – along with government Policy choices. Once, markets & policies together made coal the King of energy. Later they made oil a near exclusive global choice for transport. After that, abundant cheap natural gas grew so common last century, that it came to dominate both for making electric power - and heat.

So, market forces are fundamental - along with government policies. Lately they're helping clean energy rise yes; a sensible choice. Good. But according to science this transition isn't yet happening near fast enough, given a fast-heating Planet. Shifts like from coal & steam – to hydrocarbons – once took half-a-century. We don't have half-century now given what the best science tells us. Policies will hasten change, if governments so choose. Especially now, given clean has become cheaper and better and it will always be healthier. In sum both capital markets, along with policymaking, matter. They'll fast shape our future. Time & pace of change are of the essence. It's simple. Listening to what science and to what seas in fast decline are fairly shouting – perhaps matters like never before.

We turn now back to clean energy & green themes in broader financial markets.

Stepping back more broadly, let's include 2020 and ECO/NEX. Given both Indexes/ETFs stood out as top performers worldwide, ECO up +203%, why did they do so very well 2020? Several factors enumerated next, may help to add a bit of colour.

One factor may be our use of *decarbonization as an organizing principle stood out. Another, *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 here 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 is many recent 'clean' baskets are still steeped in greenwash; for example, they may have natural gas. Our thematic focus on true clean energy has been very consistent for 15+ years; that it's come into such favor maybe is good fortune.

We'd seen a bit similar at ECO 2004–07, when true green energy long unknown first grabbed a spotlight – sharp rises in tiny solar firms, electric car startups, li-ion batteries, storage, H_2 fuel cells. Stubbornly-held (dis)belief maybe broke down a bit - or not. Views often heard in 2004 included: Electric cars could *never* be as fast as 'real cars'; nor reach 200 miles range, nor ever be as pretty nor as 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 global overcapacity, high relative costs, and it being still just on 'promise only' around 2007-2015.

So re-think for the 2020s what's maybe possible this decade, what *may be* more promising. Perhaps: 5-million-mile batteries; whole regions competing in building renewables & electric cars; solar-electricity costs falling to <penny a kilowatt/hour, perhaps cheap 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. From a quantum-level scale up to our own macro and visible, from 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 our ECO Index® there'd been 10 components all up over +1,000% from their own past 52-weeks lows, 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 note here the *Speed by which clean energy shone as least-cost option, *Force by which policy embraces zero-carbon, & maybe soon a biggest item, *Climate Crisis. It's this last factor: how much CO_2 can we afford that's new to our species. Maybe a most vital limit. Like *C* in Physics, other matters dance around it. What can be done to decarbonize, Now, profitably?! All squarely fits within our theme. Above maybe helps explain jumps in ECO/NEX in 2020.

The Good

Digging deeper, let's just for fun call factors behind the change, or 'delta' here: the Good, the Bad, and the Ugly. One Good driver ***Huge Cost Reductions** in clean energy. Solar is now becoming **least-cost electricity* in much of the world; wind power often too. Solar will soon be the *cheapest electricity in history!* Unimaginable to so many, only a decade ago. Usually models had foreseen dirty fossils, instead, as definitively lowest cost power in 2021.

Another Good driver of delta: ***unprecedented commitments*** by the 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-Spring 2021 when a seminal new 14th 5 Year Plan publicly was released to much anticipation.

Did that mean, all greenhouse gases? Methane/CH_4, HFCs too for climate neutral - or just CO_2? How much disagreeably current dismal state of art in carbon capture & storage (CCS) plays a role, CO_2 just temporarily stored? Monoculture reforesting? Sleight of hand 'carbon intensity' for increasing use of natural gas - to be regarded as improvements(?!). Like 'CO_2 as per unit of GDP growth'? All that can/will distort true numbers around 'carbon-neutral'.

So it was a Big disappointment when its 5 year Plan released March 2021 didn't take the steps needed to end coal. The world needs coal to peak *before* 2025; biggest user China to commit to peak-coal first half this decade. It did not! Instead, it saw CO_2 peaking post-2025, presumably on steeper CO_2 cuts later. In a fudge, ocean & land 'nature-based solutions', so CO_2 sinks. Meanwhile, its lugubrious inertia-bound bureaucracy is not likely to draw down coal, given jobs. Yet pushing to post-2025 ought to be avoided. CO_2 sinks could fast become sources, even a great Amazon Forest. *Instead, China's renewables were always its best answer*. Glinda the Good Witch knew Dorothy's ruby-red slippers could always take her home. But first, Dorothy had to follow a yellow-brick road to gain such confidence. China's own ruby red & golden slippers/solutions, its new energy solar/wind plus vast new storage *could* start replacing coal now – fast becoming its 1st and best choice in 2021-2025.

Models by Tsinghua University have shown how China could reach net-zero CO_2 by 2050, all greenhouse gases 2060. It requires big, fast declines in coal power - and heat – plummeting from >70% – to <5%. To instead slowly cut coal, post-2025, means sharper cuts 2030. Far better would have been to aggressively have started to Decarbonize, Now. Immediately on a straight pathway would have been so preferable, to so many, worldwide. China instead, may ramp up nuclear first, rising from 'just' the 46 plants that were making 50 GW in 2021. No doubt its nukes will see accidents ahead, making it second-guess that choice. Regardless, China's new energy costs may top $15 trillion! A greater spend than is contemplated by Europe, or US: re-allocations to its economy. The most ambitious Plan the world has seen. Say, 10+fold fast increases in solar, 7+fold in wind. Maybe 10x-100x more solar manufacturing capacity. Tremendous ramps in storage – new 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 electric vehicles & energy storage. Apart from Tesla 2021 and maybe Ford ahead some, China is most seizing opportunities, so too Japan, South Korea, Taiwan. About 1 million EVs were sold in China 2019: 54% of world total, 3 times the US. And growing: new EV growth in China could surpass 25%/year, 4+ million EVs in 2025. Maybe again reason for big 2020 delta upswings in ECO/NEX/OCEAN! Demand helped push battery costs down 80% in 8 years, maybe ahead to <$100/kWh by 2023. Battery demand may grow 5-fold.

America's own battery leader in 2020 was Tesla, with its 35 (gigawatt/hours) GWh of lithium-ion capacity, maybe 100 GWh, aims for 3,000 GWh (3 TWh) by 2030. 3 TWh give or take, was about all world battery making capacity 2020, so change is happening! Ford announced big goals late 2021, GM aims big too. Reason for valuation deltas 2020. To make all vehicles electric, may mean >10,000 GWh new battery manufacturing/year. 2x that all energy storage to replace fossils. In EVs maybe lithium metal at anode rather than graphite as a step to solid state. Apart from lithium-ion, much ahead. Nickel/zinc or iron is heavier yet can deeply discharge on less thermal management, good longevity, cheap to boot. Vanadium or iron flow batteries maybe for storage on grid that may better resist degrading over time, etc.

China's early focus on batteries has been fruitful for it. It had in 2020, 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 have fast pulled it ahead of US. A century ago, Des Moines Iowa was a world capitol for electric cars. 30,000 EVs were registered across all the US in 1912. Yet the US (again) is letting its world-lead slip away. Something that China, lately Europe too seem very intent not to let happen to them.

All of 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 more than its 44% in 2015. Other side of ledger, China also led in clean energy growth: in 2019 China added 30 gigawatts of solar capacity, and 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 2021. Yet hopes for over >100 GW/year were dashed early 2021 on an NEA draft @60 GW. In thinking of what's needed given CO_2, it's why some **Climate** models with CO_2 levels now >400 ppm, are calling for 10x-100x that: thousands more GW global solar/wind ahead, on climatic concerns.

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

Europe 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 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 President may do. Includes whole government approaches, strong unitary executive, good green jobs in areas hard hit by coal, oil & gas losses. Tougher is a carbon tax, or a National Renewables Standard. Ending fossil tax breaks - although watch for maybe new help for clean power, alternative fuels, energy efficiency. Upstream, thinnest-margin solar & battery manufacturing may remain quite Asia-based for now, with Europe growing. But that low-cost PV can help to electrify the US. Better yet to do so with little embedded coal/carbon. In the US possibly more for EV charging, Building Back Better, and build back better world, good jobs in grid, transmission weatherization, distribution etc. Arguably Good reasons for high volatility 2020/ and falls seen 2021.

The Bad

Perhaps 'bad' factors too lay behind the 2020 rise. Bad, in a sense that drivers to some, didn't yet warrant such exuberance; Hydrogen (H_2) & fuel cells 2020 come to mind. Not that they can't, one day possibly sooner than expected - be vital. It's more that in 2020, they perhaps hadn't yet justified hype, not until breakthroughs occur. But then, this is a passive Index – not actively managed - nor actively trying to predict rises or falls. Notably too hydrogen and fuel cells in all 3 basket/s outperformed 2020. H_2 is still burdened by sparse CO_2 avoided, low efficiency, yet H_2 may become increasingly green/relevant. If from 'rock gas' (natural gas rock drilling) so inextricably tied to fossils, then it is not a worthy solution. 'Blue' H_2 from fossil fuels & sequestration only passes a low bar; it's very polluting. Big Oil may embrace a blue chimera, on subsidies for that H_2. But blue H_2 may be 'cheap' & competes with green H_2 this decade only. Neither ugly one: blue H_2 with sequestration, nor brown/grey dirty H_2 from traditional rock fossil fuels, will be both clean/green and renewable.

Far better is *green hydrogen* that's renewably & cleanly made like by solar or wind. 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, and <$2 per kilogram. Saudi Arabia is considering 4 GW of solar & wind for it; UAE is looking here too. Different is capturing a potent greenhouse gas methane (CH_4) spilling from landfills, dairies, etc: for H_2 from it via clean power - or new '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 a transition bridge.

Green H_2 by contrast *may be* hugely scalable & growing speculation is it can be more plausible than before. Demand for green H_2 *could*, *may* 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, like made on site as by offshore wind. (Blue ammonia undesirably, uses rock gas). Visuals of wind or solar making green H_2 - or 'green NH_3' - in place of oil could be painted.

The rub, is cost. H_2 affinity to react means much solar/wind power needed for electrolysis, to split water. And green H_2 2021 is too costly vs brown H_2 steam reforming gas – brown too costly in turn in its own right. So an inflection could be if: 1) solar/wind costs fall enormously; and if 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 now targeted; even far cheaper may yet arrive in whole new ways.

All that was dreaming in 2020. Green H_2 cost x-times too much everywhere, is 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 from H_2 – to electricity at fuel cell. A case may arise *if* cheap solar/wind+green H_2 'time shifts' intermittent renewables, a holy grail of abundant firm power & heat. Nearer term, a green H_2 can displace rock gas <15% to not embrittle steel. Renewable natural gas, a limited drop in fuel. Capture uncapped methane – upgrade on clean power to renewable natural gas, or 'turquoise hydrogen'; *truly* sequester C in stable form. Renewable natural gas is just defense only, vs. climate risk. Not great, but of help nearer term. In sum H_2 fuel cells are partly why clean jumped in 2020, as equities are forward-looking. But it has to deliver. And that 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 cheap power.

The Ugly

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

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

A compelling DAC would have to *Remove the CO_2 from air & seas, *Permanently, in *Practical and *Economic Ways, *Scale up to Gigatons, and be *Benign, Stable, and *Carbon Negative – not carbon neutral. An 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 is concentrating 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 here

Closing gaps, like progressing beyond past ***wrong*** views of what's possible – helped propel clean equities up. A few years ago, conventional wisdom held EVs, like solar & wind power, were costly toys at best, to be seated at a kids' table. Regarded unseriously. Rather than 'listening to the sea' or thinking holistically – electric cars were dismissed as slow silly golf carts vexed by smallest hills, their range forever under <100 miles, a sad joke.

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

It's very non-linear. Think tremendous falls back 2008/2009, early 2020 when green themes plummeted (They certainly could do so ahead again). Back a dozen years ago, profit margins went non-existent, and stayed down for years. There's non-Euclidian curved geometry here. Like disjointed compressed margins, few true straight lines. Solar margins in time becalmed a bit; we learned to make solar *least-cost electricity in history!* Learned cost-reductions led to virtuous circles. Electric cars, got better in most every way. Think of heat engines. Unfathomably they're still all around us: spark plug explosions push pistons for power by oil. Cars. Coal, gas making electricity by heat difference. Nuclear=world's costliest boiled water. Delta is in hot - vs. cool. What's used is difference in state, temperature gap "A" vs "B". But that difference in heat engines is brutally inefficient - unlike nature herself.

Mr. Babbage captured delta in a difference engine. Mr. Turing's work led to computers; there 0s and 1s did the work. Here, energy, we do not know if razor-thin solar margins may crash. If equities may again plummet like a bear market a decade ago. Or, growth *may be* possible on demand – better affordability – or the top issue of all, perhaps: physical CO_2 limits.

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

Not so on climate. Singularly, researchers are shouting. Perhaps it's Conservative then to heed science – unwise to reject it. It 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 still be saved: remember Summers lasting only 3 months? Winter? Cool nights? Coral Reefs? Sandy Beaches? How better to prevent that as a future we needlessly bequeath. Especially when more Sustainable, No Regrets paths can make us healthier, happier, richer, safer, more secure. Saving us from spiraling blood & treasure, new diseases, and despair. This may mean our intentionally embracing ahead Prevention Rather than Cure.

NEX/ECO/OCEAN themes may capture & track some possibly more sustainable paths. Decarbonize, electrify everything, low-carbon fuels, efficient heat & cooling, green industry. Many more ideas will yet emerge, areas of particular advantage, certain themes, or regions. Consider for instance, 14 of the most volatile, upside constituents in NEX mid-Q1 2021. These were most up over a past 52-weeks to early 2021, hence the 14 biggest gainers then.

As January 2021 NEX had been near highs, we (thus) avoided looking at peak time. Instead, here are figures from March of 2021 as NEX components, like most growth & innovation equities globally, were instead in steep falls. Hence these % up figures are moderated by a look as of March 3rd amidst a then -25% YTD plummet. Here then worldwide, it's much like ECO's story where we'd noted big gains were over +1,000% from their lows last 52 weeks to early March 2021. These were instances of rich gains globally. 14 NEX components with big deltas as of Q1 2021 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%**

In sum 2020 concluded with gains in all 3 Index themes. There was next in 2021 unsurprising big falls across ECO, NEX, and OCEAN. To end of Q3 2021, ECO had touched a recent low in May, near 145, NEX fell to near 400, and OCEAN dropped near 350. Should a hoped-for Infrastructure and Climate reconciliation bill utterly fail in Q4 2021 or Q1 2022 – then arguably all 3 Index themes could possibly plummet. Much farther, swiftly. And should an outlier like a US Debt default occur too, these recent high-fliers could be even more seriously hit.

What's special about this list of 2020s gainers? For sure these above gainers were remarkably diverse. Some in energy innovation are in scalable and 'on offense' against climate crisis, like solar & wind. Names in solar upstream included poly & ingot/wafer/panel manufacturing - and downstream inverters, sales, and installation. There's advanced batteries and materials. Plus, there's much more highly speculative hydrogen & fuel cells. Biofuels are diverse given that new energy innovation reflects a range of opportunities.

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

Still past equity gains like in 2020 no way foreshadow gains ahead. Indeed, such big rises may auger sharper falls 2022 and ahead. Regression to mean, nothing is certain. Or, they *may* point to better paths. Once upon a time, fossil fuels magnified our power many-fold. Yet we can't let past dominance by once-magic fossils, now waning - mean what's bad for fading coal, oil, gas - is bad for humanity. We'll be braver, wiser to set out for a once-more stable climate. Towards broad sunlit uplands of carbon near 300 ppm: this choice is seminal.

20 years ago, paths were less clear. Solar likely viable, but could it grow cheap enough? Might horizontal - or vertical axis wind turbines win in a red in tooth and claw competition? Electric vehicles: surely with better batteries, but *when* may those succeed? Can green hydrogen *ever be* economically viable? Fuel cells low-cost? All were obvious questions – no obvious answers. Questions barely imaginable then, now are: which electric jets; is green H_2, ammonia, or methanol MH_3OH better for ships; how to scale green DAC for sequestration to make carbon inert like a mineralized rock? So much yet in this decade. All open to debate. Inherently, unknowable. We well recall rather like end of last century, only some 25+ years ago.

To passively pool diverse clean energy candidates into an Index basket made great sense then – & still does now. Victors unknowable, among technologies competing to win day. Mitigating against individual stock risk via a basket was compelling: probably 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 question bedevils. It maybe makes passive Indexing like seen here in ECO/NEX/OCEAN arguably rather compelling.

Volatility is another beast. We can say with great confidence, oil prices will doubtless jerk at times sizably ahead. Natural gas maybe in long-term decline - yet events happen: 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 extreme heat & cold – given climate crisis - means jumps ahead. Unpredictability is predictable in that sense. Drought too stalks gas, like coal, and even nuke plants all needing cooling waters. Stratospheric heating in a changing climate may occur one month, weakening Jet Stream, letting super cold arctic air dip South freezing infrastructure. Or, a slowing Gulf Stream ironically may dramatically cool Europe, altering patterns. Both Streams, the Gulf + the Jet are crucial. Oil is in lugubrious long decline surely – yet we'll certainly see many price spikes ahead.

Perhaps foreshadowing more extremes ahead, deadly disaster hit Texas early in 2021 when a freeze took down its electric grid. That US blackout just showcased battles going on now in messaging. What will it take for a stronger, more reliable grid going forward? Fossil fuel, especially the gas once so dominant – lately finds itself at times on its back heels.

Case in point amid that crisis: an argument was hastily made the blackout was due to clean energy, to wind turbines freezing! Whether that was promoted by the uninformed, or by politically motivated opponents of 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 attempts then in Texas, to use chemicals to try to unfreeze turbines. They claimed that this was proof wind power was ***the main cause*** of terrible grid outages 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 of hot water lifted from a truck boiler (no chemicals) in Sweden – on a turbine lacking usual de-icing features. That compelling photo shown at a 2015 conference – was lifted for the powerful & fictional 2021 false narrative. That meme shared widely by a publicist, website & others was memorable, but clearly not true. Yet it definitely stoked misinformation and was seized on by wind's opponents as 'proof' of wind power failures. The truth in Texas was very different - but arrived days later, after this memorable photo & tall tale were already played out.

Let's dig a bit into what really caused that awful Winter freeze grid-collapse disaster in Texas. First to begin with, Texas' electricity grid early 2021 was not at all mainly powered (yet) by renewables; but instead from natural gas. 52% of its grid power was run on natural gas in 2020 – vs. about 39% of grids on gas nationwide. What's key is how well forecast energy Supply – matches 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 from natural gas: a huge projected 50 GW availability.

An excellent review of just what happened Monday February 15th – to Wednesday Feb 17th is laid out in Texas Monthly (3/3/21). As recounted there a key problem was 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: their gas lines froze. So regardless of how much gas was 'given', that 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 a wrong tree. Hence fascinating image and tale of helicopter hovering high bestride frozen wind blades confused matters. It made fascinating theater, a one-time narrative (helpful) 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 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 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 a like amount to wind – off 0.7 GW. In all 55% of unplanned capacity outage was natural gas. 22% wind. And 18% was coal. Plus nuke losses too. So each source of electrical power was hit. Truth is, smaller wind power shortages were but a fraction (near least of all) of disruptions in that crisis over 3 vexing days.

Core shortfall was in natural gas. It, suddenly fell short, by a huge 20 GW less than expected – 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 even hot place; much equipment was thus left unweatherized, and 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. 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. So some were forced – like other gas producers – to suddenly compete for meager amounts of available unfrozen gas supply while 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 expected to hit normal wholesale power rates of $24 per megawatt-hour. But because gas was unavailable on freezing temperatures, in chaos of needing to find gas right away at any price, their prices that they charged soon 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 about gaps of $50 & $100 'deltas' in gas prices.

In retrospect, understanding how to do better, means lessons can be drawn. Lesson 1 is that *more* natural gas would have solved nothing. But *winterizing - or better yet *weathering for 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 cheaper).

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

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

If most above feels like playing at edges of a teetering system bound for scrap next decades, you'd probably be right. What it shows too, is what went wrong in 2021 Texas crisis. It wasn't a small loss of wind! Wind turbines can readily be winterized; it may add 10% to turbine costs, but is done round the world. Wind works in Arctic, in US Midwest oft far colder than Texas; in fact, wind prefers cool, heavy breezes. (Natural gas too prefers cool, but no claims to contrary are made for gas – like it was for wind power!). Months after Texas' freeze, it came to light that on concerns a blackout might portray gas poorly, a campaign was fast mounted to call the renewables as 'unreliable' – and deem fossils as 'reliable energy'. Even though the *gas* thermal plants at 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 in fact a big deal. (As seen in Louisiana in Fall 2021, or the gas pains in Europe in Fall 2021; each one another story).

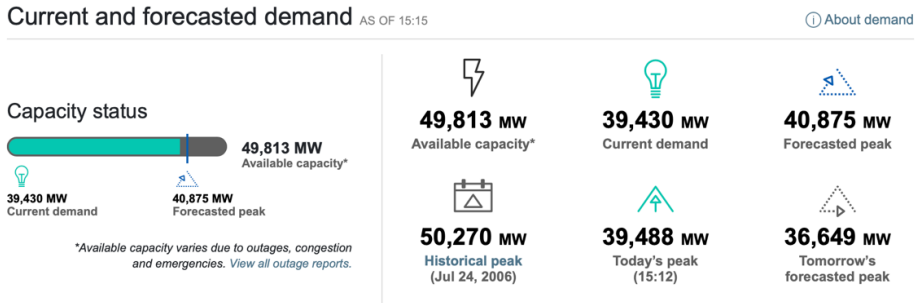
It boils down to: How ready are we for a changing climate? Honestly, not at all. A sole key oil fuel pipeline from Texas to US East Coast, if shut – could paralyze Southeastern US. Glance at a weather app like Ventusky; it shows a swirling arctic polar vortex each Winter. Bitter arctic air drops at times 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 atmosphere might weaken this 'fence' protecting us. It doesn't take much to envision Jet Stream shifting, wavering, weakening, so bitter arctic cold descends more south. While it may not sound especially harsh to the ear, consequences surely would be. Floods, drought too, increasingly imperil big thermal power plants.

Perhaps 'Climate Change', 'Global Warming' are too benign as words for a possible Calamity. Better may be 'Climate Crisis', 'Global Heating', Emergency, or Global Weirding for decades, centuries plus of a blazing Planet. Uninhabitable equator, yet not very far different from hot Poles. It does Not mean getting there shall be incremental. Or 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 becomes frozen barren places 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 could end much we know today. Science is still unsure: will it be a cooling, or warming? But it's unlikely no change at all!

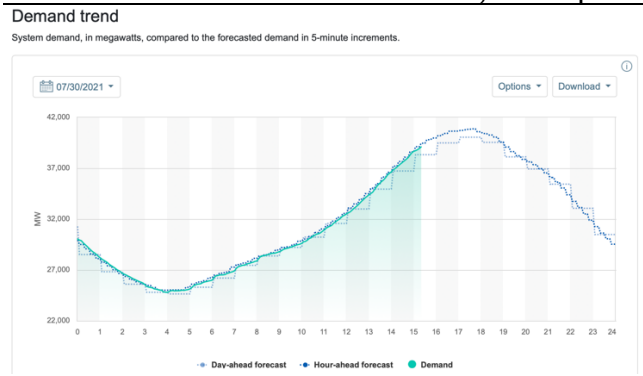
For Texas Winter 2021, gas was weakest link. Nuclear & coal were vulnerable too to cold – as they are to heat, floods & drought. For solar & wind instead, new Storage for abundant clean electricity is what's needed. Together they'll make electricity cheaper too, on renewables. Storing that clean power 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 a Summer day say end of July 2021 in California. On a typical expected hot day – here July 30, 2021 shown below, the situation in the State's grid around 3 pm is not great. As it looks that day, all power sources generate some 50,000 MW (49,813 MW). Demand is forecast to peak soon that afternoon at 40,000 MW:



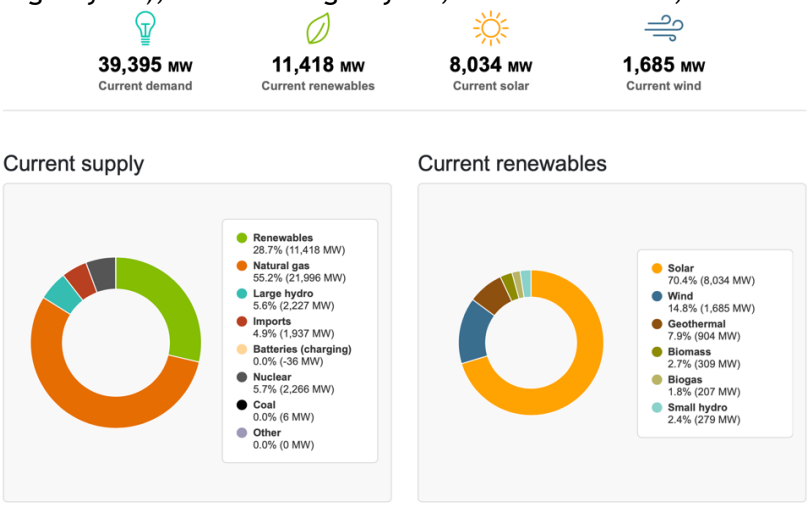
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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



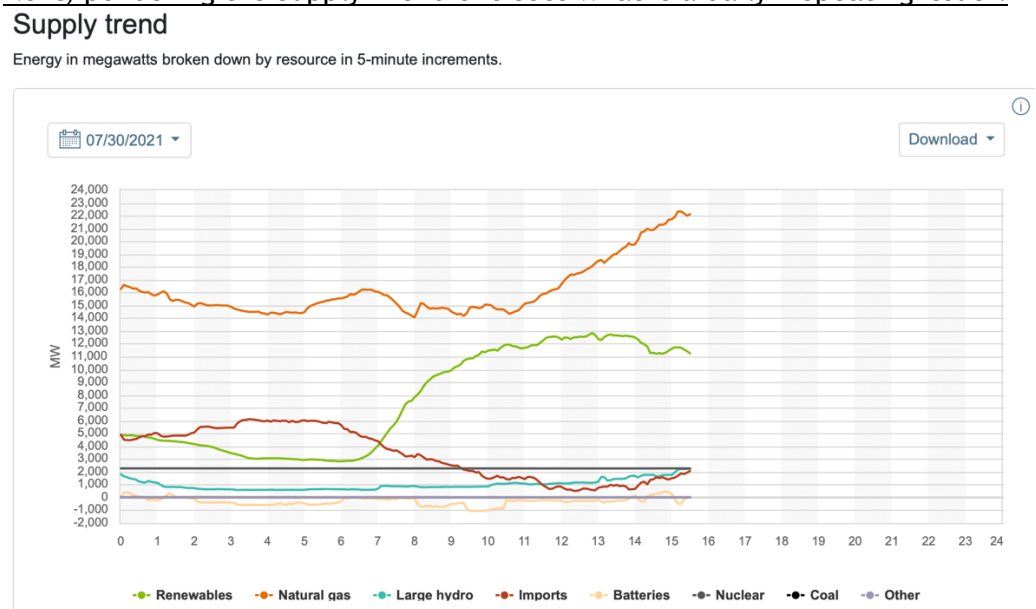
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

<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% from Renewables (other than large Hydro), 5% from 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.

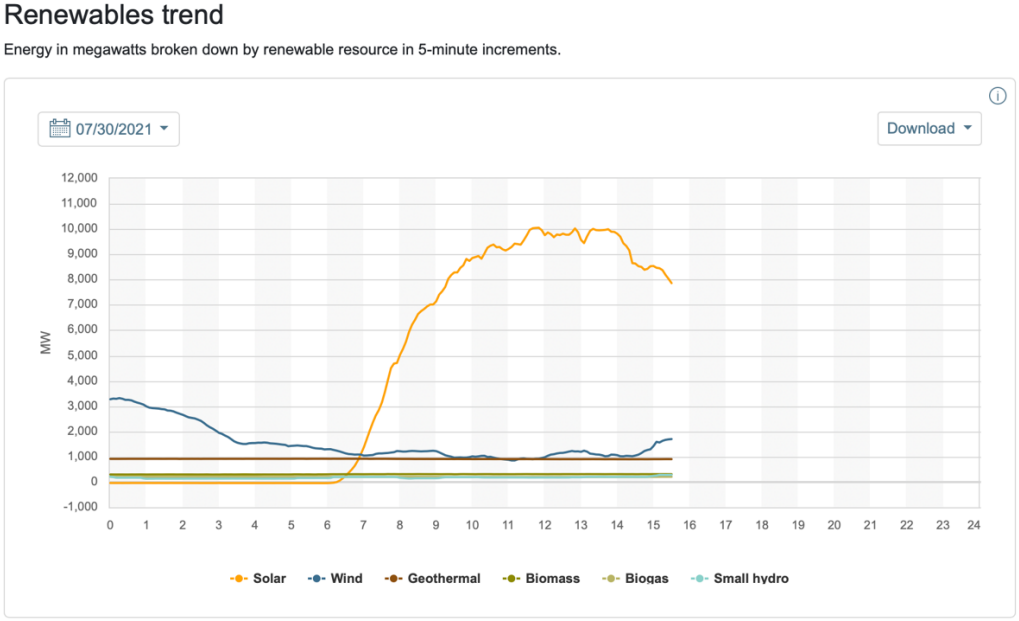
Next, pondering the Supply Trend one sees what is a daily 'repeating issue':



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

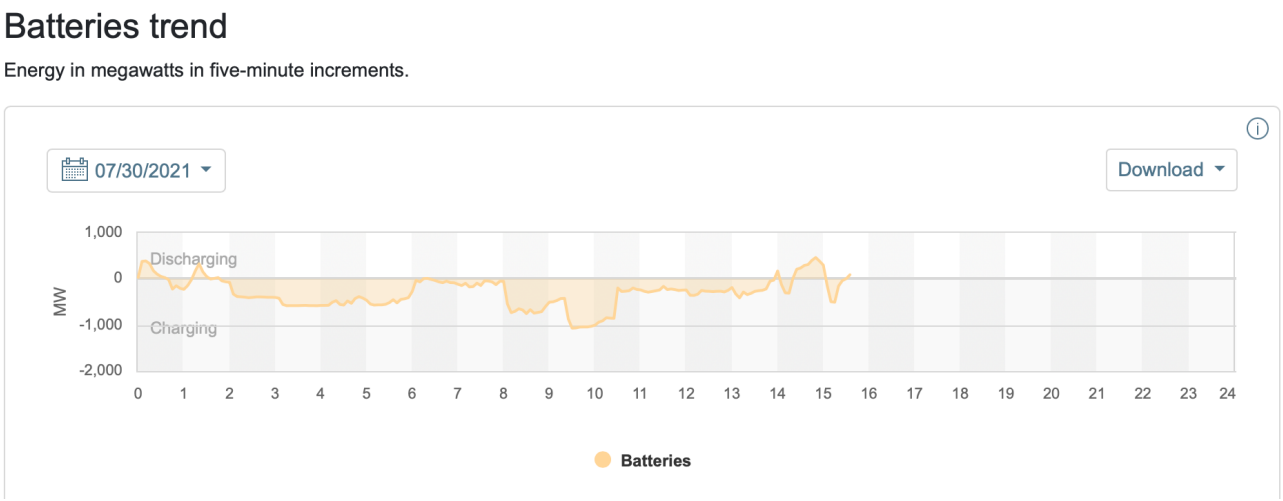
That solar power making up most of the renewables' contribution in green above, is about to drop hard, as sun begins to set. Of course, eminently forecastable! So this 11,000 MW from solar at 3 pm above to help meet 40,000 MW of demand – will fall very hard. Firm, dispatchable natural gas is generating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

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



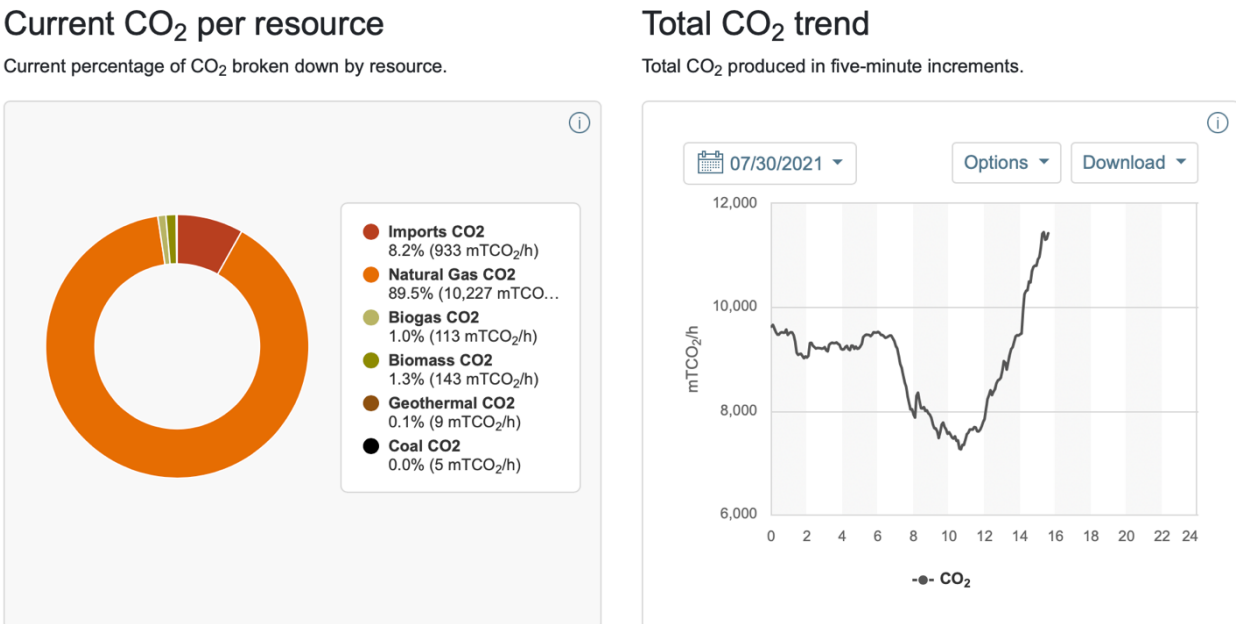
Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

In theory, one might think Batteries and/or other energy Storage would & should kick in hard. Foreseeably they could readily make up for roughly 11,000 MW lost solar after sunset, by using green power charged in day. They might then provide too 22,000 MW that was generated from natural gas. But ... reality in 2021 is that energy storage is almost entirely non-existent still. This Batteries trend below, shows only a meager 1,000 MW at play – when we now need some 50x that – or 50,000+ MW of storage! Thus it shows as negative during this day (charging) – for scant power that's soon available (today) when the sun goes down by discharging:

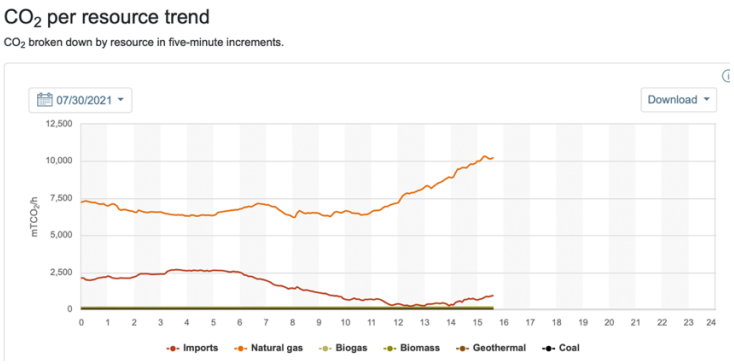


Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

Hence we all still suffer from ongoing dependence on fossils. Mainly natural gas in California – producing huge carbon emissions. Big hydro cannot be scaled up; indeed, big reservoirs like at Lake Powell and Lake Mead may soon be 'dead pools'. Natural gas may not be as odious as CO_2 from coal (worse in tons), but methane leaks badly vex the Earth and climate nonetheless. About 90% of this *measured gas* CO_2 is but one GHG (leaks are worse), 8% from Imports:



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

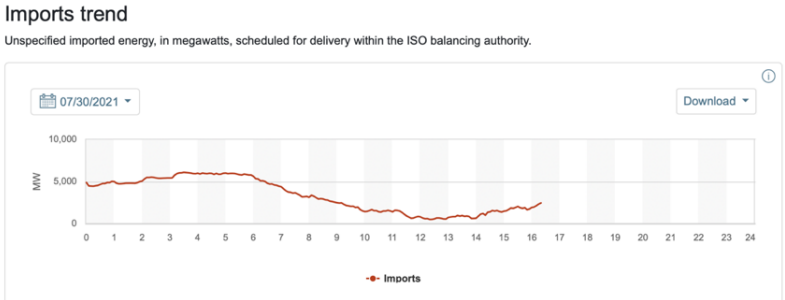


Source: CAISO.com Today's Outlook - On July 30, 2021 at approximately 3:30 p.m.

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

It gets worse. Practical Issues in California's grid early 2020s include that in a Flex Alert, CO_2 Emissions can spike to get Supply as high as possible, over >50,000 MW to meet demand. Natural gas+peaker plants are maxed at 100%, no maintenance, much power imported from out of State. Demand for example in a Heat Wave a year prior, Sept. 5, 2020 outstripped capacity. Then, rolling blackouts were threatened. California's Demand History shows both more clean Renewables + much more Batteries / Storage will have to grow very, very fast, given huge energy efficiency strides already made. And California is adding electric vehicles. That swiftly creates more demand – while it's shuttering soon its lone, current/older technology nuclear plant. That closing means 5% loss of firm generating capacity, soon.

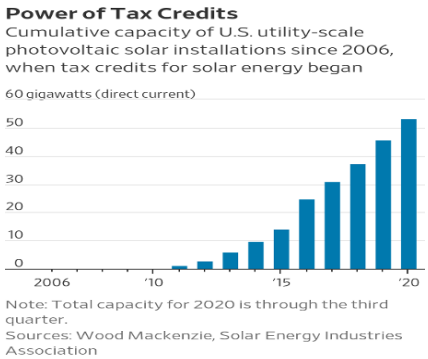
To date the State has been 'solving' this conundrum by Importing the electrons it needs – from power generated elsewhere in the West, times of insufficient supply. But that dirty *power may be generated by carbon-laden sources such as natural gas or coal - or it may be by a costly inherently dangerous source like nuclear. And those sources, all suffer more than renewables do from heat waves, from drought, or lack of water needed to cool their systems. As Texas showed Winter 2021, cold too knocks out fossils and nukes. So imported power may be a band-aid 2021, but isn't an answer long-term. What can help, is better grid to a windy Midwest U.S. To profitably export its bounty to places like California, and Texas, if the grid boasts such links. (Especially if better protected from Wildfires). Building in more storage, and a more resilient grid, makes sense 2020s. Especially as drought threatens big hydro - and gas, nuclear coal. They're all hit hard 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 let's briefly look at possible Tax incentives for eg energy storage. Back in 2020, a few proposed tax changes for storage had passed in House – but not in Senate. Nor were they supported by a then-President who opposed green. 2021 things were different. Budget-reconciliation in Senate allows for 51 votes, so consider tax credits like which once earlier had been crucial to starting up solar – could again possibly grow similarly vital to storage, batteries and grid from 2022 onwards.

It's a chicken and egg problem. Solar had needed both cheaper panels – & favorable (tax) policies, to light a fuse, prime the pump. Both were needed. This chart shows how fast solar then grew after, partly thanks to solar tax credits post-2006. Solar stands since strongly on its own now – but like all of energy, the early tax policies here had mattered:



Sources: Wood McKenzie & SEIA

Tax credits for Storage had required solar links– so were often of little help. Unleash storage 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'll need hundreds, thousands of gigawatts. No doubt we'll scale storage up with right policy. Repeating for batteries & all storage - what recently happened in fast-growing solar. That would be of great benefit to all.

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

Tax changes are perhaps possible late 2021 and 2022. They might extend solar ITC credit to 10 years at 30% plus storage, but specific prevailing wages goals may make it onerous to apply. Domestic content >55% rules, could raise to 40%. Near-term, WRO and anti-circumvention dominate some 'in the weeds' topics. For solar a possible exemption could mean helpful 30% ITC to 2030; and ability to again make use of PTC in solar would be helpful. For Wind a 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 + new base rate. Domestic content requirements to get greater tax benefits. Maybe diverse programs of the past can be replaced by 3 for clean power, transportation fuels, efficiency. Perhaps possible in 2021/2022: equity & inclusion, rural jobs, environmental justice, all top line priorities in new energy policy (with some line items for West Virginia, Arizona?!).

Last Few Years: 2019, 2020, 2021 …

Let's look briefly at a striking 12 months from March 2020 to March 2021. ECO was up at times +250%; NEX up +150%: far outpacing fossil fuels and Indexes like S&P500 and Nasdaq. ECO/NEX showed vivid non-correlation too vs dirty energy. What example of diversification! While oil & gas stories were in free fall over 2020, clean sharply rose. In 2021 they next showed non-correlation the other way as well: down! ECO & NEX again marched to a different drummer; their roles here were reversed as clean *fell* sharply – while dirty jumped up in 2021.

Or step outside that March-March period. Earlier on from 2020 vantagepoint, dirty energy was single worst performing sector of S&P500 for 4 of prior 6 years; down -30% in 2020 as clean roared up. (In an S&P500 'energy' was still mainly fossil fuels). Fossil fuels then jumped up first half 2021 – after a long time in doldrums as noted. In sum last few years to 2021 were remarkable and seminal for all energy – so we'll touch more on this important period.

Consider for instance, what transpired in an S&P500 when a Covid crash hit everything hard. That dropped markets around the world, ECO/NEX/OCEAN too, to then nadir mid-March 2020. Little slice of S&P500 that's within energy (mainly fossil fuels) was then off -51% in Q1 2020, when overall S&P500 was down 'only' -19%. Partly that was due to the 500 Index weighting methodology: just very 1 big component there in the S&P500 based on market capitalization weightings, might be potentially heftier than all its dirty fuels combined.

It is slowly greening, at snail's pace. An electric car maker was added to the 500 late 2020 – so late it was already 4th biggest US company – and regarded curiously in an 500 as 'consumer discretionary'. Enphase was added 2021. As for energy in general, we'd noted 2020 that (dirty) energy then made up just 2.5% of the S&P500. Once, it had been far bigger: it was 7% in 2015, 11% in 2010; 16% in 2008; in 1980 dirty energy was 7 of S&P's top 10 by market cap, 25%! By contrast the 18% that was technology stocks in 2010, grew to 28% by 2020. Some observers in 2020 had hoped the big EV maker's addition might have come earlier, say mid-2020, to be 1.4% of that Index. That would have been significant, given some $4 trillion in Index trackers. But it was passed over, to be added later, for Q4.

For further insight, let's consider say, US oil & gas behemoth Exxon. In 2020 Dow Jones Index announced it was dropping Exxon from its leading 30-stock Dow basket. Why? Apple was splitting 4-1 so a price-weighted Dow needed to find new component/s to keep up with other baskets. (Dow had significantly lagged performance of late). New representation was chosen - but not anything in dirty old energy/oil. Instead, they added 3 technology-heavy names. Dow Industrials dropped Exxon that in various incarnations, had been in since 1928. Once a long-serving component of Dow, no more. Only Chevron, among oil has stayed. Reflections of a prior decade perhaps when dirty energy fell fast – despite the bounce up in 2021.

Make-up of financial baskets matters. Battles are quietly going on, influencing hundreds, even thousands of billions of dollars. Back in 2018-2020, the then-Administration on Dept. of Labor ERISA law 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 fossil fuels – and to sustainable energy themes. It's been reported fossil-fuel industry & climate skeptics were an impetus then trying to slow inflows to ESG (Environment, Social, Governance) investing. They'd perhaps hoped to see 'non-pecuniary' goals, like climate change, get subverted. A new Administration from 2021 moved on from those Labor Dept aims: still it's useful to recall how a stealthy attack had recently occurred against clean in 2016-2020.

Real-world Returns for clean energy last several years, up hundreds of percent, are hardly 'non-pecuniary'! That said a Past 12 months chart say to late September 2021 show 2 top performers are this time oil & gas. They're up +83%, & +49% for striking gains 2021. ECO and NEX up around +42%. Interestingly, both fossils & clean energy are very nicely non-correlating too vs all major Indexes (that trailed). Hence it was maybe no surprise to see billions of dollars flowing into ESG, breaking all records. 2020 ESG assets more than 2x that in 2019, reaching $246 billion end of Q1 2021. Q1 2021 inflows reached $55 billion, vs. $41 billion Q1 2020. Assets in ETFs/ETPs topped $6 Trillion for a first-time in 2021. As ESG in particular grows and at times may outperform like 2020, its winning attention to climate (IB 2015-1) came under attack in 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', then that's a bit curious given these glaring Performance facts:

Past 12 months to late-September 2021:

Source: finance.yahoo.com

In a recent window 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 more big falls, like 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 Q1 2021 reached cumulative shortfall of 320 billion yuan (near USD $50 billion), 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 such big drops, surely an ongoing wild volatility, decarbonizing has begun to figure more prominently with good reason.

Global crises matter too. Taiwan's drought 2021 had a role in semiconductor chip shortages. Western US drought meant more wildfires, maybe power outages ahead. Over 2020 & 2021 smitten by diseases, wildfires, temperature extremes, blackouts, we're increasingly seeing mounting evidence the economy is wholly owned subsidiary of the environment. On the other hand if a US Infrastructure package does Not pass late 2021 or soon in 2022, if a key hope gets yanked away – then ECO & the NEX could well fall *much* farther ahead! Exogenous factors too, can play a role: a US Debt default; unprecedented Inflation; or taper leading to crash.

As for what might be in a big bill ahead: early in 2021 one item that got attention was better US battery & metals production – where China clearly is 'eating our lunch'. Well, not just ours in the US, but many would-be competitors worldwide. A question for lawmakers therefore is: how to shape US innovation policy so that American battery and minerals production may again begin to compete, having fallen so badly behind these past many years.

One problem in 2021 was US lags badly in making enough lithium/nickel etc for batteries. Also producing rare earths minerals (which in fact are not very rare) needed for motors & strategic uses. As Sen. Manchin had 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 upstream in manufacturing batteries, and for electric cars and the grid.

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

By 2030, hence less than 10 years, China is smartly on track to boast 140 big battery factories! Europe's ramping quickly too; it looks to have 17 big factories. On projected US demand for electric vehicles, we ought have 20 battery factories in 2030. Not inspiringly, half that, 10 – is what we're on track for. To be up and running say 2027, the coming US factories should be in their initial planning now in 2021/2022, with construction starting soon: 2023.

All underlines need for action now, pre-2025 to *Cut CO_2 emissions where the world is failing badly, 'Build Back Better' in a US phrase. 'B3W' is Worldwide, where Europe/China now lead. The US has fallen behind China clearly - and a more committed Western Europe too.

If America has expected 200 electric & hybrid car models out in 2024, we should be producing needed rare earths minerals for their motors. Lithium for batteries, is abundant in Earth's crust, not to be confused with rare earths (again, not so rare). Latter rare earths are necessary eg for magnets generating electricity from rotations of a wind turbine - for strong AC motors turning green electricity into lovely electro-motive power in EVs, etc etc.

As said by Mr. Nikola Tesla, as regards coming 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 inventions that are pedestrian parlor tricks by comparison, these rotating fields tapped by rare earth's have awesome traits making possible unmatched blue-sky advances. Like many batteries needing lithium and nickel, so too clean energy's applied technologies will often need rare earths for their magic.

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

Sens. Manchin, Capito, Murkowski introduced legislation to get rare earths from coal wastes, of which they've got rather a lot. Recent studies showed more greenhouse gas methane may be coming from Appalachia's old coal areas – than from all of Texas' many 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 US solar & semiconductor manufacturing, a proposed LIFT America Act that could include domestic battery-making incentives and years of support for US-sourced critical supply chains. But given where China is 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 change in direction. Sadly, the US likely may remain dependent near term on importing strategically-vital materials most often mainly from a more ambitious China.

Possible changes could lay ahead like cutting all the subsidies bizarrely still given fossil fuels. A 2017 Report found $20 billion was given to oil, gas, coal 2015/2016, more than subsidies for clean renewables. Oil & gas can write-off expenses: 'intangible drilling costs', benefits by 'lost royalties on deep-water drilling', Master Limited Partnerships for fossils. The G20 advocates eliminating ALL dirty energy subsidies; a study estimates global 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 had $8 billion in tax breaks for 77 fossil firms. Given it's all from a public purse, and public health burdens of fossils are massive, it's sensible to end that. But it would be stridently resisted by such industries and so in the US House & Senate.

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

IEA also criticized the Developed nations behind so much cumulative emissions, for 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." Pledges by corporations typically are left vague, combined with often very distant target dates.

The IEA says annual low-carbon investments must 2x+ from $2 trillion/year, to $5 trillion by 2030. It expects 30 years hence, 2/3rds of power is from renewables. It sees next 10 years EVs going from 5% - to 60% of vehicles on road (China's massive boom in vehicles 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, with China, to be effective; subsidies end for fossils including US to be effective. Green hydrogen used for high heat industry.

Change is afoot. In Q1 2020, an oil tracker crashed -70% *down* when oil fell hard, rebounding a year later in Q1/Q2 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, is subject to pricing attack. So when nearest front-month contracts 'broke' to contango 2020, near tank tops that limit storage space, that oil index went far down fast - unlike futures farther 12 months+ out for oil. It has amply proven there's a floor beneath which oil prices cannot fall – very unlike solar & wind power.

We'll discuss it ahead, but a point is oil's 2020 crash was a crisis for it – until rebounding 2021 to $60s+/barrel WTI. So in 2021 OPEC restored 2 million barrels/day production. By contrast, green themes like solar - can & do move very differently. And the prognosis for clean is thankfully different. Drivers differ for solar as there's 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 once was seen as a benefit: before, it had both made panels/and installed/serviced them. Split by a spin, newly specialized, this parent refocused downstream on selling PV in North America. A big market, albeit thin margins: new storage allows premium branding, and can get bigger. In-country work can't be outsourced, nor done overseas by cheap commoditized competitors elsewhere. Still, in 2021 a concern for solar instead became fast-rising input prices and PV price inflation.

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

Upstream, that spinoff premium PV maker has enjoyed China patent protection & pricing power (2-4 cents/Watt commercial, ~4-8 c/W residential). But margin pressures unrelenting; shipping cells, rather than full PV panels, shaves costs. There's a huge commoditization across PV upstream ('just get good panels, least cost') with module pricing ~80% from 2012. Module capacity may be up 60% from 210 GW 2019, to say 340 GW 2022. Downstream, sales of eg more efficient premium IBC (back contact), & P series helps hurdle thin margins. Fall 2021 module prices near $0.20/watt were up, unusually +16% YtD, +17 y/y, but spike seems to be subsiding. It will be interesting to see how their two performances' unfold. For as a 'new' premium solar panel maker - the the other one handling just solar sales & installs.

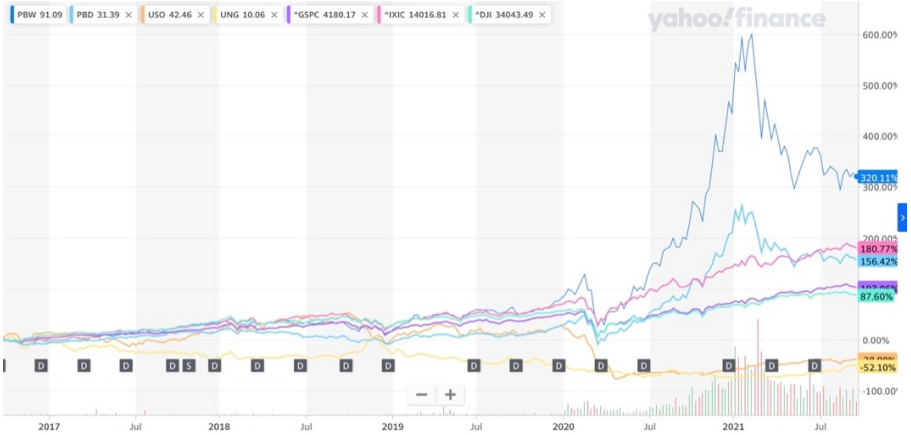
Hence a roller-coaster 2020/2021 proved exhausting & thrilling. Stock chart remarkable, nothing like it, and there's now 100 pages in an ECO Report. Overshadowing 2020/ 2021 was pandemic. Job losses jumped in a Great Lockdown. Many markets cratered 2020 – they may do so again ahead. Oil imploded to places not seen in 100 years, then bounced up hard 2021. Attention paid in 2019 to climate and clean energy solutions –initially derailed by pandemic – has again resurged from 2021 especially in light of new and ongoing weather extremes.

Moving on, let's consider a longer past 5 years. Fossil fuels stand out here for long declines, then up hard 2021 in a 5-year chart. Until a few years ago, for most past 5-years periods, ECO was generally down. Breaking that end of 2019, ECO left a long spell negative in most past 5 year timeframes. Suddenly, sharply, clean energy was past 5 years up, positive, returning +50%. End 2020 even more striking divergence. Clean was then up +300% as green themes went strongly upwards – even as dirty themes went down by -30% to -70% or worse.

Given 2016 declines, the last 5 years by mathematical coincidence could improve – even if ECO ended 2021 as flat-ish for 2021. If ECO/NEX had happened to gain a bit Q4 2021, then a past 5 years chart could rise more. That's a mathematical fluke without much significance; just please do be aware of it. 5 years captures a small sliver of time. Corrections happen, trees don't grow to the sky. And clean energy's theme, once long *down* for most past 5 years charts in prior Reports during 2010s, has shifted. A once more monolithic early 2010s with 'All of energy far down' (clean too) - lately has been changing in early 2020s, by a lot.

Striking in the 5-year Chart below, clean ECO/NEX leaves a down 2014-2016. It also reflects positive up years 2017, 2019/2020 – then down 2021. Gains in ECO, NEX, OCEAN were big in absolute ways – plus relative to major Indexes too. With clean ECO up +300% below, it left dirty fuels/and major Indexes 'in the dust'. Past 5 years to September, ECO tracker is strongest of all stories, up over +300%; 2nd is global new energy NEX up +160%. Performances by 'bogey' NASDAQ comparable as a bit better +185%; while Dow and S&P500 each are up about +100%. Normally, anything up +100% over 5 years is a 'Win'. So in an absolute sense, yes: all 3 bogeys did well. Just relative to clean, decarbonizing themes of ECO/NEX/OCEAN, did the two major Dow and S&P500 flail – only the NASDAQ is near top. Far at bottom, the two oil and natural gas themes, are each far *down* dropping some -50%!

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



Source: finance.yahoo.com

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

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

Next page past 10 years rolling, is here positive for clean. Until recently clean energy story for a last 10 years had been 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. Those were nearly final legs of steep plunge in renewables. So including any bit of those years, had bent performance downwards. Clean relatively outperformed vs. dirty at times. Still - clean also plunged back then too. This fact warrants attention. Thus seen next is a rolling chart for the rough past 10 years, Sept. 2011 - to Sept 2021.

Past 10 years the *global* NEX is up most by +160%, while ECO is up 2nd best by +120%. This period leaves a Great Recession that had thunderously dropped all in 2008-2012. That had put in bottoms for so many *non-energy* stories, many of those moving very well up afterwards. But not so energy which got hit harder, stayed down longer. Seen especially in dirty themes, much in energy went on falling farther in 2010s, with no immediate rebounding up.

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

Source: yahoofinance.com

That 2010s decade was rough too for clean energy – 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. A global NEX tracker 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. It accelerated solar & wind installations; it also meant lots of (over)supply and crushed solar/wind margins.

Solar moved somewhat past that overcapacity & commoditization, thin margins. Globally, *the* NEX is positive +160% for last 10 years as noted. ECO positive too for 10 years. Then, next is a large gap before a separate global clean energy Index (not ours) telling a far more concentrated story then; it's up but only +75%. An active-managed alternative energy fund is up +60%. Just below that an excellent, focused solar-story here is up +55%. Meanwhile oil & gas are plumbing depths, very far down some -80% to -90%. A tale of two cities: Big Declines across Dirty energy – vs Clean being all Well-Up varied degrees. That was trending some time. Until 2021's gains in oil & gas, that *might possibly* begin to create a new narrative.

Perhaps ahead in this decade, solar + electric cars increasingly converge. We wrote about that 10 years ago in '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 is Global NEX, then ECO. They 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 trailed broad Indexes not seen here like S&P500. On other hand, clean ECO & NEX clearly did 'best' here last 10 years vs. energy stories. As time rolls past earlier tough years, then green Indexes like this global NEX *could* begin telling a new story. As seen next in how NEX captures global new energy, theme definition is no backroom matter; it's very consequential.

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

Let's consider key differences as between our Global NEX with trackers in US and now Europe – vs. a differing, younger, global clean energy Index also with trackers in US and in Europe. That other global Index has several characteristics that usefully set it well apart from NEX. One had been, that the other Index was maybe a better choice if one sought a highly concentrated basket of big caps only, excluding much exposure to energy storage, electric vehicles, fuel cells, H_2 and more. Because that other basket was so highly concentrated, it differed from NEX which always reflected global clean energy diversely across solar, wind, EVs, energy storage, hydrogen, decarbonization etc. There's been more contrasts, too.

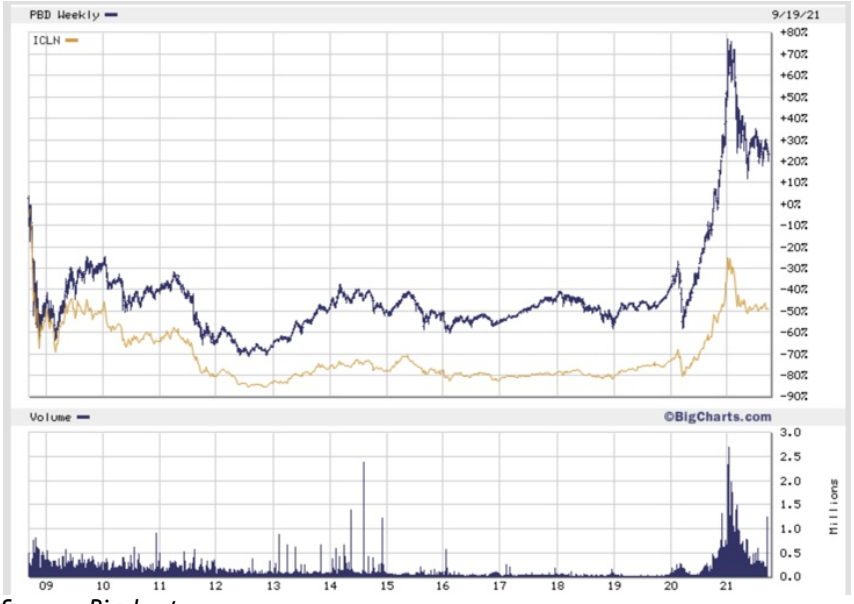
NEX is steeped in innovation, so it's unlike old classifications in a CIGS (Global Industry Classification Systems) nomenclature from 1999. One result was that the other global basket had long fallen much more heavily into what CIGS calls "Utilities". To underscore, if one had aimed for only narrow concentration, of just a few biggest names, fewer themes /countries, and little energy storage/EVs – then that other basket was maybe a better choice.

Consider too their Biggest divergence: Performance. Brief periods, NEX vs. other Index traded leadership back & forth a bit. On shorter-time-horizons, one Index might lag the other, or the other lead for brief periods. So briefer time frames, only, it was mostly a wash.

But for most all longer periods, a key fact stands out: **Global NEX (seen in bold)** has well Outperformed that other separate Index also for global clean energy **(in brown).** This stands for most all lengthy periods: Year to Date, past 1, 5, 10, 12+ years, since inception etc.

Here's a Chart 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 performances are for the two Indexes/ tracker funds. *In sum **global NEX tracker (bold)** has clearly shown much better performance capturing the global clean energy story worldwide:*

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



Source: Bigcharts.com

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

* Heavily Restricted to only bigger-caps – with far fewer themes and stocks;
* Very concentrated too in its top 30 names total (now is more post Q1 2021);
* Heavily skewed by using a modified-market capitalization style along and a cap;
* Unable to hold many stories – e.g. missed storage, EVs, alt. fuels, efficiency, grid;
* Less Diversified across clean stories and nations – relatively fewer themes represented.

Nothing was wrong with that other, *per se*. Also, it meant a good contrast between 2 clean energy Indexes. For other differences between global NEX – vs. other global energy basket, the NEX launched/went live first in early 2006 – well before that other Index. At start of Q2 2021, NEX had 125 components. That other global basket instead for years since its inception had held just 30 components, until 2021: arguably just 30 meant less clean energy scope. It isn't possible to so 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 reach upwards to nearly half (or more) of its total Index weight! In truth global clean energy is far more than only 10 dominating names. So concentrating that way meant a big few might push it up if momentum narrowly did well - or might pull that down.

As seen in performances last 1 year, 5 years, 10 years, since inception, etc, while that other Index has differed at times, and traded leadership back & forth - over most all longer periods, the NEX is doing significantly better. NEX equal weights had a much greater 125 names (and may grow) in Q4 2021, for far wider reach. And helpfully equal weighted style lets more & smaller names be included and heard: each has a voice. Given such a big difference in performance, it seems equal weighting *may be* allow passive NEX (& tracker) to better capture more - especially smaller and mid cap stocks, inherently purer plays. *Please note, Neither one approach is 'right': they're simply differing methodologies.* Varied ways for clean energy stories to be captured. One more concentrated and biased to big – one wider-ranging.

Both have trackers now in US & Europe. That other basket as a practical matter has moderately lower expense ratio trackers (although swamped by performance difference). And heavily-traded funds helpfully means liquidity. Overall, its 2 takes on this fast growing theme. An Equal weighted NEX - vs. Market cap other that skews to Top few. Perhaps it is quite useful real world ways in having 2 such differing baskets, options for this fast-emerging story.

That other Index however has faced vexed issues given how it was designed/constituted. One (arguably) was very excessive concentration. Another, its tracker had faced liquidity risks, given that design. As increasing sums flowed in, only a few names in tracker/s can overwhelm shares in even mid-cap stocks. That in turn may *distort the share price, and also *take inordinate number of days for tracker to 'fill' given such far above average volumes.

After conducting a useful public consultation in April 2021, the other Index made numerous understandable changes: Q2 2021 and forward. After long set 30 components, it was adding 52 more – and could go usefully towards 100, total unlimited. (With new unlimited ceiling it was again growing more like NEX which makes sense as this new energy story may grow ahead. This allows that other Index to also better reflect what's happening over time).

Among additions, however there could be & lately are *Non-Pure-plays* outside of global clean energy. Notably that may help reduce volatility & liquidity risk - *But…* it *may* also mean less closely adhering to essential global clean energy theme. Becoming instead 'mainly' a global clean energy basket, perhaps *less pure*, is a big new difference between other Index in 2021 at <100 – vs. NEX. That other Index before had arguably held closer to a clean energy theme. Generally for example, before it had little fossil fuel exposure, say in natural gas.

But this change meant it now holds/and could hold non-pure names. Just 2 examples are that other Index added a big natural gas utility that's not as clean – one that could Not be in NEX. Besides its natural gas generation & sales, plus with 3rd parties, that utility is in nuclear power – which is excluded from NEX (and that nuclear is being shuttered by California).

Second, it also added another electric utility, again ineligible for clean energy NEX. That 2nd name still generates much electricity from burning oil, even diesel (among last few Utilities in US to do so). In 2020 only about ~35% of that utility's power came from renewables. Even though it's based in a region blessed with abundant free sun & wind resources.

For those interested in such technical aspects of global clean energy Indexing, we'll take a brief look here next at such matters, plus ESG. Or for folks who eyes glaze at the thought, we'd suggest please skipping to section ahead – for Rolling Charts vs. Fixed charts.

In a technical matter, some years back as small caps grew more popular, big inflows made it harder for active fund managers to hold smaller equities, say <$500 million, or even <$1 billion(!) market cap. There was liquidity risk from inflows. What is 'small cap' inched up, maybe to >$5 billion market cap or more(!) to accommodate sudden growth. Some definitions of the theme got thinned out or were diluted out of target concept – no longer pure.

A ramification of fast-rising popularity was it got harder to hold small caps, as inflows grew. Whether in active managed Funds – or passive Indexes. Consider now, newer ESG thinking; green goals seeing tremendous interest lately. There's been an upswing of activity, of interest, 'net creations' especially in ETFs with focus on ESG themes. Interest grew to near one-quarter net creations in equity ETFs 2020, went higher 2021. Much interest in ESG likely is aimed at purported *clean energy* - so one may assume – the true non-fossil names.

One result is that as investors 'open up and see ESG holdings', what's in ESG funds, they may be very surprised by what's inside the baskets. Confoundingly, many ESG funds today may even hold some oil & gas companies, perhaps even coal-related names(!). That can & should be addressed: for greater understanding of ESG arguably ought prohibit such inclusion.

In a rush to ESG, clean energy may receive new attention and arguably a priority should be on staying in green/clean. Not being pushed out into brown energy. Otherwise, a consequence of addressing volatility or liquidity risk via huge stocks, may be prior focus on desired targets (say true green, zero-carbon clean energy) may get pushed somewhat off-theme.

How in the world can oil & gas be included in an ESG basket? Make claims to be green, or ESG leaders? One rather unfortunate way is via a 'carbon-intensity' metric. That allows a big fossil fuel producer say with revenues of 70% from oil & 30% from natural gas – to massively just ramp its gas production so it becomes say, 60% natural gas, 30% oil, 10% biofuels – and then claim it's 'clean'! Because CH_4 /natural gas spews relatively somewhat less CO_2 - vs. oil or vs. coal – then as per unit of revenue - it misleadingly might claim a new green hue.

Nothing of the sort is true. But 'carbon-intensity' lends false numeracy. Greenwash. And a seeming quantitative rigor - when it's the opposite. Left side of equation is correct: carbon footprint measured in tons of CO_2 - Scope 1, 2, 3. But right side of equation, 'intensity' grafts on 'value' in Dollars, Renminbi, Euros. The air cares not a whit how profitably a CO_2 molecule was made. More *profitably*, or less so. Yet an upshot is the fossils are given a pass.

What 'carbon intensity' can do is lend fossils a fig leaf. Seems quantitative, lets very polluting firms claim a green mantle in transitioning from oil or coal – to more natural gas. On clever marketing, fossil producers may even join a few 'clean' baskets – even in ESG. Using other-conceived notions of profits, revenue per ton/CO_2, makes 'intensity' slippery.

Perniciously subtle. Consider a startup solar firm with tiny CO_2 emissions, negative revenues; it won't score well for carbon intensity with few sales. By contrast, a big fossil fuels producer that massively increasing fossil gas sales, gobs of revenues, scores well. That CO_2 is eclipsed by swelling profits, providing better CO_2 'intensity'. Something's wrong with that picture.

As to how a green fund or passive Index performs, let's return to Weighting Methodologies. Interestingly we've seen Equal-weighted NEX outperformed YTD the last 1, 5, 10, 12+ years – vs. that Market cap weighted other Index. Smaller pure plays in NEX is inherently purer, with room to grow> for how that may be relevant to outperformance; consider a Chart below.

The much better results seen here in equal-weighted NEX concurs with the literature. *The Economist* in 2021 wrote about their own clean energy Index portfolio modeling. They constructed a Green Index seen at right: when Equal-weighted it nicely doubled going up fast from 100 in 2020 to over 200 and so up over +100% … vs a market cap weighted version that instead went up by less, from 100 to 150 or +50%. In 'Climate Finance: The Green Meme' (May 22, 2021) they report that:

Source: The Economist (2021)

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

Describing how inflows 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: it's surprising and dismaying to find 'brown' fossil fuel names in ESG funds. Likewise in clean energy funds at all.

For a small note, volatility here isn't particularly due to *Global* aspect of this theme. Consider *global* NEX vs *US-listings only* in ECO. These 2 have longest track records in the industry (15+ years, 13+ years) - so put aside a moment that other, separate, global clean energy Index. Glancing at NEX/ECO, a few thoughts come to mind on their sizable moves. One, is that US-listings-only ECO *may* be more volatile. Head-to-head, day to day eg first 6 weeks of 2021, NEX tracker had sizably 14 days of 3% or more change/day to March 15. Yet a tracker for US listings-only ECO had even more: 24 days with 3%+ change/day. So NEX may have had some leveling due to many more nations, more stories, more components.

Hence *global,* by itself, doesn't confer volatility. But new or clean energy, or innovation might somewhat. NEX has eg risky names in H_2 & fuel cells – like other clean energy baskets. Europe is faster greening its industry and *may* seek to move towards H_2. Continental Europe lacks gas reserves (it's no Texas) so imports gas from uncertain suppliers. It may seek green H_2 on climate too. Says nothing about how equities may perform (maybe down like 2021, maybe up like 2020): it just reflects maybe interest in greening of late. These 2 themes nonetheless remain very risky, volatile, uncertain: both clean - and global new energy innovation.

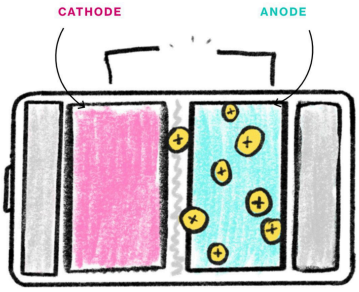
In 2021 the International Renewable Energy Agency (IRENA) reported a startling $131 *Trillion* may be needed for clean energy by 2050 to avoid heating >1.5 degrees C. In that case, coal/oil use *may* drop fast in Europe, gas *could* peak 2025; global electrolyzer capacity *may* go from puny 0.3 GW – to 5,000 GW. Green H_2 may be feedstock for 'green ammonia' (or for methanol CH_3OH, - but neither methanol nor ammonia is green if made from fossil gas, like now, that is greenwashing). Europe, potentially, *might* become a world leader. China may ramp up new nuclear power – while regrettably only slowly reducing (if at all) its coal use to 2025.

Great uncertainty about all the above, helps give rise to huge volatility and great risk here. Moving on, particular areas in clean/new energy are seeing intense activity. Technological advances, mainly incremental, may also possibly see some disruptive jumps. Energy storage and batteries plainly is in focus – ECO & NEX have had evolving components here past 15+ years. Other baskets are, or may be coming to storage as well. (It seems possible that other longstanding Index for global clean energy may conceivably add Energy Storage names ahead; that could make it easier too to increase components to over 100+ for purer plays, be more consistent with a clean energy theme and help better reflect the story; more pure plays may be a way to also help address liquidity risk and volatility).

As for storage: the world arguably needs far more, better & cheaper – 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 nicely-visual piece, we post several good illustrations below.

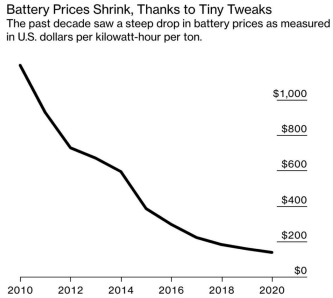
First off, the 'lithium ion' type includes a constellation of batteries; all may need materials besides lithium, like Iron, Nickel, and Manganese. There's considerable effort now to use less - or no - cobalt. While differing chemistries each favor diverse characteristics, all basically consist of *Cathode, *Anode, *Separator, *Electrolyte. The anode is partly 'settled' for now as graphite & some silicon. At the cathode a few chemistries dominate; each for particular uses where certain strengths are favored. Traits to be balanced include cost, energy density, weight, calendar longevity, cycle life, fast charging ability, temperature range. Favoring one trait like better energy density, may come as a trade-off of reduced cycle life.

a) 4 basic battery parts:



Source: Bloomberg Businessweek

Battery prices are falling hard:

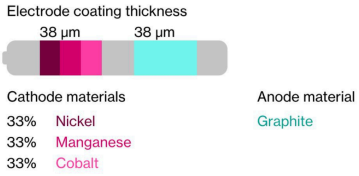


Source: Bloomberg Businessweek

b) Nickel Manganese Cobalt (NMC) in Zoe:

Source: Bloomberg Businessweek

NMC Composition in 2012:

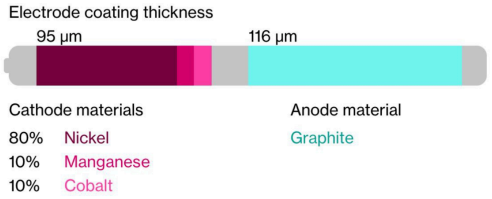


Source: Bloomberg Businessweek

c) NMC as seen more recently in a Nio:

Source: Bloomberg Businessweek

Much Nickel, little Cobalt = thicker:

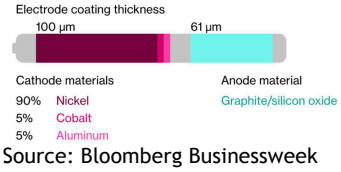


Source: Bloomberg Businessweek

d) Tesla 3 using a new NCA:

Source: Bloomberg Businessweek

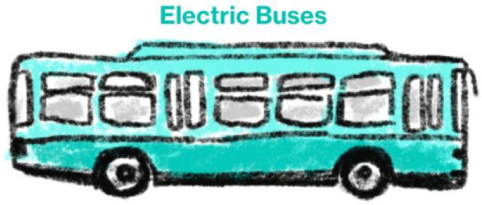
NCA, a light strong battery, no manganese:



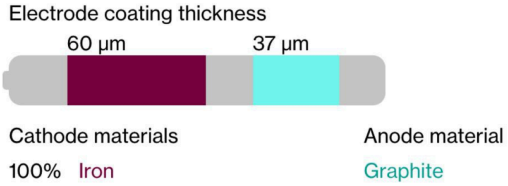
Source: Bloomberg Businessweek

Or, a use may favor cost, vs performance. LFP or an iron battery won't have high performance of say, an NCA cathode, but it's less costly. (We'd had an early electric bike here 2001 with LFP chemistry). Or, less cobalt, but more manganese. 2 iron LFP examples might be a bus with less range where weight's a non-issue – or in a price-conscious but fast EV sedan:

e) Electric Buses using LFP lower-cost iron:



Source: Bloomberg Businessweek

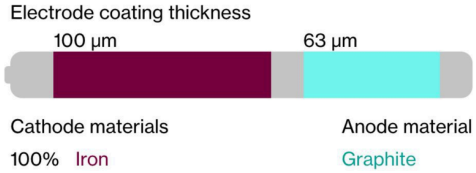


---

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

Source: Bloomberg Businessweek

Thicker Electrode, is less costly using iron:



Source: Bloomberg Businessweek

Efforts are ongoing like better cathodes, varied chemistries for particular uses like in cell phones vs. in ebikes vs. EVs etc. Depending on if say, energy density - or lower cost is most desired. It's certain cathodes will continue evolving, improvements ahead. For example nickel is costly & relatively scarce plus on a desire for using less cobalt, attention's being paid to improving energy densities via less-costly iron/phosphate (LFP) batteries. Or in spiffy NCA (nickel, cobalt aluminum) performance cells. A huge LFP supplier in China (where else?) is seeing new LFP competition, adding leverage for EV makers to consider options.

To add a bit of silicon, at anode without swelling, may show promise. Farther ahead exciting metallic lithium batteries could be – ought to be, very impressive. Fire risk though, was still untenable on 2021 state of the art; since 'dendrites' can penetrate the electrolyte. But newer-generation solid-state batteries in this decade are tantalizing. A drumbeat of wistful hopes, ever-on horizon goes on. Solid-state batteries ever-elusive *may* be getting closer. Possibly non-incremental bold advances like solid-state, can make one hopeful.

Recent research shows how self-healing hierarchical instabilities, *may* fortify separator at cathode/anode, ensuring no puncture. Liquid electrolytes, may then be replaced by a solid-state core for ultra-high current densities. On new 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, a standard was 80% capacity @500 cycles (at which point Li-ion battery is 'dead' for EV purposes). Thus early electric cars strove for 200-mile range, given 500 charge/discharge cycles, with a 200 miles range – added up acceptably to a 100,000 miles electric car battery. Afterwards it might have 2nd life uses like say stationary storage where less than 80% remaining is acceptable. So should 10,000 cycles or even well short of that in future solid-state batteries *possibly* enter production this decade, then it's like going from vacuum tubes (we recall building radios with in the '70s) – to solid-state transistors. Or leaping on to wondrous computer IC chips – where solid-state *might* be again game-changing.

Nearer term may make sense to shift from so much nickel, which is costly - to greater iron in batteries. Making batteries from an element like iron that's abundant, cheap & easy (unlike nickel), non-toxic and benign, is good strategy. Consider iron. Most abundant metal of all. Yet not found on Earth in a pure elemental state; in this sense the ore is like hydrogen (an energy carrier so reactive, latter is only found as in water, hydrocarbons, carbohydrates etc). Pure iron is thus only found newly arrived from outside our Planet, like meteorites. Once on Earth iron rapidly corrodes – rusts - from exposure to moisture/oxygen in air. 4th most common element in Earth's crust, very likely too our planet's far larger, enormous core, is mostly iron. So abundant in our solar system, one would hope to find it of good use in batteries.

Partly too since ubiquitous & benign here for billions of years, iron became essential since the earliest forms of life. It's vital for plants – making chlorophyll needed to survive. Animals depend on it too to carry oxygen via hemoglobin in bloodstream, making blood red.

Origins of iron are so fundamental, we're almost fated to see it on Earth in abundance. Stars like our Sun burn by fusion of lightest element, hydrogen – into 2nd lightest helium, releasing light/heat in reaction. Over billions of years of fusing, stars age, creating helium atoms which in turn fuse to be heavier carbon; then oxygen atoms, then silicon at core. For supergiant stars, iron becomes terminal element conclusion as stars age. A super stable atom, once iron is the star's core, it begins to die (giving life in turn after its death). For once it reaches a terminal iron core, no further energy can be released by fusion. More energy's required than is generated and it may go supernova. That enormous resulting explosion is what spews out immense amounts of iron, oxygen, carbon etc atoms to space. If and when gravity coalesces those elements to what may become planets, asteroids etc, the iron is easily found.

So iron is quite literally, everywhere! One sees it in a red-tint on Mars due to its iron. Iron is to thank for Earth's vital magnetic core. Molten iron creates the magnetic shield that protects most life on our planet from intense solar radiation that otherwise kills. Miners already are starting to look at making 'green' iron ore in steel, as a 'two-fer' when they can supply it for batteries too. On gigawatts of green electrolyzer capacity, with Europe & Asia leading.

So much is possible. Besides li-ion, an interesting idea may be iron-air batteries. They operate by discharging desired power as they take in oxygen, making rust. In turn they're charged using electricity to change rust back into metallic iron – releasing oxygen. Besides making use of a super-abundant mineral, they can also readily be recycled. Anyway, improving on the recyclability of lithium-ion batteries is an area too where so much progress is needed.

Or, of interest one day perhaps, zinc-ion batteries. Similarly using more abundant materials vs. li-ion that better resists degrading – perhaps without a traditional zinc anode.

Ideas like new batteries are technological advances. Very fundamentally, they differ from greenwash that only dresses up old carbon or fossils in spiffier-sounding ways. That greenwashing is something to comprehend, as it may perpetuate use of dirty fuels. Please be aware some such recent phrases may already mislead a bit. For example 'carbon intensity' isn't actually based around lowering absolute CO_2 - but instead is based around ideas of economics & profitability. A strongly scoring 'E Pillar' in an ESG rating does not correlate necessarily to lower-CO_2 emissions. Or a big oil & gas producer, may promise 'low emissions' but of its own operations (scope 1) and not scope 3 emissions, or regard better efficiency as a responsibility of buyers. 'Carbon credits', or 'offsets' may be used in ways that game more accurate, truer emissions reductions. Plus terms like 'net zero', 'sequestration' or 'offsets', coupled to distant-2050 promises, may divert from today's more-pressing goals. These are real decarbonization and movements towards zero-carbon over this decade.

Lest that disappoint, consider such gaslighting, greenwash or dissembling is oft the last gasps of a dying industry. Fossil interests many times now sees the writing on the walls. Solar & Wind, like Electric Vehicles, arguably already are seen as having won on superior technology. This decade will be filling in the blanks. Mid-term, natural gas faces stiffening competition from batteries & storage enabling firm power ahead. Longer-term, riskier and just maybe, green H_2 *might* be a viable clean heat in buildings, and industry. It's important as each of the 3 Indexes is a basket to capture this dynamic fast-evolving theme. Both looking back since early 2000s – and ahead to innovations in the decades that are yet to come. Let's briefly return to Index Charts, for one small final point of elucidation there.

A last small point on Charts. A little problem with **rolling** Charts past 1, 5, 10 years etc, is that in a few years they *may* show very strong returns ahead for ECO & NEX. Once charts leave huge falls in 2008-2012 and tough past energy times 2014-2016, then relative drops removed both ECO/NEX *may* show far greater relative gains. For that reason, a view is needed too with ECO's huge declines of 2008/2009 preserved: hence this Chart below. From a fixed (not rolling) 2008, it looks onward. Longer-running ECO + tracker might have begun 2005, yet other trackers didn't commence until later – so earliest feasible start was mid-2008.

Over now 13+ years & growing, this *non-rolling* chart shows Very Big declines. Unsurprisingly, fossil fuels again lag green, sizably. But, relative to a rolling 10 years that was quite positive - a vibrant difference is the global crash 2009 has been highlighted, forever preserved. What energy may do ahead, in 2020s, will doubtless be of interest as years scroll forward.

Still farther back, we just note an ECO predecessor, the WilderHill Hydrogen Fuel Cell Index had calculated 1999-2007. Given this ECO chart below picks up 2008, we uniquely have been capturing hydrogen & fuel cells for over 20 years now, since 1999! For H_2 FCs, one could visit our 20+ year-old 'predecessor site', at Hydrogen Fuel Institute, http://h2fuelcells.org

This chart below preserves as in amber, big 2008+ drops in energy after rising early-2000s. From 2008, as some trackers were just commencing at near peaks, all soon plunged. That 2008/2009 crisis hit countless themes globally. A bog & deep mire afterwards stretched across clean and dirty energy, for years, brightly preserved below forever.

Starting from the bottom we see both fossil fuels oil and gas are down here some -95%. Next 'above' them is solar well off -70%. Then an independent, other global clean energy basket off -60%; that theme which fell hard and long had just 30 components differs greatly vs. NEX. An actively managed alternative energy mutual fund is down -55%. 'Well above' those, steeply rising yet still down by -28% after dramatic falls 2008, is ECO. Clearly 'highest' energy basket here is global NEX though near nil, -2%. Broad major Indexes outside energy (not seen here) did *far* 'better' – yet they differ sizably as energy is a sliver there. Plus 2017-2020, clean energy has shown quite upwards volatility too, which *may* yet change things ahead:

Roughly Last 13+ Years starting from a Fixed June 1, 2008 to Sept. 2021:

Source: yahoofinance.com

In side note, a clean energy plummet early 2020 had left only 1 ECO component positive at bottom, March 18, 2020. That inflection point was a bit memorable: ECO had opened at 51.88, fell to intra-day low 45.85, closed at 47.37. This basket thus dropped by ½ early 2020, down from its 93.65 high intraday Feb. 20 closing at 92.53. In just weeks, ECO plummeted -50%! World markets were crashing then too global amidst fears about 2nd Depression like unemployment. All seemed on brink that moment. Lest we over-emphasize negatives, in spotlighting falls like Q1 2021, or in those long ago prior decades - there's also sharp rises here at times too, like in 2003-2006. Or more recently say, 2017-2020. For example ECO components jumped over 3 days in 2020, up from a March 24th nadir in sharp +25% rebound. Volatility from those lows had then pushed ECO upwards some +15% in hours.

Closing <50 on March 23, 2020 at 48.75 on fears of 25% unemployment & Depression, it went up to 55.87 on March 24. It closed at 55.74 on hopes of $2 Trillion stimulus. Focused green support wasn't expected in a new stimulus back in 2020; and as expected help didn't come – for it was opposed politically. Yet clean energy was fast growing cost-competitive - even *without any* subsidies ahead (unlike fossil fuels and nuclear, that need continued support).

So gains *may* happen at times in volatile clean energy theme. Maybe alongside broad markets, perhaps on greater volatility. Consider say April 6th to 10th of 2020. In 1 week an S&P 500 & Dow rose +12%, the biggest 1-week S&P gain since 1974, and the 7th largest for Dow. While both ECO & NEX can at times plummet; here they rose for an even more volatile week upside: ECO rose +19%, while volatile NEX gained over +12%. Broadly they were rising themes.

Compared to market cap weighted Index, just one name in ECO/NEX won't have so great an impact. Recall for a moment that other, cap-weighted global clean energy Index: there just 1 fuel cell component had risen to be some 10% of it in Q1. When that 1 sharply fell in March, it pulled that other Index down by a sizable amount. Not by so much in NEX/ECO.

Hydrogen fuel cells have for 2 decades shown extreme volatility. They can fall fast – or rise, no doubt. Whether green H_2 can be made at scale is uncertain, breakthroughs are needed in cost-reduction, production, storage and more. Meanwhile for fuel cells to make electricity from green H_2 would need breakthroughs to be cost-competitive, durable. Green hydrogen and fuel cells are really leveraged by 'hope' now; they were not yet on the cusp in 2021.

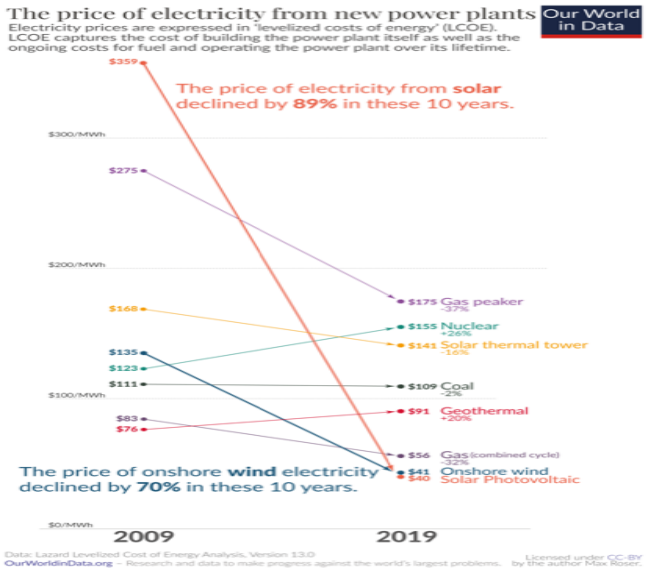
Solar & wind, EVs are different. They are more likely to grow, vs. a far less certain green H_2. That said, there's now growing H_2 interest. Also in much easier to transport 'green ammonia' (H_2+nitrogen), even methanol later. H_2 like energy currency - though watch for greenwashing. Where super-hot temperatures are needed as in making steel, cement, aluminum - clean made electrons from solar PV/wind can't normally accomplish that. But by adding a step, it could. On electrolysis by cheap green electrons, green H_2 from water (H_2O) – can burn for high temperatures. One firm is looking at >90% efficient electrolysis, no membrane needed, <$1/kg! 'Green' ammonia, or methanol (not blue/nor from rock gas) as energy carriers.

Applications will immediately show themselves if green hydrogen can come under $1. Making sponge-iron for steel produces 7% of carbon dioxide emissions globally. It's 10% of CO_2 emitted by Sweden. A green H_2 test there aims instead to make only 25 kilograms CO_2/metric ton steel – vs. 1.6 tons today. Affordable green hydrogen ideals so long talked about for decades, could just possibly advance H_2 & fuel cells. Or use of abundant wind/hydro power, say in Northern Norway in order to make batteries and more, could likewise help Decarbonize.

Yet a flip side of America's starting from zilch in 2010 - is where we stand on renewables now, is *Awful*. 2021 US offshore wind capacity 'should already' have been in hundreds of GWs; instead, it was non-existent. (The US had total 7 offshore wind turbines in 2021, Europe had 5,400). Solar in 2021 was making only 3.4% & wind 8.1% of America's electricity. In a year solar & wind *could* have been meeting 100% of US electricity demand. Instead, electric 'fuel' for US cars, trucks, ships, planes was a tiny rounding error in 2021. So it may feel we've come a ways – *but only given how pathetically we began*. The World Economic Forum observed in 'Our World in Data' (OWiD) that fossil fuels made 79% of energy production worldwide 2019. Unsurprisingly that's long been due to their being cheapest option. Low-cost had meant all – as well as that they were uniquely alone as firm power. But not much longer.

Solar is forecast to wallop dirty on cost, with its price plummet of 89% in 10 years to 2020. Costs in solar, like wind & storage, had dropped hard to 2020. Coal, oil, gas, suddenly by contrast were becoming relatively-costlier – fossils must pay for fuel. Fossils are thus always bound to be costly to operate, plus they must pollute, and are powerless to reduce their cost follies much further. Unsustainably, they've created 87% of the global emissions of CO_2. Estimates are that their air pollution alone caused 3.6 million deaths every year. That is 6-fold more than all the annual war deaths, terrorist attacks, and murders combined!!

This Report is focused on energy but it's a broad topic, including heat and other power. Coal is the most harmful energy source that still generated in 2020, 37% of our electricity and with it, the most CO2. Natural gas at 2nd, makes 24% of our power, while also generating overall much CO_2. Coal's costs were mainly flat last decade, while gas costs dropped sizably in the fracking era – yet gas costs shot up 2021. Still changes there have been dwarfed by renewables, solar costs down -89%, and wind where costs are down -70% as seen here:



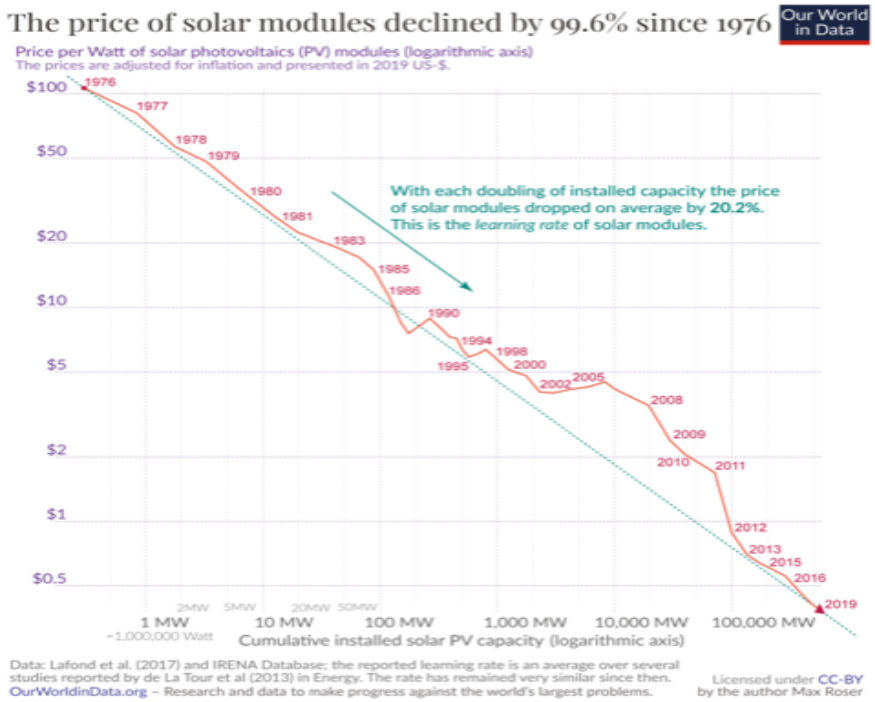
Source: Roser, Why Did Renewables Become So Cheap So Fast? Our World in Data (Dec. 2020).

So fossils & nuclear are poorly situated 2020s as ways to make electric power. Think about it: they're vexed by *unending fuel costs, & *by Wastes (nukes store for centuries, millennia after shut-down!). Their *High Operating Costs come with hundreds+ of employees; those costs won't decline. Every new non-standardized US nuclear plant costs yet *more* to build on the current 2022 technology(!) – an exact opposite of better solar/wind/batteries.

In a coal plant, fuel costs may eat up 40% of operating costs. For gas, fuel costs had earlier declined the 10 years to 2020; but not in a long-term trend, 2021 they went far higher.

Renewables solar & wind - instead enjoy *zero costs for fuel. Relatively-speaking *close 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, nuclear plants, can they hope to reduce costs significantly til extant plants age-out. Comparing like for like, new solar/ and wind are simply much more affordable on levelized costs/LCOE – so better than the rest.

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

So solar module/panel prices fell enormously -99.6% since 1976(!) on technology. If the White House repeals tariffs ahead and China (Vietnam etc) PV enters US freely, then it goes cheaper still. Fossils – by contrast - are Not all about technology and they may be doomed. Declines above in wind power too are impossible for dirty to try to catch. How can coal, oil, even gas hope to keep up for decades with this lovely curve? They can't, if economics is a metric. But fossils do have inertia, influence, capital, lobbying power and will deploy (more on it later). No doubt they will Not go gently into that good night. Still, it's no wonder solar & wind make up most of new power plants today. Now in a clean energy basket, storage grows significant. And just how an Index here is constructed – as we note – is very significant as well.

Meaningful are initial choices by an Index. They shape it. Early-on vision, impacts the later performance mightily. Even passive baskets are much shaped by the 'mind's eye' for a theme. Take a well-known 'FTSE 100'. Based in the UK, oft called 'Footsie', this Financial Times Stock Exchange Index is made up of 100 largest blue-chip firms on London Stock Exchange. Bit of prosperity gauge for UK's economy, it's also among the most widely used measures of how well the British stock market and firms domiciled there, are doing.

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

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

This (not great) return was No straight climb. As noted in MoneyWeek in 2021, it had peaked in 1999 earlier at 6,930. Later it passed that 2016, next peaking 2018 at 7,877. But Jan. 2021, it at 6,400 stood out as only +11% higher than where it had been some 15 years prior.

Much stronger growth was seen 1984 to 2005 when it had a much better return compound average growth of +12.5% (real terms +8.5%). But then 2005 through January 2021, annual growth rates became much slower. Only 2% ahead of an inflation that then was at +4.7%.

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

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

As a market cap weighted Index, it may auto-adjust for awful returns in CO_2 old school oil. As its once-big firms decline, lose Index prominence, it should allow faster-growing smaller firms to instead take up leadership positions. But a problem is the rest of that Index as remember, literally the 100 largest firms, have similarly been in slow areas like mining (8 names in 2021, but had been 12), retail, and tobacco. Thus not in innovation or technology. Therefore it's not been similar to an S&P500 (though it only recently added its 1st EV maker). And surely it is not at all similar to an Innovation-heavy US Index, like say popular Nasdaq 100.

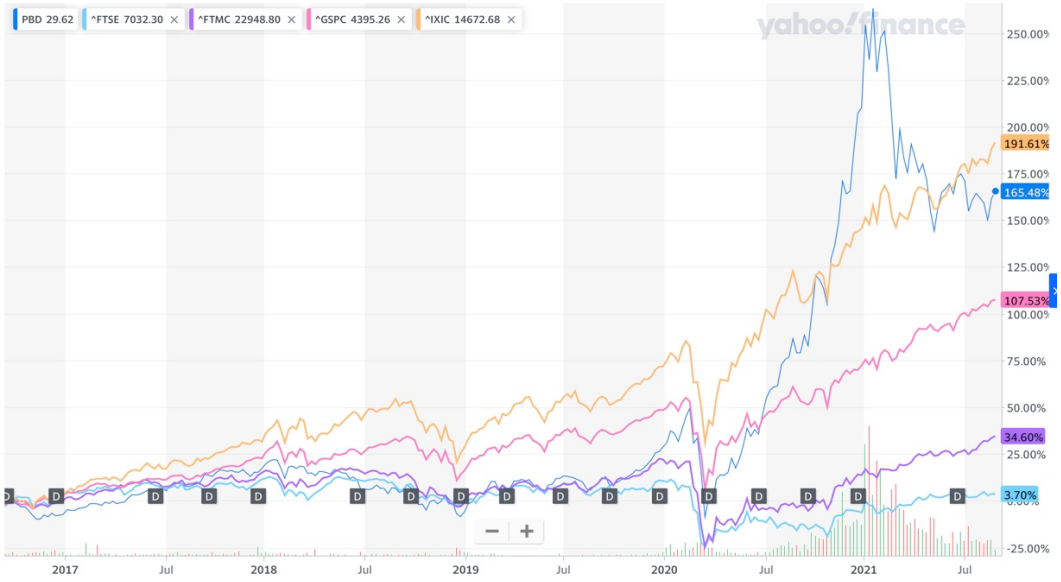
What's was in the FTSE 100 in 2021? Royal Dutch Shell was near top. Of 277 past components in FTSE 100, many have been retail like Boots (health & beauty retail), or old energy like BOC (now part of Linde). Banks, once UK giants in FTSE have faded. British American Tobacco and Imperial both tobacco –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

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

As pointed out, partly the FTSE 100's issue is an absence of organic growth in its components. Sage plc has enterprise software. Next plc has clothing retail, but much had entered top 100 by mergers & acquisitions – not a good long-term ramp for growth. Innovation tech Nasdaq 100, Nasdaq Composite - or an S&P500 are different. As noted in MoneyWeek, the S&P had had 19 technology stocks in 2005 – when FTSE 100 then had 1. In 2020 more tech names joined FTSE 100. Still by contrast, US Indexes reflected considerably more tech. Mid/smaller FTSE 250 enjoyed more momentum 2020/2021, more innovation-equities, than FTSE 100. In this 2021 chart below clearly the performance most at bottom past 5 years is FTSE 100, light blue. It was up relatively little, this 5 years period to September 2021, at a very puny +4%.

Next up, a mid-cap FTSE 250 in purple did sizably better, +35%. Tech-rich S&P500 in pink has doubled here, +110%. Tech innovation-heavy Nasdaq composite, gold is most up +192%; while **NEX in blue** is up +165%. To be sure innovation themes are very risky: at times they will drop very hard. Conservative = less risky. Yet recent periods tech & energy innovation had outperformed by far. So much so, one must be very wary of a bubble – and recall NEX - like risky very volatile ECO & OCEAN too - can and will at times surely 'drop like a rock':

Past 5 years to Sept. 2021; FTSE 100 bottom, **S&P500** middle, vs. NASDAQ & **NEX** at top:



Source:YahooFinance.com

In some ways the 250 is similar to 100 – other ways different. As the name implies it's the top 250 by market cap listed in London. From 1985 to Jan. 2021, it returned a more significant +8.5%, putting is well ahead of larger cap 100 (that was up, but by 3.6% less per year).

Of course, all identifiable in hindsight only. It's impossible to say beforehand, what Indexes like which companies, will do well ahead. Some factors may be additive, like an emphasis on smaller/innovation in recent years. (While big/more conservative maybe better down years). In the FTSE 100, large firms in old energy in 2021 made up 9%, and mining (materials) too were 13% - for all in 22%. By contrast in the US, those 2 stories make up just 5% of the market. In Europe they were 10%. In the US, technology made up 28%; and healthcare 14% of S&P500. In a Europe-wide Index (ex-UK) they too were 10% & 16%. By contrast they were just 1.3% & 10% in the UK. In sum rules and construction of an Index can be thought of as shaping a theme. They do matter. Next, let's look at possibilities ahead in a world fast changing.

Recent Past under Covid – & perhaps possibilities ahead:

Passage of that big Reconciliation bill in late 2021 or 2022 *may be* historic for clean energy. *Possibly* impactful across this decade. Consider our future: young voters rightly demand a far more sustainable, more equitable, clean zero-carbon future than what us 'oldies' had ever contemplated. Even if that bill fails, it's clear that youth are demanding a green future.

A glimpse of what may be sought post 2022 is seen in a 500 page Select House Committee on the Climate Crisis Report from Summer 2020 that's increasingly relevant today, https://climatecrisis.house.gov/sites/climatecrisis.house.gov/files/Climate%20Crisis%20Action%20Plan.pdf This is worth a look for voluminous changes contemplated. Not near all will be accomplished, and more aggressive goals may be dashed on rocks of reality (consider Manchin, Sinema). Yet any real steps begun early this decade towards decarbonization, would be a big change.

This Plan is no small beer. Far more ambitious & aggressive than was contemplated early in 2020. On new White House+Senate, this decade **may* be unlike anything in clean energy. "Transformative" is a big word - yet it *could* be, along with ambitious Europe & China. Yet, bear in mind if expectations get too ahead of reality – eg on unmoored *hype* like before in hydrogen fuel cells (called 'fool sells' by many), big drops grow more likely. Plus, expectations may yet shatter as greater changes like a national renewable energy standard, or carbon tax - require legislation & so Senate - home to compromise, inertia, realpolitik.

Consider as well, how little truly was done for US clean energy in 2020 to Q3 2021. Summer of 2020, federal pandemic aid for fossil fuel-heavy sectors reached $68 billion; much of that went to prop up airlines. By contrast $27 billion went to only slightly, green-related areas mainly well outside clean energy. (To be sure this may change ahead 2022 and after).

Direct fossil interests got $3 billion in forgivable small businesses loans back in 2020. Contrasts with little specific help for clean energy. Impossible to know if we're in calm before another pandemic wave. Still, solar in 2021 had clearly re-gained some of its momentum, Utility scale PV was up 43% in 2020 to 19 GW. Costs dropped 5%-8%, as many big installers re-reached pre-Covid expected levels. Early 2021 US residential solar grew by 25%-30% for 2021 YoY.

Back in early 2020, big offshore wind globally did especially well - despite Covid-19. In fact, first 6 months of that year were best yet recorded for offshore wind! First part of 2020 more investments went into new offshore wind, $35 billion, than all 2019. This had tripled the world's figure first half 2019. Major offshore wind array decisions in 2020 had included a new 1.5 GW Vattenfall project off The Netherlands and it was then largest to date at $3.9 billion; a 1.1 GW SSE Seagreen offshore farm in the U.K. for about $3.8 billion; a 600 MW Changfang Xidao project offshore Taiwan at $3.6 billion; and some 17 coming installations being financed by China such as the 600 MW Guandong Yudean that was expected to cost $1.8 billion.

Two big drivers had been huge declines in offshore wind costs – plus looming subsidy cliffs. Unlike solar, based so strongly in semiconductors (cramming ever more capacity into semi chips), wind is more about advances like in heavy fabrication. Ever-bigger blade designs. From 2012 to 2021 levelized offshore wind costs dropped 67%. Unlike onshore-wind that rubbed up against limited space, oceans are immense windy places for massive turbines far from view. Big wind farms have been providing desirable, reliable, returns on capital. Thus, renewables investments had risen in the 1st half 2020 to $132 billion, vs 1H 2019 at $125 billion. Much wind both onshore and offshore - was rather well growing in diverse places worldwide.

Even with Covid-19, 3 nations had experienced big renewables investments in part thanks to their offshore wind in 2020. China was up some +40% over 2019; France had tripled, and The Netherlands had gained 2.5 fold in 2020 - vs 1H 2020 in the prior year. Let's take a look at a particular offshore wind development 2021 that stood out. That 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 had 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. This is near £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 £83,000 MW/year paid by a joint venture of Total & Macquarie to another site. And it was way more than the £89,000 MW/year & £76,000 MW/year in the 2 bids 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, was paying high prices. In a sense its hand was forced: it has promised to go carbon neutral by 2050. But there's a cost to coming late. Its shareholders have earned higher-returns from older oil exploration & production. So, BP may feel some considerable pressure to earn something like those 8%-10% returns.

Problem is, BP paying so much at start makes it hard to reap higher returns later. Arguably 10% returns are a tough target anytime, especially aiming for no-risk. Too, oil & gas have shown poor returns for years. US behemoths too like ExxonMobil have shrunk considerably. Past-high times are hard to match, even on 2021's gains. A 23-year-old oil rig roughneck once could earn $100K+ working part year: but that bubble is largely gone. Hard to think of any new industry/jobs that match what fossil fuels once paid, and let workers stay same place their whole lives. Today in green energy a worker in wind, years of experience and training can make good salary around $80Ks/year. Geothermal with drilling, $80Ks. Solar with some years of experience in the $70Ks. Unionization rates have dipped everywhere, including some fossil fuels production. But areas like pipefitters, unionization rates relatively higher that come with sizably better Wages and Benefits – fossils had been hard for anything to beat.

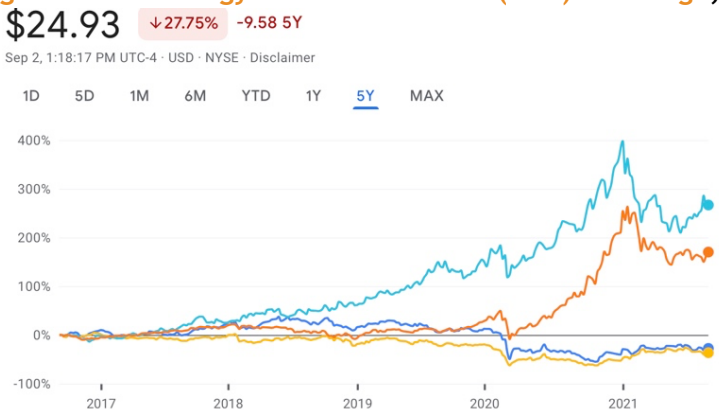
Wind farms once built, can offer investors stable returns that's attractive to capital. Still, this is a province of business venture where fortune favors the bold. Greatest returns in new energy innovation, likely to be enjoyed by first-mover risk-takers. Otherwise, lumbering fossil fuel giants like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

In sum a number of serious bidders lost to BP. Shell for instance offered nowhere close as much. Yet in offshore wind, Europe's supermajors BP, TotalEnergies, & Shell may at last be starting to genuinely transform into 'energy companies' (not mere greenwash) That puts them well ahead of US oil supermajors. A good example is Orsted of Denmark. It divested out of old oil & gas - to focus on true green energy. Leader Orsted, a more slowly-changing BP, Shell, or Total of Europe – all contrast sharply with America's Big Oil. US oil may yet cling to 'sequestrating carbon' and hopeful marketing – soldiering on in its fossil-centered business models. All those perhaps non-starters, as was reflected in market cap trends.

Consider 2020 Raymond James data on renewable/clean tech investments at large cap oil & gas firms. They show that of the 7 Big Oil firms committing to net-zero emissions 2040 to 2050 - fully 6 are based in Europe. For these top 7 in Big Oil, their name/country and the estimated % of capital expenditures on clean energy figures in 2020 were: Repsol, of Spain (at 26%), TotalEnergies, 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 and clean tech, might not be terribly inspiring. However, ExxonMobil in the US is spending much less: under 1%; same for Chevron. Big Oil hadn't even made net-zero pledges until 2018. Since 2021, the pace is quickening a bit. Partnerships, acquisitions, and activity by Big Oil Europe shows biofuels, biomass, wind, solar, H_2 leading. Plus, as one may expect, much on treatments of carbon & 'sequestration'. Shareholder actions is likely to be increasingly successful prioritizing climate action.

Backdrop following 2020 cuts by OPEC+, and then ratcheting back up of supply after some recovery in oil price 2021 - is Big Oil stock valuations mainly Declined past 5 years etc. That's important: perhaps the more that fossil behemoths as in the US greenwash & defy change, the more they *may* head long term towards becoming 'Not-Such-Large-Caps'. Those most wedded to highest-CO_2 models – might possibly (Ahem, no polite way of saying this) move towards Irrelevance some 30 years from now. Like coal, & steam before. Take for instance, 5 years to Sept. 2021. Here's is **BP in dark blue**, a Big Oil example, at bottom, down by -27%. Hardly different, also well negative is carbon-heavy **ExxonMobil, in gold**. In sharp contrast are Orsted in light teal, highest at +266% (once in oil & gas, but sold that & instead now is clean renewables like offshore wind). And then near it a tracker for decarbonization NEX in **global new energy innovation Index (NEX) in orange**, 2nd from top up some +170%:



Source: GoogleFinance

Denmark's Orsted is rather posterchild for a once oil & gas firm, transitioning truly to clean new energy – successfully so. And growing more profitable to boot! No half steps, nor dithering with 'sequestration' to prolong fossils. Orsted robustly, had launched into wind, solar, bioenergy. Benefits since shown in its fast rising market capitalization (above) - even as BP & Exxon lose. Results will be underscored in Scope 1, 2, 3 rankings, for emissions. Scope 1 means direct emissions by a company's operations. Scope 2 is indirect by say its power suppliers; those can be reduced even if a firm goes on selling fossil products. So Big Oil could thus stay in its dirty fossil lane, while reducing Scope 1 & 2. But, Scope 3 refers to customers' carbon footprint using their product/s. Hence only a green transition (like Orsted) to sustainable energy will satisfy this measure. Even if US Big Oil is determined to stay dirty energy. Perhaps on facile CO_2 accounting, and claimed 'offsets' pretending rock gas is 'clean' or 'renewable'. Or with dubious marketing claims – yet Scope 3 nonetheless grows ever-tougher.

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

Lessons learned by UK in ocean wind can assist the US. Infrastructure like undersea cables, facilitating offtake of power in first-place. In this and more, the US has badly trailed behind the UK in offshore wind policy. In 2021 there was just 10 GW in UK still ranking it as world-leader. The UK aims to quadruple that in this decade - to 40 GW offshore wind - enough to power much. Yet they can do much more. The US by contrast in 2021, had pathetically close to zero offshore wind despite a vast country, big oceans, and lengthy shorelines!

Data from a top-notch Bloomberg New Energy Finance, BNEF (our long-time prior NEX partner) - and US National Renewable Energy Lab in 2021 showed how badly America lagged Europe/ China in offshore wind. We all can use same big turbines – GE Haliade 12 MW, Siemens 14 MW, Vestas 15 MW, or 16 MW next from China - so consider a key obstacle is US regulations. All of America in 2021 had but 2 tiny offshore wind farms. One was a 30 MW site, so equivalent to just 2 great turbines! That can/should now change – but it's happening much too slowly.

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

Changing this like 'pig in a python' are projects bulging at near start. Projects in site control, or offtake stage increased +200% from a small base in 2018/2019. Early 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: 30 MW, or 0.1% of 28 GW planned in 2021 with tiny 12 MW in final approval. But … new 6 GW of coming US wind was advancing towards permit offtake, 22%. It's a big ocean; some 60% of that 28 GW pipeline or 17 GW was in lease/site control steps. There's several years to go yet in this decade - but it is at least some progress.

US states farthest along early in 2021 were in Site Control/Permitting were Massachusetts at 8 GW to come; New Jersey 4 GW perhaps ahead; New York 3 GW; North Carolina 3 GW; and Virginia 2 GW. Only one State had offshore wind at Construction in 2021; Virginia 12 MW energized. Overall, the US is 'progressing' far too slowly, many years to unfold.

Confoundingly, all but 2 of the 11 US States in wind pipeline 2021 were on the East Coast. Despite great Pacific Ocean wind resources! One might have guessed there'd already be tens of gigawatts including Texas/Louisiana coasts - yet only California & Hawaii had in 2021 any potential projects. A mere 1 GW in planning - with much needed like submerged cabling. That said, BNEF raised estimated US offshore wind projections +70%. From 11 GW by 2030 that was estimated in 2018 – to a 19 GW by 2030 then projected a year later in 2019. And growing.

For Indexes NEX, ECO, OCEAN there may be interesting changes soon in offshore wind technology relevant to all 3 themes. For the scope of change, consider a gaping hole/ offshore wind absence prior to 2019. Then, what *may* soon after come post-2021, in just 5 years 2021–2025. Much change *might be* seen, especially in the latter part of these new 5 years.

Up to 2019, global cumulative offshore wind capacity had reached 27 GW. But concentrated in a few places: UK, Germany, China, Denmark, Belgium, Netherlands. Moreover in 2019, just 5 nations had accounted for 99% of new installations. Fast-growing China then began to lead. It swiftly added nearly half (47%) of all the new global capacity in that one year 2019.

A decade before, UK's steady growth had built up most installed offshore wind: 8 GW. Germany started later and it grew faster. Then China recently has had sharpest ramp up. Lumping China, Europe & US as one: world pipeline for all estimated offshore wind 1990 to 2038 goes from 27 GW operating 2020 – fast up to 230 GW projected in 2038. China especially, goes from just 10 GW wind in construction 2019, to leading the globe in offshore wind.

More granularly it gets interesting from 2024 as the US may be a significant player in *floating* offshore wind. That opens immense tracts of available space. Offshore wind on the seabed is entirely still on America's East Coast; a trailing edge margin means shallow waters. Opening up deep US West Coast waters, thousands of feet deep would be a new ballgame.

Hence floating platforms, only tethered to a distant seafloor can be a game-changer for ocean wind. Here the US may actually hold its own, a significant change vs. Europe - and vs. Asia. In this new arena each one, Asia - US - & Europe - may be about 1/3rd of the floating pipeline. A 25 MW test Float Atlantic in Europe became operational in 2020 and proved the potential. It's very early days yet. But Asian leadership in floating wind isn't just in China, nor in Japan; it could include South Korea (1.7 GW) and Taiwan (1 GW) in pipeline. Also UK, France, Spain proposed much for Europe, each already has had operating floating test units in 2021.

A startling change may be America's 2.3 GW proposed pipeline. Castle Wind off California at 1 GW may float above 900 meters' depth. All 7 proposed US projects may use steel semi-submersible platforms, easiest of 3 main types of floating substructures. On shallow draft they might be built dockside, towed out without heavy lift install vessels. That design made up 89% of the substructures when a choice was made. And note 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 for a monopile wind affixed to seafloor for jackup depths >50 meters. Vessels considering America's Jones Act, & new port infrastructure must be built from scratch for growth of both fixed & floating wind.

Crucial to all in wind is pricing. Like solar it's falling – wind more modestly than solar – but is falling. And both renewables are growing very favorable - vs. costly current tech nukes, like dirty coal, oil & gas. Old energy is unable to compete with price declines of their own.

In Europe, levelized offshore wind costs were already down in 2021 from about 18 cents/kWh, to 9 cents. US offshore wind was 9 cents 2020. Mayflower Wind off Massachusetts one of the world's best-priced ocean wind projects, 6.9 cents; and US tax changes 2021 made it better. Floating wind, looks like it could fall to about 6 cents in coming years as well.

Once *offshore wind* gets a toe-hold, regulations are in place, then *floating* wind may have a far, far greater presence. America's 1st floating ocean wind project only began late in 2020. Meanwhile, China has begun already its much faster growth in its offshore wind. Of course, solar too is fast advancing there: China confounded expectations for slow solar 2020 due to Covid: instead, its solar manufacturing gained speed in pandemic. First half (1H) 2020, China had produced 59 GW of solar panels, that was about 15% greater than in 1H of 2019.

Europe had gains in solar & wind. In 2020 the EU made more power renewably – than from fossil fuels. Note nations there with **more* renewables in 2020 - enjoyed *cheaper* electricity prices – obliterating a 'higher cost' argument oft leveled against green. Critics ding renewables as 'suffering' from intermittency. Yet there was strong electricity supply all 2020 in Europe - unlike big power interruptions in California, & Texas. That said late 2021 & 2022 look dicey for Europe with possible blackouts – though there on mainly natural gas issues.

But back in 2020 of the 27 EU members, wind, solar, hydro, bioenergy made 40% of electricity overall. Fossil fuels were 34%. In early 2020 renewables made up 44%. Austria then made 93% mainly using its hydro from renewables, Portugal made 67%, and Germany 54%.

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

So Wind & solar are growing – it's true. From just 13% of EU electricity 2016, to 22% 1H 2020. Yet from the more pressing perspective, there's a long, long way to go given CO_2. Greater renewables, more flexibility, ability to export excess power, transmission, batteries: all are Faster Needed! US is making much less progress. Renewables were just 18% US electricity generated 2019, fossils 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 its Retail power costs higher than in the US – but that's a differing matter.

In a surprise late 2020 the US House/Senate did extend 26% ITC tax credit by 2 years for solar & fuel cells; PTC of $0.15/kWh for wind 1 year. Yet hoped for 'in lieu' cash from Treasury didn't materialize. Batteries alone couldn't yet get credit unless bundled with solar. Nor was $7,500 credit re-extended for 2 EV makers. But the future looks modestly better. In 2020 consolidations continued and solar went 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 faster growth; those were 'grown-ups' moves in solar – a commodity business where low price is all. A long way from few, small solar listings possible for ECO and global NEX we well recall back in 2006, even 2010. Yet in 2021, very fast rising cost inflation across solar inputs – had meant projects were pushed off.

Facts reveal an energy landscape changing so fast, it challenges 'all we know' about energy. Clean energy is now bettering fossil fuel on price. Even more compellingly, clean energy soon – *Without Subsidies* – is *becoming more affordable than all fossil fuels & nuclear!!* Economics more than anything changes everything. And yet. Carbon awareness lags. Economics is vital and bringing change – but much too slowly. Coal, oil, nuclear will shrivel without their highly-needed subsidies – that it will be too late. Not our Grandparent's energy world.

Coal's price long hovered – as renewables (and natural gas) got far more affordable. Thus, did renewables (and natural gas) suddenly become leaders. Especially on a 2020 demand loss, when Utilities turned 1st to their lowest-cost sources. Those were renewables sun & wind - plus natural gas. Coal was left out. Gas is capable, flexible. Fracking meant fuel price collapse – although with big price spikes since in 2021. But fossils still lack prospects for sustainable many decades ahead – especially vs. the cleaner and decarbonizing themes today.

Just possibly, green thinking *may* flower. In key cases like never before. Consider say electric vehicles. Here, Carnot's Limit helps explain why new electric cars were destined to outdo traditional oil burning 'gassers'. Today's best gassers are inefficient, sadly archaic at their best. Their diesel or gasoline heat engines of cars or trucks only let them reach a theoretical best near 40% efficiency. More typical car heat engines are sadly just 20% efficient(!). Gigantic heavy SUVs anchored further by low-torque heat engines, are relegated as so slow, they suffer from often silly model differentiation like based on the quantity of cupholders.

Not-surprising, early 2020s will see an outpouring of fresh-faced electric vehicles globally. Equity markets had long under-appreciated what lithium-ion batteries lashed to efficient (>90%) and torquey AC motors could do. Next improving swiftly on better, cheaper batteries. Past 20 years non-linear enhancement. As a consequence, there's oft been volatility (up) – with strong non-correlation between EV equity pure plays - vs. the broader markets.

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

As we learned 100 years ago, from Mr. Einstein, and in later quantum work, 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 that time's arrow, 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 wave + particle as discrete quanta; we've learned to harness photons in solar panels ever better over 50+ years. On researching wavelengths, new solar panels may enjoy maximum efficiency ceilings even farther 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 a learning curve here profoundly pushing only-downwards on solar costs, often very rapidly.

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

In a metaphor, fossil fuels served us for centuries and we 'learned' within limits, constraints that we still accept today. Yet much we 'know' about energy is actually wrong. For instance we've long accepted that electricity generation – has to closely match demand. Given great costs of power plants, to avoid waste we'd never build something that's 'too big'.

Yet like Newtonian Physics, what's long been 'known' may mislead. Semiconductors at nano-scale, rockets into space, we've lately learned quantum strangeness, to make use of that. Smallest scales around us, space/time, gravity all differ from past Newtonian suppositions. Better, weirdly different Quantum theory so bizarre to us, has increasingly explained reality for greater new understanding – so that weirdness is being usefully-harnessed.

Essential now in cell phones, GPS, Lasers, MRI Imaging, LEDs; even ubiquitous computers rely on quantum effects not-heretofore known in prior centuries. Revolutionary ideas like superposition of objects in two or more states at same time. Einstein-Podoleky-Rosen paradox where 2 entangled particles though far distant from one another, may seem linked in real-time so appearing to share information - inconceivably faster than light! (Entanglement and Copenhagen interpretation solved that latter, thorny quantum puzzle). We've thus progressed as we learn. Space is no complete vacuum; virtual particles may briefly snap in & out of existence. Photons may act 4 possible ways, 2 actually observed, and 2 options cancelling each other out – wonderful Feynman Rules of probability weirdly, profoundly deterministic - in what is the Hong-Ou-Mandel effect. (If interested in more here, see e.g. the Quantum Centre at the UK University of Sheffield, https://www.youtube.com/watch?v=ld2r2IMt4vg).

A point being in (clean) energy too we're learning novelties, some of which at first seem strange. Novel ideas, that may be embraced ahead in modern energy technologies – given *this is how the world actually works*. A few sacred old ideas may be thrown out is progress! Jarring yes, but leverage for how we advance – including new energy innovation. Especially as we're moving (one hopes) ever-towards zero CO_2 and towards softer, more natural energy paths.

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

Yet intriguingly solar will be super-cheap. Electricity must be used immediately, when it's generated – so we've learned to avoid oversizing. But in a new world to possibly 'waste' some solar on overcapacity sunniest days, may obviate need for (costlier) storage. Nothing like an oversupply of dirty-brown electrons which carried all kinds of downsides. If clean abundant renewable electricity is there at no cost, then green H_2 & fuel cells (fool sells) once staggeringly 'foolish' 20 years ago, *might* just begin to make some sense.

Leaving academic musings aside, let's return to markets and decarbonizing. ECO/NEX/OCEAN all saw sharp equity gains 2020 - dirty oil, gas & coal flailed by comparison. Clean energy clearly 'beat' brown energy then. Next in a recent turn, fossil fuels did much better in 2021. And solar power, even with all its green credentials, like anything else may suffer unneeded, undesirable risks. We'll address a sad political risk next, one that's so unnecessary of late. This is a possibility of unneeded/unwanted forced labor within one unique region.

An issue lately come to light is allegations of forced labor in a Xinjiang Uighur Autonomous Region of desert in northwestern China. Of note here, Xinjiang as a major source for silicon in manufacturing solar panels: processed polysilicon is used in solar made worldwide, including in the US. 'Poly' prices plummeted over many years, to where it's become a cheap commodity. 3/4s of the 2021 global PV polysilicon supply came from China – and of that coming from China, fully >½ of it was coming in 2020 from that unique Xinjiang region.

There's in early 2021 no evidence that any forced labor is involved in silicon manufacturing. But, this matter is clearly grave enough to be looked at very carefully; it's extremely serious.

5 companies were lately noted by a consulting firm for having Xinjiang-region supplied content. A couple have US listed shares and they are widely found in many US and global Indexes – they also are in a great many active funds. One in early 2021 was in 135 mutual funds, the other in 165 mutual funds. Without doubt this issue warrants attention.

What's tough is there's no independent confirmation, one way or another. Solar companies themselves strongly deny any connection. Plus there's zero need for forced labor. In the US, the Solar Energy Industries Assn. was seeking 2021 to ensure no forced labor in any part of the solar chain. SEIA aims for a protocol to ensure zero raw materials onwards contain it.

Nonetheless one company named was downgraded 2021 to Neutral rating on that possibility; again no evidence, but without clarity, the US Congress or Executive will likely act given this gravity. 2 solar firms emphatically state they condemn forced labor, that 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 the US had not yet early 2021 'called out' the solar manufacturers in Xinjiang, clearly the notion of even-possible abusive labor rightly raises warning flags. That Report's source was right to point global attention here. Just the possibility of it, has to be of great concern.

Side-note separate issue: China mining Rare Earths was also raised by that source, elsewhere – but for far different reasons. (Besides too mining's myriad ecological challenges). Given a vital role that the Rare Earths will have across clean energy's spectrum in solar, wind, electric vehicles, batteries etc - another one of its reports looked at dominance of China in mining strategic rare Earths. Reliance here on China is placing the world at disadvantage.

The US imports over 80% of needed rare Earths from China, including for defense systems. That dominance could well provide China great tactical or strategic advantages and leverage, as clean new energy innovation gains steam. It also potentially greatly impacts the seas, crucial for the OCEAN theme. http://fullmeasure.news/news/shows/the-battle-below

In conclusion for Xinjiang a burden for solar, wind, quartz, textiles etc – may be to prove the Non-existence of forced labor. Clearly if evidence to contrary arises, that's enough to lead to changes in an Index. It's an unnecessary unwanted risk, to be watched closely with moral implications as well. It's possible all suppliers, all products from Xinjiang may face a burden to prove No forced labor. Some firms may relocate from that cheap coal powered region. Others, may move listings off US exchanges, to China Exchanges/Star. Likely: traceability services, 3rd party Independent Audit Verification, as there's no call for unacceptable practices to seep in supply chains. It's very different vs. cheap green (non-coal) power helping grow say, fast-industrializing, decarboning Northern Sweden, Northern Norway.

Moving on, let's see where PV poly solar supply pricing generally stood in 2021. We've cited at times reports as from Raymond James, Roth, Piper, etc. This time, we utilize a report from Roth Capital on: 'Sustainability, The Solar Snapshot: Some Perspective on Module Input Cost Inflation' (2021) – along with a 2nd Roth Report from March 2021.

They note rising solar demand & capacity constraints had pushed poly prices upwards 1H 2021. 2020 poly priced $10/kg or $11/kg. Poly went past RMB 100/kg in 2021 (1 Renminbi=$0.15 USD), RMB 150/kg or $21/kg ex-VAT. They'd seen risk of solar poly 150 RMB in 2021, and it hit that on high demand. Wafer suppliers do need to ensure supply so turn to longer term contracts. A major supplier was almost fully booked through 2022, demand heavy into 2023, 2024. Raising added capital via China (STAR) listing 2021, may add capacity 40, 80, 100 MT. On strong demand Tier 1 costs 2021 were near RMB 30-40/kg or $5-$6/kg, there was scope maybe for margin expansion. And growth might occur in eg Inner Mongolia & Yunnan; if prices rise quickly, that may draw in idled Tier 2 suppliers. Generally, 2021 saw rising demand for PV and inflation, pricier solar glass, silver, and freight too. In the US Utility scale solar pricing was at around 25-27 cents/watt; nearer to 29 cents/watt in the 2nd half 2021.

Solar's situation back >10 years ago had been so different! Then, pricing 2010 for *finished* modules was near $2+/watt. Costs have dropped so hard since. From $2/watt modules in 2010 - falling in 10 years to just 0.20/watt by 2021! Poly commonly is a key input in solar panels so costs are critical. Poly 2010 had cost some $55/kg, that spiked on shortage 2011 to $80/kg. But after that, it mainly dropped considerably lower. By early 2021 poly was down to around $11/kg - $21/kg in 1H 2021. So perhaps brief rises given demand spikes, but figure of ~$11/kg in 2020 became far less costly, allowing much cheaper solar in the 2020s.

Back when poly was costly, different materials and designs were tried to avoid its use. Plus over time poly supply located out to China's lowest-cost regions, co-locating with PV manufacturers. Increasingly PV became automated processes especially panel manufacturing. In future poly & solar makers may co-locate say to parts of Europe, North Africa, Middle East. On automated processes, a renewables-Middle East could export maybe Green Hydrogen, 'green ammonia', later methanol. PV made from super-abundant sunshine/sand. Making it again a leading energy exporter worldwide - not of oil – but of zero-CO_2 green power!

By 2021, much world poly supply was coming from Northwestern China. It wasn't always thus. Let's briefly look back, to excerpts from our 2005 WilderHill ECO Index Report detailing notable poly shortages then: https://wildershares.com/pdf/Quarterly%20Report.2005%20Q1Q2.pdf

> *Moving to solar, which is a major component of the WilderHill Clean Energy Index (ECO), there's some interesting news here. In the course of Q1/Q2 2005 (especially before, in Q4 2004) the market capitalization of Index component Evergreen Solar (ESLR) rose notably. Some general and technical factors may have contributed to this. One cause is their sales increased rather a lot, especially in Europe (ESLR sells 2/3 of its modules in Europe) - and Evergreen simply participated in this growth like other pure- play solar PV makers.*
>
> *A 2nd factor unique to Evergreen, is that its special string ribbon process makes laser-cut silicon wafers from Gemini II furnaces half thickness of competitors, under 150 micrometers. A result is only 1/3 as much silicon needed for their PV wafers processed to solar cells and panels. ESLR estimates they can produce 2x as many wafers/ton of silicon, as competitors.*

This is an issue in the solar industry globally now, because of shortages in the silicon that's needed to grow new facilities and production lines. Like when there's an absence of the tax credit for wind power, or when poor transmission capacity slows wind power growth, the lack of silicon has been an unneeded obstacle that's now hindering PV.

With ribbon capability and desiring to open a European facility, ESLR contemplated whether to build a factory there, or to find a partner in Germany. It chose the latter. In Q1/Q2 they announced a new joint venture with a large German solar PV maker Q-Cells AG. This potentially combines scaling-up skills, and module efficiencies (suited to high latitude sites) of Q-Cells, with more efficient silicon manufacturing of ESLR.

Interestingly for the Index, ESLR share price had already risen fast and reached such weight (6%) in a Quarter within ECO, there was some concern an inevitable regression to the mean and price correction at ESLR, may unduly impact the whole Index. However this highlights another facet to Indexing: all components must be left to reach their own level, without Index managers trying to guess an exact time to sell and so reduce position in that stock. Indeed rebalancing ECO each Quarter and a 4% cap helps prevent undue influence from any individual stock, which might otherwise reach double- digit weight in the Index. Ultimately, passive-management tends to perform well.

In our case, a different frustration felt in 2004 & 2005 was over an inability to include stocks listed outside the U.S., particularly German solar PV makers. Because ECO Index Rules require component stocks be listed on major U.S. markets (NYSE, AMEX, NASDAQ) and adequate volume, we were prevented from holding them a time German solar was thriving. For instance, Solar World AG is expanding wafer capacity from 120 MW to 150 MW. Solar-Fabrik AG went from 17 MW, to 40 MW of capacity. Alfasolar Gmbh was 4.5 MW in 2004 and aims to expand to 20 MW (if it gets silicon supply). Heckert Solar GmbH made 5 MW in 2004, and aims to grow to 2x that in 2005 (with enough silicon). Well-known Q-Cells grew from 48 MW of capacity in 2003, to 150 MW capacity 2004 (its production too was limited by silicon supply). Despite shortages, stock performance of European PV makers was remarkable 2004-2005.

*Silicon shortage *may* possibly mean some opportunity. One component, Energy Conversion Devices (ENER) makes thin-film solar PV modules made of amorphous silicon that allows more panels despite shortages faced by others (but overall profitability has been an issue); their subsidiary, United Solar Ovonics, seeks to expand capacity. As noted, ESLR is robustly growing; they're planning 40-50 MW more capacity with Q-Cells venture to perhaps start producing 2006. A Belgian company Photovoltech makes both regular cells and fascinating cells with backside-contacts only; this importantly allows high efficiencies (>17%) since contacts on the front of panels are absent. That permits more sunlight/photons to directly reach each cell. For 2006, they'd like to increase their PV manufacturing capacity to 75-85 MW.*

Silicon shortages now vexing PV makers may be rather short-lived, perhaps a few years. The PV industry normally buys surplus silicon from semi manufacturers: they produce roughly 30,000 tonnes/year. In 2004, however, 1/3 of supply went into producing a surprising 1 GW of solar PV. Tight markets weren't foreseen, by the few producers of high-purity-grade silicon. This situation is a bit ironic since silicon is widely on Earth, and surely can be remedied ….

That was long ago in 2005. At any rate, it was perhaps of interest to recall such poly/PV situation when the poly needed for solar, was just a small surplus of that for other purposes. When there was no concern for how green it was made, the sourcing, possible tariffs etc etc. Things are very different now. Let's look forward over various fronts coming 2020s next.

We avoid politics. So side-note is that zero hope had existed in 2020 for a US green energy stimulus. 180 lawmakers had sent a Letter to House Leadership asking for relief given 600,000 clean energy jobs were lost in pandemic. But a calculus then, for any direct green funding – even any far short of that being vetted in Europe – wasn't aligned 2020. Senate leaders were squarely opposed, plus it was a non-starter in a then White House too. But that - was then.

Musing on dynamics from 2021 onwards, backdrops are changing. Mainly it's incremental change. And yet. Trillions *might* be spent ahead globally on climate solutions, infrastructure improvements to grow more green. In the US large utility-scale solar for example, could grow to over >100 GW/year. US battery storage could fast grow by over >50 GW/year; in time approaching today's total installed electric generating capacity. And US is a laggard.

For start of 2022, new attention's being paid to a Europe/UK that have had slower GDP growth in past than the US. A past stolid approach to their own economies, is lately being reassessed. Yet 2 things seem certain short-term: One is: European/UK moves early away from coal & natural gas will mean energy crises there first half of this decade – but not due to renewables. The UK for example has shut down much of its gas storage capability, little is left. With very little gas stored, heating, cooling, and electricity there can & will get very costly.

Resulting spikes in gas costs, due to limited gas storage, are arguably more faults of gas – than of renewables. And those crises would happen had solar and wind power never existed. But renewables will surely be blamed – rather than the vagaries of gas markets. A draw-down of coal & gas – with still so little yet clean renewables storage – risks populist backlash. Especially as all energy prices spike. Yet around the world, people are now on an energy learning curve. So mis-directions like Texas, where blame was placed on wind (when natural gas froze off) will face the truth. Still with China's voracious coal, oil & gas use, moves from fossils in Europe yet fossils still setting energy prices, energy crunches and bitter crises are certain.

Another certain thing will be new Opportunities. Northern Scandinavia looking to wind & hydro to be core in green manufacturing. UK can ramp wind exports, like Morocco for solar, Iceland geothermal etc. Spain, Portugal may export solar power across the EU. Ukraine, maybe modify pipeline infrastructure to export green H_2 (to compete say, with the brown CH_4 of Nord Stream 2). Undersea cables better enable export by grids globally.

Maybe world flowering green growth. A robust carbon tax in US arguably simplest most direct way to get there, though politics continues to get in the way. Countless crises and obstacles ahead. So too are opportunities. So think about very low hanging fruit. For instance cheaper batteries are a hardy perennial – lodestones to improving intermittent renewables & EVs. Battery capacity may go from <300 Wh/kg to >500 Wh/kg. "Made in U.S.A." can & must = good jobs. Solar manufacturing must fast go over >100s+ of GW/yr. Scary climate scenarios, power crises - each & both are striking calls for *Terawatts* more clean batteries/storage.

This decade so-far laggard US *may* pivot towards a carbon free grid, saving money to boot. It's now feasible! We'll look at freshening possibilities next. It *may* become a transformative decade for Europe, US and Asia. Let's start with the US, to envision possibilities to 2035. These lately can go far, far beyond what only a few years' ago was thought possible.

Where has the US power grid stood? What will it take to get to zero carbon? Let's take a look using recent 2019 data from the US Energy Information Administration. Electricity generation in 2019 had accounted for a large part (though far from all) of US CO_2 emissions; power generation made 4,127 terawatt/hours of electricity. Most of that, 38% was made by natural gas plants; another 23% came from coal; 19% from nuclear; 7% wind, 7% hydropower; only roughly 2% of US power came from solar, while 2% was from miscellaneous other sources.

As noted, US coal waned under Covid over 2020/2021. Given natural gas & renewables became the cheapest, best power - an outsized reduction in CO_2 resulted just from simply shuttering some very polluting coal plants in the US (and Europe). But that's been only a blip.

Numbers above show what a huge slog will lay 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 actually is the most profitable. US Nuclear can't offer much help; unlike solar & wind each year getting cheaper & better – US nuclear instead has been going up in cost. Nuclear plants once 'just' $7 billion each. Now 2 ridiculously-costly plants going up in Georgia cost $25 billion+! Their inflexibility, once touted as an asset instead has been flipped to be a liability vs. renewables.

Getting to US zero CO_2 from here means eliminating in 15 years, 668 coal plants, and most of 6,080 gas-fired plants. Fast-ramping solar/wind, with say 15% faceplate capacity – making 9% of US energy (2019) because they're non-firm; intermittent still days, no solar at night.

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

That's far, far too late given CO_2. So instead, consider triple 2021 growth in renewables. Back of napkin we'd need to replace 791 gigawatts of fossil power generation, to be 100% clean by 2035. For rough $ cost estimate, a 1,500 MW (1.5 GW) of wind power in Oklahoma in 2019 had cost around $2 billion. That leads to a figure about $1 trillion to replace US fossil power – something over twice that to account for intermittency (resolved too by new storage).

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

It's been assumed this requires (an unwanted) top-down *diktat* from government. But fast solar and wind growth in Texas – vs. slower rates in more heavily-regulated California - suggests opening markets to competition can spur on renewables. After all, it's estimated US solar and wind can naturally make up some 55% by 2035 just based on their better price alone. Adding wonkier mechanisms, like tech-neutral 'clean tax cuts' – 'Clean Asset Bonds & Loans', or a carbon tax - can doubtless help get us to 100% with not much help needed.

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

1st let's assume science is correct. If so, we all must act far faster to cut CO_2 emissions by ½ by 2030, to hit 'only' 1.5 degrees C ravaging warming. Yet we're nowhere near 50% cuts! Actual global trends at 2021 still go weakly languidly decades before really decarbonizing. That creates much too hot a world, genuinely zero-CO_2 goals realized far too late.

If action is desired soon, note how plunging solar, wind, & energy storage costs *immediately changes everything*. A US grid with 90% (in our case, 100%) less CO_2 is not only feasible, it can be reached 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 the Andlinger Center and High Meadows Environmental Institute. Additional Reports coming. But we'll cite here this 2020 Report, from U.C. Berkeley.

It shows how carbon-free can be achieved swiftly in 15 years to 2035. Retail electricity costs in 2035 should be 10% less for consumers than today. Past assumptions thus got it wrong on how hard it is (can be done) - and how costly (saves money) on a cleaner U.S. path.

Remarkably zero CO_2 is a 'no-regrets' path sensible in its own right, better than status-quo, No New Policy. A "2035 Report: Plummeting Solar, Wind, and Battery Costs Can Accelerate Our Clean Electricity Future" (2020), https://www.2035report.com – offers new conclusions that interestingly differ sharply from reports of just 8-10 years ago. Those had once foreseen carbon-free electricity as adding many new costs. Instead, it now 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 all known 'zero-carbon' generation options. As expected, a focus is on cleanest: solar, wind, energy storage. Yet a baseload with hydro, geothermal, biomass, and even nuclear may be permitted. (And in theory fossil fuel with carbon capture/ sequestration – but least-cost models do not include any newer nuclear, or sequestration). In contrast to Zero Carbon path, No New Policy merely is state & federal trends status-quo. That latter model reaches only 55% clean by 2035 so would fall way far short of what's required. Crucially this better clean plan means reliable, firm power fully dispatchable, as needed. It meets all demands in every hour of each day. There's no compromise on performance.

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

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

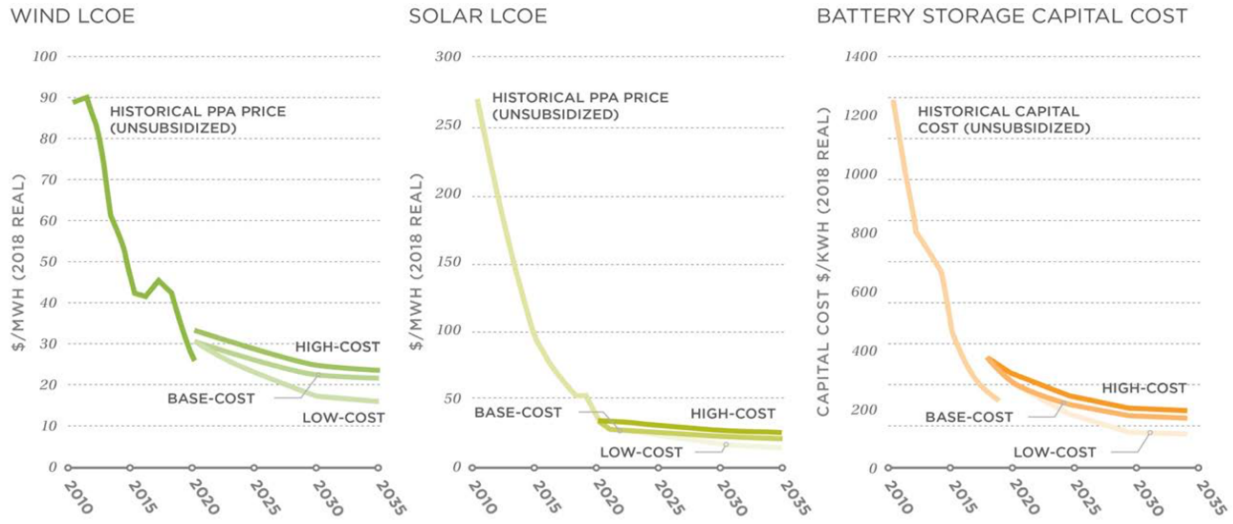
Happily, only modest new transmission or spur lines are needed to interconnect expanding clean power, so a less pressing need for costly, slow-to-build intergenerational lines. No tough overturning grid infrastructure, requiring longer lead times. But what changes, is composition of both generation and storage over this now here & fast-arriving 15 years.

First off, all U.S. coal plants will need to be permanently shuttered by 2035 under this plan. Places like California, it's already done. Extant coal elsewhere generally has been running for many years now, so 15 added years in this Plan leaves time to recoup capital investments. It is doubtful coal owners would want to burn much longer, given the higher costs and liabilities vs. clean power – but recouping those costs is addressed in this Report.

Second, *no new* U.S. natural gas fired plants are built. Existing gas plants and those going up now can remain; they'll play a decreasing role though 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 of gas capacity operating in the U.S.; in this Plan 361 GW of that dispatchable natural 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.

As gas-plants pay for fuel, the reduction helps achieve wholesale electricity costs 2035, *10% less* than now. In low solar & wind generation periods, gas does have a key backup role – but utilization rates of only 10%. The Plan suggests a federal 'clean' (carbon-free) standard of 55% by 2025, 75% by 2030, 90% by 2035; and 100% by 2045. In past when renewables were much more costly, than the fossil fuels, such standard was not yet embraced.

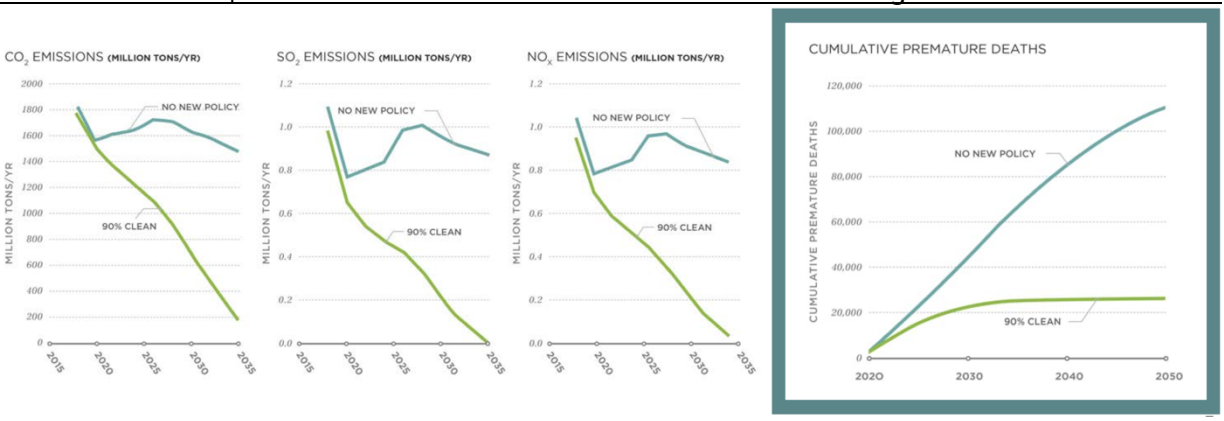
<u>Dramatic Declines in Costs Have Arrived 2020 Far Sooner than Expected:</u>



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 a whopping 88% by 2035. As a direct human health consideration, that reduces human exposure to the 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(!).

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



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

So 3 fundamental points are: 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 the country. The public may assume solar needs warmest climates, but in fact solar power does quite well thank you in freezing temps – working even say, at Poles or literally in space.

Electricity in this model is made by solar for less than 3.5 cents per kilowatt/hour (kWh) in the places shown here in yellow/green: thus most of the U.S. Wind power similarly is made at less than 3.5 cents kWh in much of the country, shared widely via grid etc or stored. Such zero-carbon renewable energy prices are, remarkably, less than any of fossil fuels. (And one wonders in 2021, if even this projection is off; 2035 renewables being much cheaper!)

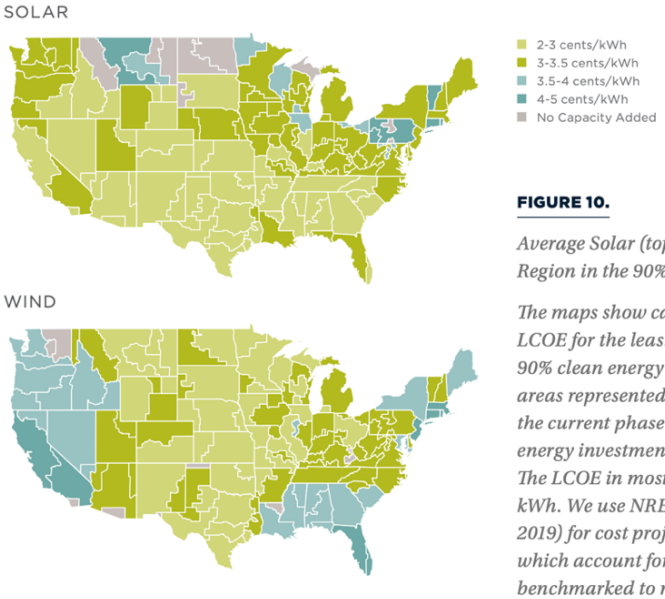


FIGURE 10.

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 this is a cumulative 29 million job-years. Many new jobs can & should be located near closing fossil fuel power plants; better jobs building solar, wind, storage going in where fossils shutter. Jobs to be front-loaded & prolific in construction - not so much later operations since neither fuels, nor much maintenance is required. It's surely crucial to assist local communities too once dependent on coal; shoring up pensions, healthcare, jobs & training programs in a move to green energy. A recent Survey (World Economic Forum, Fall 2020) laid out goals of a *Just Transition* - more than half favored working in renewables.

So if to keep below 'only' 1.5 degrees C warming in the 2018 IPCC Report, global emissions have to be halved by 2030. This green Plan alone isn't near enough; it means a 27% reduction in CO_2 from U.S. electricity generation. It doesn't give U.S. -50% by 2030, nor globally, but there'll be (one hopes) big reductions too in industry, buildings, etc. And under this Plan's glidepath, finishing up with a roughly 100% CO_2-free grid 2035 could be compelling.

Delivering *less-costly* power in 2035 that's also *cleaner* – wasn't regarded as feasible before - studies done a dozen years ago, even 8 years ago, didn't foresee how drastically solar, wind & storage costs would fall. Now that they have, modeling far-less-costly electric power may be undertaken. This lets us see how storage is key for non-firm nature of renewables.

Dependability in modeling for this Plan 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. This was 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 crucial ingredient in making all possible, is how far storage costs have dropped – and will do so ahead. 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 goal. 20% of daily electricity demand is then met by storage. (Limitations to computer models keep battery storage capabilities envisioned to this 4-hour window). Real world data in Appendixes, show how hard it had been 2020 for California to meet 50,000 MW of demand; storage is key.

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

Over 7 weather years modeled, in normal conditions, wind, solar, battery storage generally, regularly provide 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 will only contribute around 10% of annual electricity generation these bridge years.

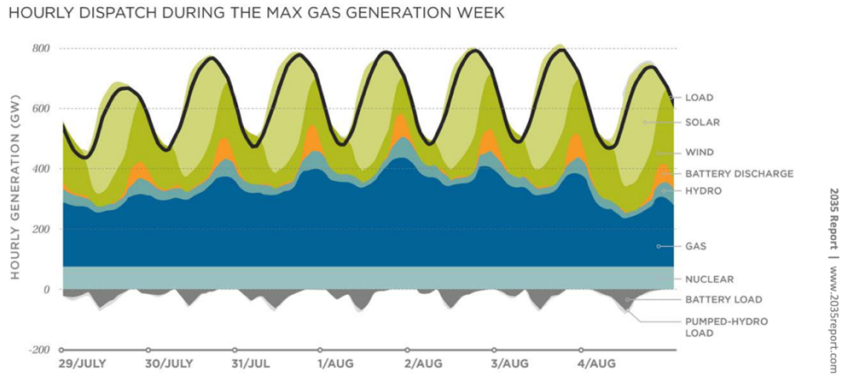
This Plan is so different from what's seen today, one may naturally ask: How is this done? We know solar is pretty binary, each 12 hours making zero power all night long. So what happens when high demand in evening – overlaps with little wind – drastically curtailing output?

Let's start with a tough-case; no-solar evening hour, little wind as well. Total solar & wind generation are 94% below rated capacity, a mere puff of wind somewhere in grid - when 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 the largest gap between green power (solar, wind, storage) – and dirty generation to compensate.

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

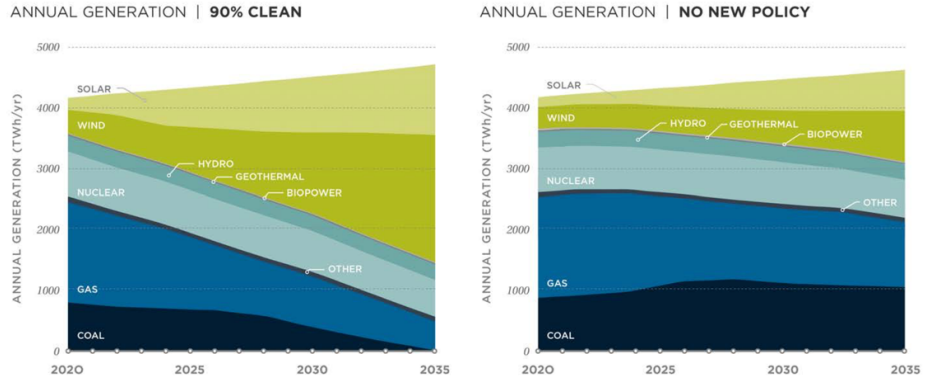
A Worst-Case Generation Period for Renewables: Still Moving Off of Fossil Fuels/Nuclear:



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

Over 7 weather years, highest demand hour for natural gas baseload is always August, on least wind and at nighttime so zero solar. But gas-fired power needs over 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. An enormous sum, though akin to COVID stimulus rounds, with enormous positive lasting benefits. (And more efficiency improvements ahead too like barium sulfate-white rooftops, better lower demand).

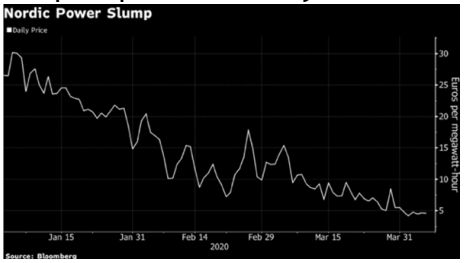
Moving on let's recall *applied* clean energy in 2020: when renewables' prices can and did fall swiftly – happening in good snowballing ways (unlike oil). Start 1st with Solar; costs hit a Record Low cost of *only 1.35 cents per kilowatt/hour* at a big 1.5 gigawatt solar farm going up in Abu Dhabi! True, that's in excellent solar circumstances, desert for instance. But there's great deserts in Western U.S., arid regions in Southern Europe too, and 1.35 cents is cheaper than any new coal power, today, tomorrow, ever. New solar power for a penny is less pricey than new natural gas. Frankly, no new fossil plant comes close. Inflation in after in 2021 has vexed solar, from its poly inputs through PV installation – the future remains to be seen.

As a practical matter, consider 2 renewables joining together at a world-leader, say Sweden. There clean energy tells bit of a startling story. Especially as more renewables get built, as is happening, interesting synergistic eco-possibilities may be repeated. So consider how April 2020 when Sweden's then-largest onshore wind farm opened, right away it changed context for inflexible nuclear plants – given how wind (like hydro power, solar power) can in good circumstances, heartily underprice more costly non-renewables like nuclear. That wind farm owned by a Dutch Pension Fund consists of 80 large turbines each 3.6 MW, for together near 300 MW of installed capacity expected to annually make 900 GWh. That's big – but certainly not huge in size for Europe, see https://www.vasavind.se/askalen-eng.aspx

And wind isn't only big renewable operating there. Sweden already has hydropower plants, so it's harnessing water in addition to wind. Indeed, most all the planet could use myriad untapped renewables, even if inexplicably they are ignored; blowing winds onshore or offshore, often good sunlight for solar power, geothermal potential, or run of river small hydro that ecologically could be much better than non-scalable big-hydroelectric etc etc.

So Sweden already has hydropower for significant power. And very rapidly, indeed just 1 day after this wind farm opened with hydropower too already making abundant cheap power, then 2 units at a big costly nuclear plant north of Stockholm had to ratchet down to just 50% power production. With 2 other units at an older nuke plant also shut due to a national shift away from nuclear, these two renewables were obviously fast becoming impactful.

If it happens that wind farms are capitalizing on windy days – plus good hydropower conditions – then together they may make good use of all 'free'. Such increasingly crowds out fixed fossil fuels & nuclear plants that must pay much for fuel and operations. An upshot was Sweden's electricity prices start of April 2020 were hitting welcome new Lows. Note too wind in Sweden like Norway, frozen Arctic, Minnesota etc works great freezing areas; puts a lie to opponents who wrongly claimed when Texas froze in 2021),that renewables can't work in cold. There, a lack of weatherization across natural gas, coal, wind, even nuclear shut down much power. And, future fleets of electric cars – with Vehicle to Grid (V2G) could use cars to store/sell cheap surplus electricity back into the grid, as needed, making money for their drivers.



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

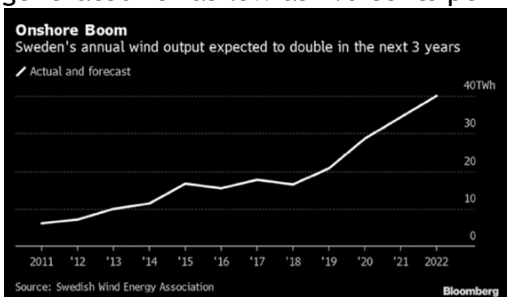
So yes, most renewables are intermittent. There's not always blowing wind, nor seasonal rains for hydro. At times other renewables too may be tapped; for instance geothermal, a renewable, might possibly grow more common as firm power. Especially if oil rig counts drop, then geothermal may become more attractive. Idled oil drilling capability could be harnessed helping to accelerate geothermal as baseload power. Capital is what's needed; geothermal may need deeper wells, and wider bore holes; it's also costlier upfront vs solar or wind.

US big Oil hadn't looked much at big renewables projects. But if oil is near just $50s/barrel, renewable projects could rival the $$ returns of a new oil field. Geothermal is too costly now – maybe 3x or 4x more-than wind/solar. But geothermal is firm power, and build-out utilizes skills well-understood in oil/gas: how to drill holes deep in the ground. In time geothermal might grow more affordable. It may be exported too, say from Iceland in varied forms.

So natural situations in Sweden are exacerbated in good ways when windy days coincide with high-hydropower output. Charts from Bloomberg New Energy Finance (BNEF, prior longtime partner on the global new energy innovation NEX) illustrate nicely how daily wholesale power costs in Sweden had been driven down "naturally" by hydro/wind to lowest-ever. In Spring 2020 electric power day-ahead pricing fell by half. For comparison, to get to just break-even before profit, that region's nuclear plants need a much higher price floor. Costly-nuclear faces a thorny pricing dilemma given how low renewables *can* go. Especially if a region combines natural resources, say rain, and wind, and maybe with solar power too.

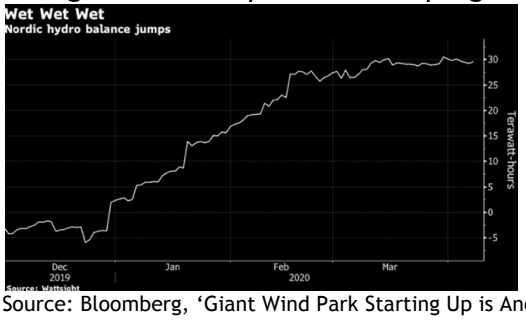
Recall dirty, cheap, coal in northwestern China attracted industries there, simply on low cost electricity; like Liuzhou's incentives for making EVs. Northern Sweden can do it one-better! Cheap/er clean power, can better make green steel, aluminum etc! Local industries welcome low-priced big hydro and now wind. Sweden's mills, its smelters, miners, aluminum manufacturers are all energy-sensitive. Big hydro is a static source, potential capped, limited to big dam-able areas, huge ecological burdens. So recently wind power helps to scale more and in a very major way. A BNEF article aptly called "Sweden is Becoming Europe's Texas for Wind Power" - shows how Sweden, a bit like Texas, is in the midst of a wind boom.

Indeed Texas added in 2020 nearly as much new wind capacity, as it did in a prior 5 years. Solar there too has jumped from 3,800 MW, to maybe 21,000 MW in 2023. This US renewables leader with 29,000+ MW solar & wind, beat 13,000 MW in California. Texas' ERCOT queue in 2020 had 77,000 MW contemplated; 13,000 MW each in solar/ & in wind in its queue, a portion of which may be built. As wind, solar, hydro enjoy free fuel, they can get *very* inexpensive (painful to Utility, bonanza to off-takers) in abundant times. Combine hydro with abundant scalable wind, & solar, and benefits snowball. Clean power potentially gets very inexpensive (below even zero cost!). Woohoo for off-takers! Little wonder wind power in Texas was generated for as low as 2.6 cents per kWh in 2020. Here's booming Wind, seen in Sweden:



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

Energy-intensive industries in for instance Northern Sweden where there's abundant hydro resources, are enjoying booming renewables; that may push energy prices lower even than dirty coal in northwestern China. (China's aim of "carbon neutrality" if not a tougher "climate neutrality" by 2060 may put an end to coal there – just not nearly soon enough). Costly nuclear is set to ramp up in China unless it changes course (such as after an accident). Intermittency is always an issue on renewables; solar yields zero all night predictably; less forecastable it drops hard on cloudiness. Wind is best windy days obviously. Hydropower too requires dimpled landscape, snow/rain; some seasons less precipitation. But, the landscape that gives hydro can also mean pumped water storage; an abundant geothermal in not-distant Iceland; industrial processes could ramp windy days for off-takers of power, etc. We are in very early innings and one hopes fantastic progress is ahead - like seen of late in Sweden:



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

As for the US, it's making some progress – thankfully now beyond big hydro. A decade ago renewables made up just 10% of US electric power in 2010 – much of that was from big hydro. Despite vexed ecological impacts, limited room for hydro growth. Somewhat noteworthy then, is in the US renewables' slice grew to near 20% by end of 2020 - thanks mainly to rises in far more scalable, greener, solar and wind which have enormous room to grow.

End of last decade, US installed solar capacity rose to near ~100 GW. (A gigawatt may be thought of as roughly one smallish nuclear plant's output, yet solar is intermittent - unlike nuclear, coal, gas). 2020 solar & wind went from near zero - to 10% of US electric power. Hopeful – yet underwhelming: we need 10x that! Note too how growth happened. Partly by China pushing down solar costs via consolidation. World's biggest solar firm 2017 went bust. Some 180 solar firms died, 2016-2020. In 2010, 1,000 employees at a China solar plant made 350 MW of product; in 2020 that 1,000 people made 6,000 MW. Price per watt in solar crashed -90% that decade. Partly too on US 2009 meltdown. American jobs were lost at a huge rate. In response, the $800 billion stimulus American Recovery and Reinvestment Act (ARRA) gave a then crucial $90 billion for clean energy, electric vehicles, efficiency etc.

At that time, in 2008, solar made up only 0.1 percent of America's electricity(!). Wind less than 1 percent. So they were vanishingly small within the total U.S. energy mix. ARRA sought to change all that while creating good jobs and growth. It contained a then-large $25 billion for renewables, another $20 billion for energy efficiency, there was $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 liquid cash payouts. Developers were allowed as much as 30% of project costs, instead of tax credits. 2009 stimulus helped prime a pump for growth since. Also of help, at start of that decade, a US SunShot Initiative reached its goal early helping make solar much more competitive vs. dominant dirty energy. In a decade since the Recovery Act, US solar power generation capacity had since grown by 48-fold, though starting from a very tiny base. Wind generation capacity had grown 4-fold plus.

Of key importance was China's strong entry in solar & wind. Seeking market share in a big way, it began pushing down price per kilowatt - dramatically. That put many established firms out of business, in Japan, Germany, US and elsewhere. Profit margins dried up. So many legacy firms couldn't keep up. China's firms enjoyed low costs of capital, cheap labor, often free land, less environmental regulations. Local governments there glad to see the big employment gains these factories brought. Solar costs, pricing & margins plummeted.

Germany did ramp installations in 2010s. In 2012 it placed 7.6 GW of solar panels. And with other European nations like Denmark also embraced wind power. Thus by 2013, subsidized wind power reached cost-competitiveness many places, with coal & gas. Where winds are plentiful, the equation grew *very* favorable; America's Midwest saw power auctions for just 2.5 cents per kilowatt/hour (kWh) in some bids for wind power, making it best choice.

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

Seen by generation type, renewables were pulling ahead of nukes. In a first in a long industrial history, U.K. made more renewable power in 2019 – than fossil fuels combined. Not-sunny it still made clear renewables work: wind, hydro, & solar etc (plus not-green biomass). On April 20, 2020 solar made 9.7 megawatts, meeting 1/3rd of its power demand; a one-off, and 10 times what it normally produces in a day there. Yet what a change; in 2010 its dirty fossil fuels met ¾ of demand, 10 times the renewables. Renewables since jumped to 40% by 2020 and gaining since. And U.K. coal-fired power fell from 70% in 1990, to under 4%. Coal ending in the U.K. by 2025. The E.U. aims for climate neutrality by 2050 – more likely sooner.

Global annual solar panel production changed enormously from a once-puny 15 GW 2010. Yet, as emphasized a key issue for many renewables (except geothermal and hydro) is now their intermittency. That's held them back - but needn't do so ahead. Like overcoming high early costs of solar & wind – a need for firm power spotlights batteries & energy storage. Intermittency's an issue. *Yet it can surely be overcome*. Coordinating renewables in grid, maybe innovations like flow batteries, carbon taxes, even green H_2 as energy carrier (with breakthroughs) - may ascend one day. We *can do much* to advance renewables.

Asia made a commitment to advancing batteries years ago. Lately Europe is trying to catch up in EVs, batteries, for new leadership in technology & manufacturing. Decarbonizing everything can move all things forward. Yet inexplicably, the US ceded ground early on as in energy storage and batteries. And China, having once missed out on early prowess in making 'regular' gasoline powered cars – now seems determined not to make a same mistake twice with coming electric vehicles. Essentially EVs are a big battery surrounded by 4 wheels, China may soon 'own' much EV space. Innovation in various storage/batteries will be part & parcel of advancing renewables worldwide, beginning right now start of this new decade.

There are practical issues. A Great Lockdown 2020 at first slashed jobs in US clean energy - as in other industries and nations. March 2020, 100,000 new unemployment claims were filed in the US clean energy space. According to the group E2, these included 69,800 job loss claims in energy efficiency, another 16,500 in renewable energy, 12,300 from clean vehicles, and 7,700 jobs lost in grid, storage, and cleaner fuels. It looked very bad Spring 2020.

Early 2020 there was perhaps some 600,000 clean energy jobs lost in the US. Yet as will be discussed, far greater losses have been seen over years in coal, and oil. There, things are far worse. Coal now is a shadow of its former heft – due to mechanization by that industry itself – and not due to any clean companies. Here, in clean energy, there'd been waning consumer confidence Q1 2020 meaning residential solar cancellations, a caution at Utilities, auctions halted on fresh wind/solar projects. That said, Q3 / Q4 2020 grew better fast - and far side after this pandemic – that, if reached, could bring more green activity.

One useful change could be for Utility procurement processes to better consider all potential power sources – including green alternatives. The fact that wind and solar power are already often heaps better than coal – is accepted in many places – but not yet everywhere. When vertically-integrated Utilities tilt procurement to fossil fuels, to the status quo and their own bottom-lines, that means an excess of power generation – rather than desirably leaner cleaner competition, a keener look at the climate impacts, and truly lowest-cost power.

Places that have decoupled Utility's revenue - from amount of power produced – bottom lines may better advance real efficiencies and lower system costs. 'Steel for fuel' swaps reward operational savings from 'steel' (new wind & solar farms) - over uneconomic older fuel-intensive fossil fuels generation. Without total re/views, encumbered inertia and old-ways of thinking can allow more-costly fossil fuels and heavy CO_2 to unduly linger.

Change is happening so fast, young-ish decisionmakers who 'knew' in 2000 that 'Renewables were the most-costly' – are startled by this change. It's something of a wonder: in not even a decade 2010 to 2018, Utility-scale Solar Power capacity grew amazingly 30x, a 30-fold scaling-up to swiftly reach over 60 GW. It looked to potentially double again in another 5 years (although perhaps not quite as fast due to pandemic). Yet we need far more!

In clean technology, cost reductions once learned – like green capacity once built – will not forgotten or lost. New solar, or wind that's sited in favorable circumstances, often now makes electricity in the most economical way of all as noted. Two-thirds of the world now sees well-sited solar and wind generation as the very *least expensive* forms of new power!

According to ever useful Lazard Reports, clean renewables were under half the cost of current generation nuclear power (that still have centuries of costly toxic waste to dispose of). Thusly are renewables clearly now preferable to once-cheap King coal. Lower than 'cheap' natural gas. Issues are now shifting to energy *storage* – last piece in the firm power picture.

What's key to consider here, is *levelized costs* of energy - that is all in including fuel costs. End of day, fossil fuels increasingly struggle with the fact of 'free' solar/wind. Especially as solar & wind gear only get cheaper. Take solar cells, built soon using more wavelengths. On group III-V semiconducting materials, more solar output may be captured than recent cells. Concentrate that sun further, with mirrors, and it may then be possible ahead for innovative solar cells to capture 400 times more solar power, over an equivalent surface area!

Consider Perovskites as we are in early PV innings technologically speaking. These solar materials with crystal lattice structure are nicely cheap and abundant; they could become some 50% more efficient than solar cells today. Able to capture low light, too, they might open entire new possibilities over years ahead. Solar getting (much) cheaper still. But as we emphasize, clean energy in 2021 was still so puny, nowhere close to what's needed.

In reality, the Paris Accord's targets are not close to being met, even though the US returned into that Treaty 2021. Rising CO_2 hit new records in 2018, 2019, 2020, 2021 etc etc. Peak global CO_2/ greenhouse gases aren't expected any soon-year. Not by 2025, 2026, 2030 etc – this despite flowery aspirational words to the contrary and aiming for 'just' 1.5 or even 2 degrees C of warming ahead. Blowing past the hopes of Paris is already a certainty.

2020 brought some inspiring wins at margins. Scotland had met 97% of its electric needs by renewables; though heating & transportation there have a ways to go. First half 2020 Ireland's slice of electricity made from wind, surpassed all sources including natural gas; wind met 43% of Ireland's demand – vs. 41% met by natural gas. Spain, looking to its natural blessings turned on Europe's then largest solar farm, 500 megawatts (MW) of power for 250,000 people. In May of that year a bigger 690 megawatt US solar farm was approved in Nevada for as many people (since Americans consume much more); notably it includes 380 MW of battery storage.

But things are bleak on CO_2. Coal remains worst carbon source, hundreds of new coal plants were built 2021 across Asia. In China and in India, coal still a cheap and leading main fuel given lax rules. Given laxness, coal power can cost some 30% less than renewables. Solar & wind are growing cheaper, in China, maybe they will beat coal 2026 in the wealthier regions. That said China had still had remained heavily dependent on coal (and on big hydro) for some 83% of its electricity mix - vs. growing wind and solar that were still only 7% in 2018.

2019, coal capacity in China had grown by a staggering 37 GW, or "more than the whole world" - for while coal was being shut other places like in Europe, U.K., and US - enough permits had been granted in China to potentially expand coal by about another 25% more. Not all will be built, but early 2020, China had already permitted, or it had under construction, an enormous 135 GW of new coal capacity; that's about half the entire built U.S. coal fleet capacity. As China finances most new coal built globally.

Besides the coal going up in China & in India, wealthy-Japan is set to burn coal for decades. Look at Japan in 2020: to 2025 it might build 22 new coal plants, up to 17 locations. If all get built, they'll emit nearly roughly as much new CO_2, as all new cars sold in the US, annually. Even Germany was getting ~33% of its electricity from coal. While renewables were over 40% there, it ok'd one (final) coal plant in 2020. Many plans in Europe to shut coal are being brought forward, shuttering sooner post-pandemic – but that's not happening everywhere. It's all tremendous current to swim against - if one aims not just to *slow rates of growth* in emissions – but to absolutely *Cut* total CO_2 emissions and concentrations in the atmosphere.

There's a Paris Agreement. Yet wealthy Japan set itself a very low bar aiming for meager 26% less greenhouse gases by 2030, than 2013. Even that merely a goal. Coal makes up one third of Japan's power; by 2030 it expects coal to still be ¼. Renewables, 10% of its power in 2010, 2018 only made up 17% and much of that was from big hydro. In sharp contrast, France expects to fully shut all its coal plants by 2022 (though by leaning on its nukes)

Japan's course has been uninspiring. While renewables could be cheap power there by 2025, it's stood by coal. Unsurprisingly after a horrific nuclear accident, nuclear fell from some 1/3rd of its power, to under 4%. Yet fossil fuels instead grew to 4/5ths. And its renewables have been dominated by non-optimal, big hydropower. Exporting bad practices; China was financing coal plants overseas – but late 2021 indicated it would end it. There's airy talk of so-called 'clean coal', yet always off in future for a concept that's never been real.

In US, demand for thermal coal itself is dropping. 2019 it was 556 million tones, then less in 2020. Europe had declined to some 534 million tons in 2020 and dropping too - especially with renewables becoming least-cost, best option. Yet necessarily measured against declining numbers of US and Western Europe - are increases in Asia – China alone in 2020 used around 3.6 billion tons thermal coal: their figure is growing for half world demand/ consumption. India used 946 million tons thermal coal and it too is adding coal power plants. So while the US and Europe are decreasing coal burning, closing 22 gigawatts of coal power – that's swamped by the maybe 49 gigawatts of new coal plants across Asia-Pacific.

Europe carbon credit costs jumped 70% from March 2020 lows, to August 2020 – reaching $30 a metric ton - which hit dirty coal very hard. And while price of thermal coal for burning in power plants dipped 2% to $50/ton, that was overwhelmed by a 60% decline in natural gas to $1.50 per million BTUs – making gas a winner (though hiccupping on shuttered oil wells).

Germany's Utilities may *lose* money selling coal-fired electricity. Natural gas on other hand, is relatively bit less filthy, needs fewer carbon credits, and is more profitable for Utilities. So for them it's a mixed bag. But for the Earth and future, all fossils must go, coal first.

It makes sense: global average solar costs in 2019 were 6.8 cents per kWh; onshore wind just 5 cents per kWh. Average solar costs since continued to fall; maybe under 3 cents. So beyond China & India (less burdened by environmental health and safety rules letting coal become cheap), renewables are making progress. Ironically China is crucial in making renewables cheaper today. Not a Petrostate, it might in future be an 'Electrostate'.

Yet confronting all, is Earth doesn't care about renewables' strong growth at first from zilch. And we oughtn't pretend impacts on us alone, are all that matters. As air-breathing mammals, we see only these terrestrial impacts. That's a mistake. Earth's surface is mainly covered by seas: their health declining fast. Skeptics questioning CO_2 and warming air, have no ground on which to stand with ocean acidification. For oceans' CO_2 uptake is undeniable; rising CO_2 concentrations doubtless equal acidifying seas. Devastating harms thus ahead for reefs, for kelp forests, fish populations, shellfish, marine mammals, more. Marine life, once weakened by acidification, then stands a lesser chance of surviving marine heat waves.

Ways shellfish, for example, calcify to grow shells from surrounding seawater are understood. Hence it's perplexing that we know acidification lowers pH, no doubt enfeebling the species essential to ecosystems, *yet we care not a bit*. Shells getting too thin, accreting calcium from seawater gets too difficult – likely meaning tipping points, catastrophic collapses. Naturally perturbated places with more 'acidic' waters like those nearby volcanic seeps, both fish and habitats are now negatively impacted by CO_2 levels only a little above that today.

And there's warming. Post-2050 deep seas might warm at rates maybe 7x those now – a climate velocity sure to overthrow life evolved in very stable deep thermal settings. There will be tipping points, complex & cascading losses. In sum, renewables are vital. We perceive of clean energy – and oceans - as being quite separate, when they're intimately linked.

Since the industrial revolution, ~1,700 gigatons of CO_2 ($GtCO_2$) has been put in air, leaving room for ~200 Gt more before we may go over 1.5 C warming. Releasing 40 $GtCO_2$ /year now, means we may have <5 years to 2025 at today's rates, before we're in big trouble. That's why distant vague promises about 2050, are absurd. Reducing CO_2 now mid-2020s is vital.

We already know from the science, major threats to oceans include changing climate from CO_2 & greenhouse gases like methane; overfishing; non-point source pollution; habitat destruction, acidification etc – all harmful to marine and other biodiversity. Each presents a daunting problem to overcome. Each locked-in, difficult to resolve to protect oceans.

Seemingly most intractable, most vexed, and hardest of all to remedy, is CO_2 & climate. So it's surprising a solution here is economically/ecologically sensible – and it saves money! Key of course will be far more clean renewable power; solar shines brightly, another option blows overhead, wind's story. The question is, how to get there, given inertia in early 2020s? What will it take to instead power the entire world, off mainly clean solar and wind power?

Seen another way - given guardrails imposed by CO_2: how much solar is needed fast to reach the Paris Climate Accord's Goal of achieving under 1.5 degrees C of global warming?

In short solar manufacturing capacity worldwide was in 2020 less than $1/10^{th}$, maybe only $1/100^{th}$ of where we need to be in building PV panels fast enough. 2020 we'd made a little over 100 GW/year. (Still, better than puny 0.250 GW in 2010!). We've seen PV manufacturing become a low-margin commodity business. A decade of consolidations and wringing out costs, growing capacity, solar in 2020 was profitable. 2021 then saw fast rising inflation.

By 2021 roughly ~9 of every 10 panels was being made in China/Asia. The planet's biggest solar production plant is going up in Anhui Province, China: it may have capacity for 60 GW new PV modules by end of 2023, each & every year. But given economics, it's in 4 phases to $2.5 billion. From a standpoint of where we need to be on CO_2 2035, it's but a (small) start. A beginning… wildly small still if we're to make ~60% total global electricity from solar.

Consider: without vastly ramping current trends, global capacity may be (just) ~400 GW/year ahead of PV. Incrementally that increases global PV installed capacity; it is growing, but far, far too slowly. On those economics, it will take too many decades to get to that 60%.

Given where we should be, given CO_2, solar had *needed to become* the world's cheapest energy! It has. Now arguably we'll need Policy Changes as well, that can allow much fasted ramping. It's a hand that CO_2 has forced on us all. If carbon levels >400 ppm are considered, then we stand 2021 having nowhere near enough installed solar, nor manufacturing capacity to vastly ramp PV fast enough to 2025. Hence policy changes are needed. China has been fast growing world's most existing installed solar capacity; the European Union was 2^{nd} and was growing; the US was third. As emphasized none are yet near where they need to be. From so little installed solar capacity – PV manufacturing capabilities would have to get far bigger, fast, to hit 60% of world electricity generation. Given climate, ramping *might* get underway early 2020s to get us where we need to be 2035. Europe may lead soon on this.

So consider a 2020 Report from Solar Power Europe, and LUT University: "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 and reach notable conclusions. Startling observations include that moving faster costs less, and that solar (& wind) powering Europe is feasible.

Almost every sentence in their initial paragraph 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.

There's several points above, that challenge conventional wisdom so are worth unpacking. Start with moving more quickly towards decarbonizing, costs *Less $,* than the status-quo of incremental additions of solar & wind. Partly on renewables getting cheap; their 'Leaders' scenario shows greenhouse emissions falling 60% (from a 1990 base) to 2030, in 10 years – reaching zero in 2040, a decade ahead of 2050. By contrast incrementalism of conventional wisdom would have Europe reaching only 53% emissions cuts by 2030. And this Solar Power Report here assumes no nuclear power, not due to its risks, but rather its higher costs.

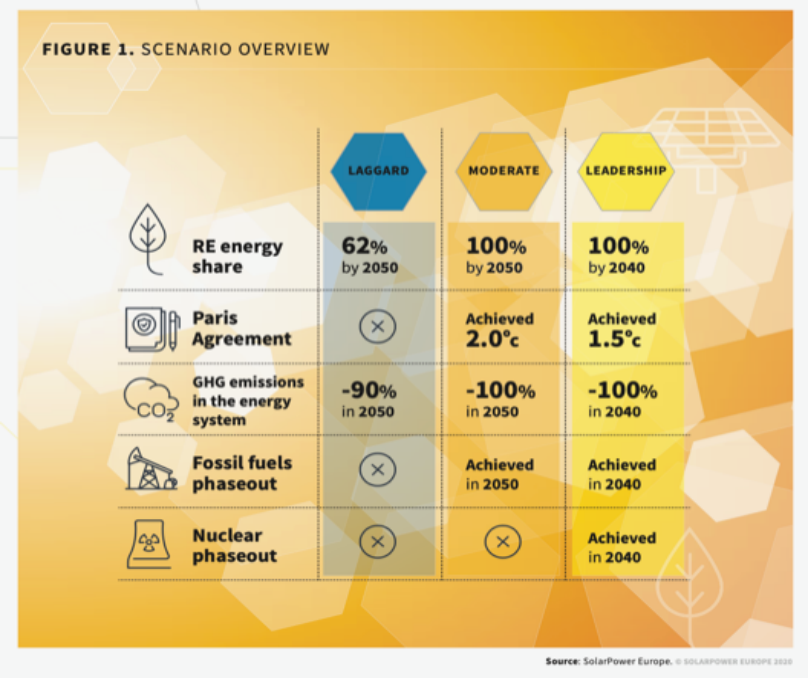
This Report recommends policy makers immediately begin by creating a new framework targeting installed 7 TW of solar power – plus 1.7 TW of wind reached well before 2040.

That assumes 2 factors: starting an upswing now, as soon as possible – and growing PV manufacturing abilities harder and faster. Given CO_2 as a pressing issue, then we may need to build 100 factories worldwide, each capable of make ~60 GW of PV like that one factory going up in 4 stages in China. Ramping to around that 7 TW of solar in 2040. Clearly this is possible. Raw materials can ramp fast – we'll also doubtless find ways to make PV much more cheaply, efficiently. The US in World War II ramped greatly weapons and materiel. Only this time, it's the whole world to our own rescue. CO_2 was rising 1 ppm/year at a first Earth Day; lately scarily it's by 2.5+ ppm/year. That number is only growing, accelerating.

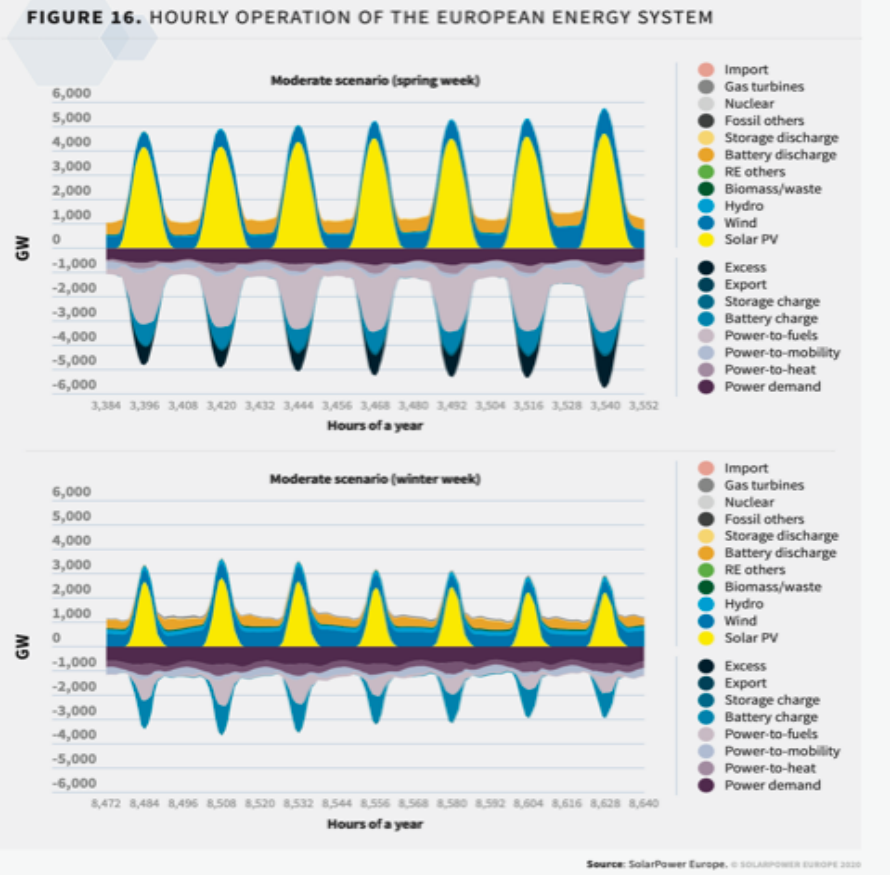
2 scenarios are presented, for a Moderate approach – and a Leadership one that's quicker. A former meets only the 2.0 degrees of warming goal under Paris. The latter meets the more robust, better 1.5 degrees goal. Again it's a matter of when ramp begins, and the angle of departure. But interestingly, stronger the action, the more $$ is saved over time!

Moderate speed does not achieve 100% renewables, until 2050. By contrast the Leadership path gets to 100%, 10 years sooner, in 2040. Better to move fast. Under it, Southern Europe is making vast amounts of solar power in e.g. Spain, Italy; & Eastwards. Northern & Western Europe region mainly uses wind, given the natural resources of Denmark, Norway, Sweden, Finland, etc. Similar approaches, under both Moderate and Leadership scenarios.

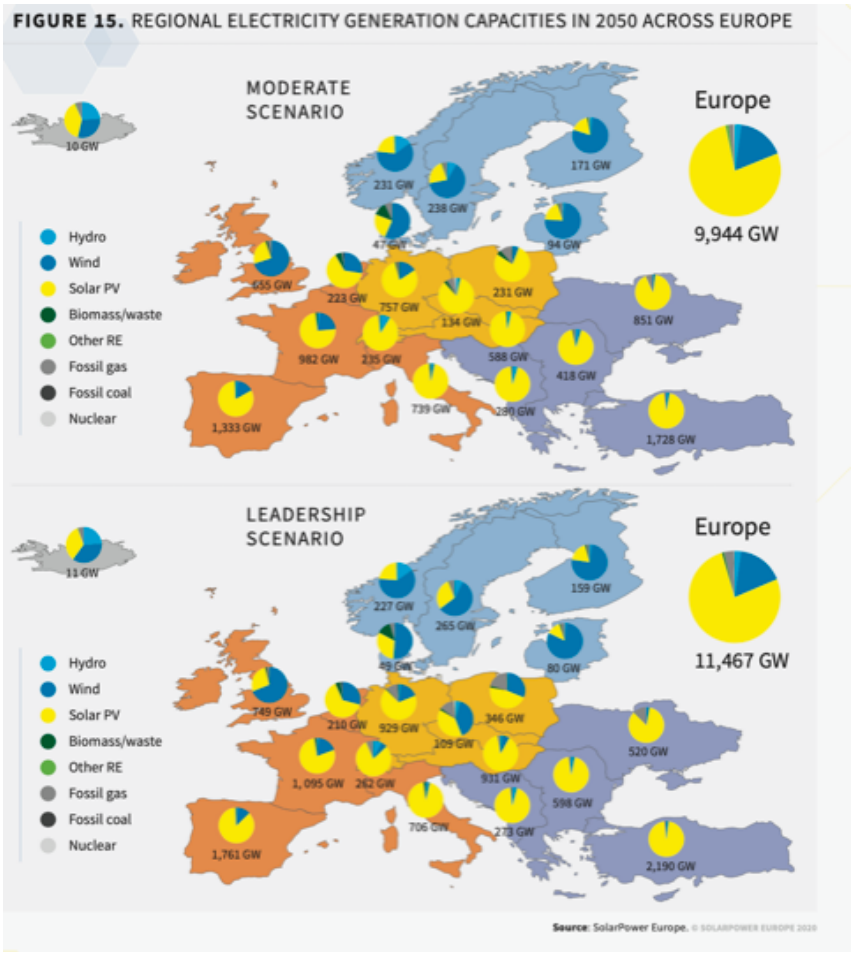
Seminally, Europe has enough renewables to power its entire needs by 2040. Electrification of everything. About 63% is solar overall, 30% is wind on a Leadership path. As for costs, the Moderate path costs less over time than Laggard, while the Leadership path beats Moderate. Unlike a game of rock, paper, scissors, then – in this Policy Framework there is a winner.



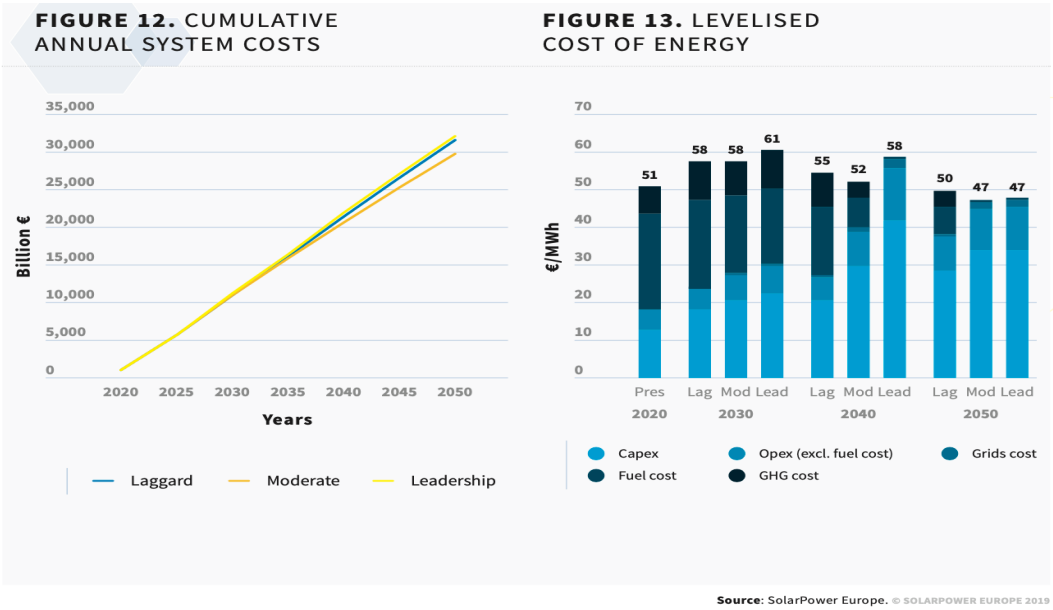
Source: Solar Power Europe 2020.



Source: Solar Power Europe 2020.

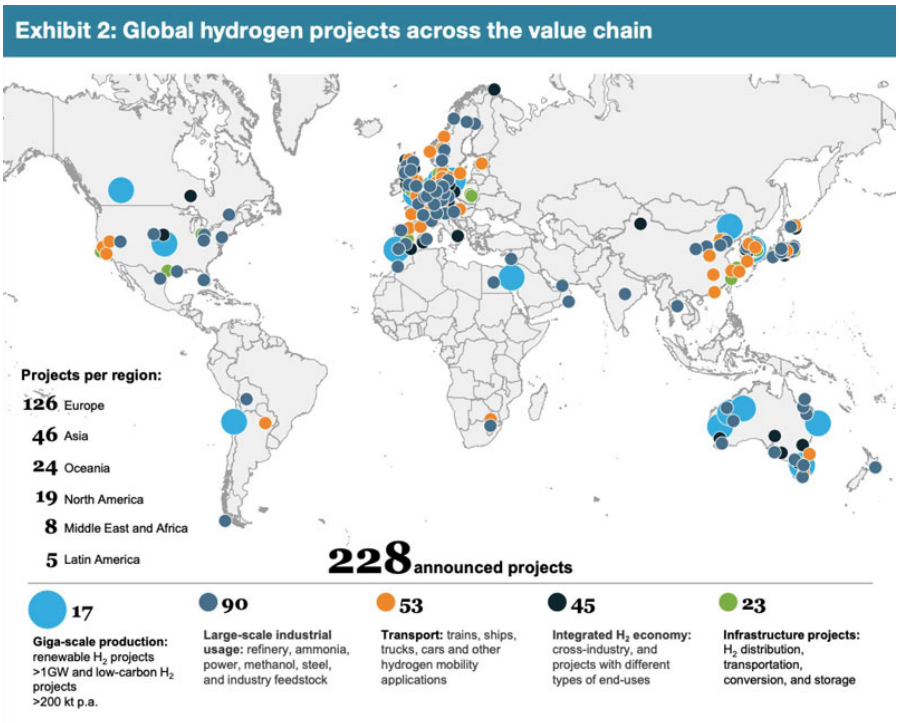


Source: Solar Power Europe 2020.



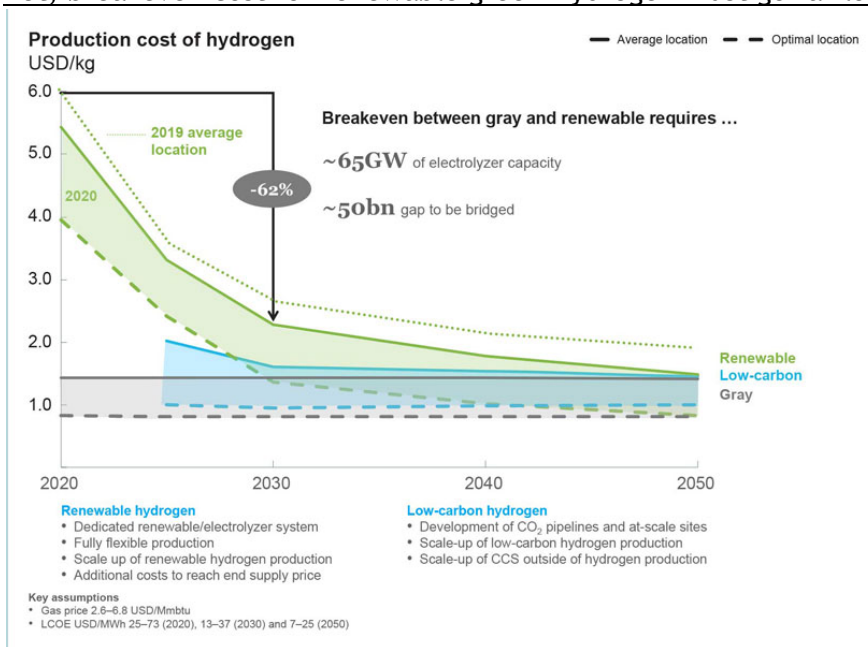
Source: Solar Power Europe 2020.

Taking a look at Hydrogen, the Financial Times had laid out a 2021 this view (reproduced in Anthropocene Magazine) depicting 228 large, H_2 projects, much of them then in Europe:



Source: Financial Times; in Anthropocene Magazine (2021)

<u>Yet, breakeven cost for renewable green Hydrogen must go far lower, to match brown H2:</u>



Source: Hydrogen Council; reproduced in Anthropocene Magazine (2021)

What may lay ahead for solar, 2020s? On an equities standpoint, as always: Nothing's certain. There were fewer Analysts the past decade in clean/sustainable/decarbonizing - than in oil & gas. That may change ahead! Over 15 years plus we've at times cited excellent Raymond James, Roth, and Piper reports etc. Here's similarly brief excerpt below from a good report by P. Shen et. al. Roth Capital Partners, in Solar Snapshot (Dec. 24, 2020):

ROTH: "Key Themes for 2021

2020 was just the beginning: Look for the multiple expansion across our sector to continue in 2021.

1. **Despite the recent Covid-19 surge, we continue to expect strong global demand in 2021.**
2. **ITC/PTC extension reduces 2021 pull-in of U.S. demand, but supports higher medium-term growth.**
3. **We expect the cost of solar ABS financing to continue to decline.**
4. **Rising input costs could remain a challenge.**
5. ….

1. 2020 was just the beginning: Look for the multiple expansion across our sector to continue in 2021.

- **Look for a greater mix of unsubsidized economic solar projects to support improving revenue visibility, increasing earnings quality, and multiple expansion.** …. While the U.S. is clearly a subsidized market, by H2'21 China should be largely unsubsidized. Many other countries around the world have been and are starting to see meaningful solar demand not based on subsidies.
- **Our tag line for this mega-trend is "the wholesale transformation of the power industry from the inside out."** With this and other energy transition mega-trends, we expect more capital to continue to flow into renewables from ESG, energy funds, retail, etc. …. All in, we expect the positive sentiment and momentum in our sector to continue until we get a narrative break. And we currently don't see anything meaningful on the horizon.
- **We recently saw another wave of announcements for PPAs linked to large scale solar projects across the globe.** … unsubsidized solar demonstrated increasing momentum with a number of PPAs signed in countries such as Germany, U.S., Egypt, Italy, Philippines, France and South Africa. Amazon, McDonalds, and Coca-Cola were among offtakers for this wave of PPAs.
- **The European corporate PPA market could be set for an influx of new generation capacity.** ….

2. We expect strong demand globally in 2021 as the solar industry continues to navigate well through the recent Covid-19 surge.

- **Global demand outlook: It's still very much about China.** …. Grid parity projects in China generally need module prices of RMB ~1.45/W (~19.5c/W) or lower, but prices are currently ~1.65/W RMB (~22-23c/W USD). If prices drop faster than expected to ~19.5c/W, 2021 demand could move toward the higher end of the range. Notably, a speech by Xi Jinping earlier in December seemed to drive increasing confidence that annual demand in China could eventually reach 70-75GW. That said, few specific policy details were provided, and we maintain a bit more conservative view. Ultimately, we believe module prices will be key and despite the recent raw material cost increases, substantial capacity expansion could put downward pressure on module ASPs.
- **We continue to see 25-30% growth for U.S. resi in 2021.** The extension of the 26% ITC for two years, once official, removes the potential rush of demand ahead of what was an ITC step down at Year End 2021 ….
- **Restrictions in Europe may have only a modest impact on solar installs.** Checks … before the more severe shutdowns — suggested that increased Covid-19 restrictions in Europe should have only a modest impact on resi solar installations. One contact is seeing record bookings and expects 30% YoY growth in December in the EU, though Spain and France could be somewhat weaker than other regions in Europe. It appears the strength is due in part to the success of online/virtual sales practices, which were implemented even before Covid-19. Another suggested that the lockdown in the Netherlands is not preventing solar installations, though some may be taking an early break for the holidays. Notably, our checks were done prior to the latest UK lockdown announcement, but after the announcement of the five week lockdown in the Netherlands, effective 12/15 until at least 1/19. This will be important to continue monitoring to see if the narrative shifts or even breaks.

….

After a decade+ of falling solar prices, inflation lately is at issue – how deep/long is unclear. Given that renewables uniquely thrive on ever-lower prices – let's contrast that next by looking instead closely at **Oil** in its remarkable 2020. Oil then moved *very differently*.

Major Crash of Oil in Spring 2020

Intriguingly 2020 brought a maybe once-in-lifetime oil crash. While some have called that oil crash illogical, it had arguably unfolded with a rather explainable logic of its own. To start, Oil Demand collapsed on Covid-19. Businesses froze globally. Very quickly, surplus oil began backing up worldwide, as we'd forecast here March in the Q1 2020 Report. Demand destruction swiftly grew so large, as anticipated, where to store oil had by late April, become a real question (especially when narrowly oil prices as expected, went negative).

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

Normally, slightly slackening demand for whatever reason, supply can be slightly curtailed. Excess stored, soon mopped up. But instead, Saudi Arabia & Russia had *ramped* production up wrestling for market control. One one 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.

March U.S. benchmark West Texas Intermediate (WTI) crude had fallen -60%, an historic drop, from $60 to $20. One big factor was Saudi/Russia ramp; greater was *demand* was dropping tremendously by -25% or more as world economies halted. A fear come the Ides of March 2020, was America's crude might yet drop well under $20/barrel absent intervention; there may be 1.8 billion surplus barrels of crude, yet 'only' 1.6 billion of storage capacity.

Pricing <$50 vexed, so <$30 is a threat to America's oil industry, both shale & conventional producers. Tiny to huge, they're a diverse lot and all felt pain. Texas 2020 had some 174,000 wells of most every imaginable kind – some so curious as to be hard to believe. Latter Q1 2020 then the White House 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 barest floor for many. Particularly, indebted shale producers. But oil was near just $20 at that point, likely going lower due to demand destruction: it could go briefly below zero some places maybe on volatile futures contracts trading. Storage was filling, near tank tops, so fixes were badly needed as a 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. May contracts would need to be unwound fast by traders with neither desire, nor capacity to take crude delivery; it pushed front-end WTI oil briefly under zero, to some -$37 by April 20th. That brief, artificial move as a matter of finance wasn't really a great surprise at all! Not too much should be read into -$37 close. Contracts many months out were less distorted than May contracts, soon 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 near zero.

Oil near $20, further meant production changes worldwide. Perhaps 1 million oil patch jobs & expertise may potentially disappear. Rig counts fast dropping, capacity tightening, wells shut-in, bankruptcies – some wells perhaps never (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 put-down to timing. In 2014-2016, opening spigots failed: in a 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 boom. And the shale which did bounce-back strongly, put something of an upper cap on prices WTI oil might soon 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).

Here in 2020 on pandemic+tank tops, oil unexpectedly <$20 - to quickly revive economies & get oil demand back up was essential. Oil-wealthy nations might ideally seek higher crude prices nearer $80 - $100. In theory it lets them better balance their own books and national budgets. But now, regaining firmer oil demand came first. Proposed conventional new oil projects are anyways oft uneconomic, without oil at least well above $40s/$50s.

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

Globally then oil industry faced pressing fears 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 difficult to move; suddenly, that mounting product upended all, raising fears of runaway cratering. Vast demand destruction further benighted by the industry's fast evaporating total storage, and that was changing everything. This was a 'logic' of oil's fears and a crisis as it were Spring 2020.

So it was April 2020, OPEC+ with Russia agreed to production cuts of 10 million barrels/day. With 25 or 30 million barrels of demand gone – 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 '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.

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

It was about getting past immediate crisis, re-starting oil demand in 1H 2021. Crude might then rise organically – like especially on say the inevitable heat waves or cold snaps. Free markets are how U.S. oil prices work, rather than by fiat, so paths were envisioned to stimulate that rebounding. If say the US States begin re-opening in Q2 2021, Covid-19 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 new vaccines for Covid ably treat the new variants too, there were thus hopes for some return to demand normalcy.

A fascinating side effect of plunging oil, was that coal – the long dirtiest cheapest energy – though still dirtiest in Q1 2020 became costly. Fracking long ago had pushed down natural gas prices wildly. Natural gas -90% cheaper became in 2020 very attractive for making power. Unsurprisingly, one after another US coal-fired power plant was closing.

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

Surest path to oil rebounding 2021 would be if economies revive, demand returns. Production cuts then linger to eat up slack. Oil's crash had drawn uncomfortably near to upending more in the oil patch. A key hub is Cushing: it's 4 huge tanks nervously grew fuller. Pipelines that normally 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 sending refined product from Gulf Coast to a mid-Atlantic stopped accepting gasoline, no contracted-buyers as off-takers, a fascinating and scary April 2020, might have yielded to a much different 2021.

As many hoped, oil prices did rebounded June 2020 to $40s.That was mainly on partially reviving economies, as well as production cuts by OPEC+ largely complied with (Iran pumped rather freely). A Q2 2020 that began with oil on everyone's lips, ended with oil largely unnoticed to end Q4 – or at least not so pressing concern as other matters at the fore.

Throughout, clean energy was hardly (among energy broadly) affected by oil's demand crisis. Instead, to grow energy storage fast enough was a different issue. Storing electricity can be simple if little is needed; push water or weights higher up, release if power is needed; inject air into caverns etc. Vaster storage needed, means maybe '5 million mile batteries', infrastructure for innovative flow batteries, H2, etc etc. For immense scale of what's needed, consider Texas. In 2019 it had 5.5 GW of solar, still only 1.35% of State's electricity supply; a healthier 17.5% from wind power. That 5.5 GW of solar 2019 was only a start. Nonetheless, were Texas a nation, it would rank 5th after China (30 GW), EU (16 GW), whole US (13.3 GW), Japan (7 GW) – ahead of say, the nation of Vietnam which had 4.8 GW in 2019.

Very generally let's think of fast needing 20x more renewables capacity than now, given need to also convert industrial processes like steel & cement to green energy. Roughly a dozen-fold increase in solar capacity – and more so wind capacity. A 1,300 MW (1.3 GW) a Texas solar farm coming online 2023 is just a start. Far more energy storage needed, too, starting from scratch: That's so enormous, needs are not readily measurable by 'x-fold'.

Beyond oil's wild ride downwards 2020 then up 2021, another big trend stands out in energy's landscape: *Coal lost a huge slice of US energy pie last 10 years*. As Yogi Berra said, "It's tough to make predictions, especially about the future" – so let's glance backwards at now-seminal shift. It's been movement away from coal in the US and in Europe now far underway.

Little thought was given 2005 to notions US coal could soon see dramatic losses. At that time 'King coal' had made up some 50% of US electric power generation. Minor early gains (small in absolute terms, bigger as percentages) had just started in solar & wind – in gas more so – but hit coal only incrementally, taking coal 'down' only a bit to 45% by 2010. After 2010, US coal dropped harder, down from about ½ to <¼ of American power generation. Renewables by 2020 were (only) near 20% then and rising, natural gas near 40%. Why, is easy. Fracking's revolution pushed down natural gas costs tremendously. In a power plant with 30+ year-life, natural gas doesn't so suffer opprobrium vexing coal. Gas embraced by industry is an easy choice. Dispatchable, firm, less-dirty, stable priced, it's widely unquestioned.

What's also interesting is a bigger change beginning to unfold as clean renewables became best bet. Even in that tough 2020, it was **due to, because of** tough conditions and given the superiority of solar & wind (and gas so cheap), that coal was jettisoned. Prospects for inflexible, big, 2022 current generation nuclear dimmed considerably many places as well.

For retail consumers, how electricity is delivered matters. Recall nimble Texas: some things it does pretty well on less regulations and more competition. Its 2021 wind power can be plentiful at night, costs retail under 9 cents/kWh. Texas residential power rates can be 37% less than California; its commercial & industrial rates may be 50% less. But other things are not as good there; Texas still makes ~20% of its power (ugh) by coal, around half by gas. Wind in US is growing fast, but America was not yet past a >20% figure. And lacking interconnections between the US Eastern, Western, and the Texas grids, it's all somewhat islanded.

California's power is costly. Night great for cheap EV charging – like Texas; but eg San Diego fast jumps up to costly 29 cents in day – and may leap to 50 cents afternoons. And California must import much CO_2-laden brown power especially in heat roiling the West. Texas had blackouts in 2021 but there due to natural gas freezing – not due to renewables. UK & Europe faced possible blackouts Winter 2021/2022 - but on little gas & loss of France/UK grid cable. Notably, *in all these cases, it wasn't 'too much' renewables that was the key problem. It was a lack of enough renewables/storage - as natural gas was oft the core problem*.

Texas isn't yet a Clean Energy incubator, nor an innovator. Oil & gas, yes. But Texas is open to clean energy innovation – less regulation/more flexibility - and vulnerable to climate crisis. CO_2 *may* cause sudden heating in stratosphere, weakening polar vortex bounding the Arctic; ironically global warming *might* mean then bitter cold Arctic air reaching briefly say, Texas. Record cold snaps once seen every 100 years, may need to be regarded as every 20, even 10 years. Weather extremes that hit fossil infrastructure. Texas lacks US interconnections, and sparse demand response there's an issue, as well as antiquated grid. Outside of Texas wind is rising fast a a percentage of power: 2020 Iowa (once an EV capitol) made 57% of its power from wind; it's not hard to envision conservative Iowa going over 100% by 2030! Conservative and red Oklahoma, Kansas, the Dakotas, all made over 30% power by wind 2020 – like Liberal blue Colorado, New Mexico, Nevada, Vermont. Offshore wind may come to the Great Lakes, US Gulf coast, West Coast: maybe offshore wind powerhouses ahead. With equity, inclusion, environmental justice – while building back better + with world as 'B3W'.

Consider CO_2: A Topic Gaining Importance

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

For just one acute sample of the science, a 2020 article in the Proceedings of National Academy of Sciences warns that in a span of just a "coming 50 years, 1 to 3 billion people are projected to be left outside the 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 brief excursion in these Reports as climate is so relevant to clean energy's story. And 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 frozen, zero degree C surface temperatures. Instead, warming thanks to CO_2 in small concentrations well under 400 ppm, meant greenhouse gases naturally gifted average temperatures near ideal for us 59 degrees F. We'd habituated to it over thousands/tens of thousands of years.

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

In 1992 a global compact was reached. Signed in Rio, the U.N. 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. Rio only implied *cuts,* like calling for global emissions to be -20% lower in 2005. Instead, CO_2 it turned out only grew - going +34% *higher by 2005*. Looking back it would go on rising another +22% higher by 2017 - to over 400 ppm in 2020s. That's higher than 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, 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 a mockery of 'acting' on CO_2. International agreements were again tried in 2009; that Copenhagen event also failed. CO_2 levels continued increasing, temperatures spiked up. In 2015 a Paris Agreement was roughly more of the same, CO_2 is still on a fast uphill, scary climb. By 2020, only 3 countries had met early target Paris terms: the Marshall Islands, Suriname, & Norway which made up only 0.1% of emissions globally. So there's No cause for optimism. A gathering in Glasgow 2021 meant to take stock of progress – yet the truth is despite the flowery words, there's been woefully none.

In sum commitment Isn't there. That's why it's arguably crucial to see 1) clean energy costs *unsubsidized,* can beat fossil fuels; 2) growing recognition of the science, first in Europe, and 3) since a Covid-19 crash, the idea of big change – like decarbonizing away from dirty fossils – into cleaner paths while creating jobs – seems more approachable worldwide.

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

Yet if we regard highest end of Representative Concentration Pathway (RCP) 8.5 unlikely, heaviest CO_2 emissions in 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 seen, and No use of coal. Neither (especially the latter) was close to accurate early 2020s.

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

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, 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 past under 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 influence of incoming solar energy vs. outgoing balance in our altered Earth-atmosphere system. Consequences of that may be dire for our species *for centuries* ahead, yet seems about what one might 'hope for'.

Next and 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 >400 & rising fast, rises in this view to 'just' some 650 ppm – unlikely, but stopping there. Strong decarbonization is assumed to be undertaken, from now, with CO_2 dropping. That *may* be possible, although it's a huge stretch to be sure. And arguably unlikely given present CO_2 is already some 50% greater than roughly 280 ppm pre-industrial era; rising fast. Arguably 4.5 is very improbable, as hundreds of new coal plants are *being built, right now* early 2020s. Each with life of 20 years or more, hence in operations in the 2040s and after, unless they are prematurely shuttered.

With renewables making only some 20% of electricity in many nations although growing, coal still burned widely, cars run on oil - a very ambitious RCP 4.5 with 2.7C or 4.9 F heating is an unlikely bet. That said 'unexpected' ice sheets destabilizing, heatwaves, floods, drought, may catalyze action. Sudden scary events may hasten action on climate. Models too inevitably are getting more complicated. Until recently, they'd ignored eg ice sheet destabilization. If a big pulse of melting of change gets visibly underway, skeptics may melt away too. Especially with clean energy becoming *the most economical choice*, creating jobs to boot.

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

Let's imagine, just a few decades hence. Europe & US using low-cost solar PV from China, cheap energy storage and great efforts, 1st reached 100% net carbon free power by 2035. Much of world later on got there by 2050. Electric vehicles had scaled faster than expected! Green H_2 came to lead in industry, as richer nations were climate neutral by 2050. China on much new nuclear got there by 2060, meeting its targets. Rest of world by 2070 though with much fudging like 'sequestration', and hopes that the Earth's 'natural sinks' remain so.

That timeline, fairly ambitious, is absolutely do-able. Unfortunately, mainstream science also implies that the inertia in that CO_2 scenario may destroy much of the world's low-lying lands & megacities from sea-level rise & climate crisis. It blows past a 2 C Paris goals (to say nothing of 1.5 C aspirations) and could land us all unbearably at 5 or 6+ degrees C hotter.

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

Imagine say, just ~80 years hence. Some aspects of what's projected by UN Intergovernmental Panel on Climate Change (IPCC) about sea level rise, in 2100, may be just a bit misleading. End of century, rise may be unwinding at more rapidly accelerating rates, than what's projected by the IPCC. Getting that wrong, lax policy may be allowing too much CO_2 and so inertia & heat in seas to build unduly. Something that can't then be halted, nor unwound.

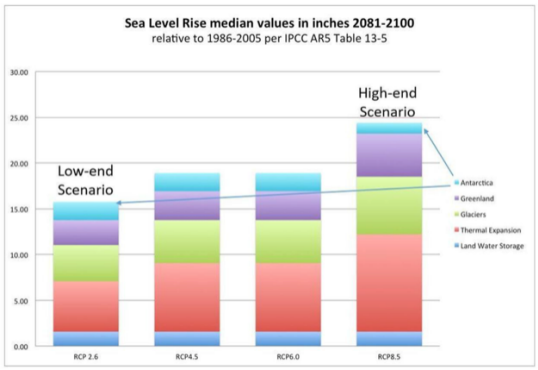
That the actual sea levels seen in 2100, could be greater than IPCC projections is well laid out in the 2020 piece, 'Twenty-first century sea-level rise could exceed IPCC projections for strong-warming futures' by M. Siegert et al., One Earth, 3 (Dec. 18, 2020).
https://doi.org/10.1016/j.oneear.2020.11.002

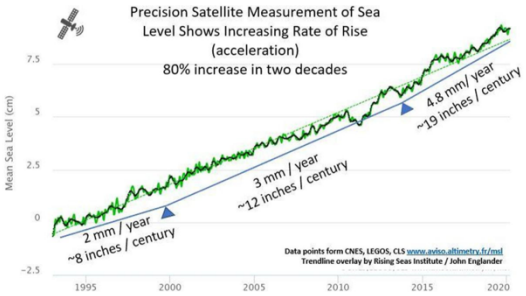
Their first paragraph nicely lays out in cogent clear words what scientists may find mainstream – yet these same thoughts ought to be viewed by a wider public with alarm:

> 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 a 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 out at about 1.1 meters (~3 feet) – yet that's in fact not true ceiling at all. It could be much higher.

Because uncertainty cloaks immense Antarctic dynamics, computer models exclude unclear mechanisms – so potential rise is hazy. Shorn of important details, an absence of certainty here strongly suggests the rise also *may max out at more than* 1.10 meters, >roughly 3 ft. Difficulty in modeling ice sheet/glacier dynamics has in a nutshell potentially left out possibly greater Antarctica contributions. It removed complex & cascading rise potential as a major factor. Especially in high heat scenarios, where we seem to be trending when comparing most recent models to reality. And still the IPCC high-end curiously indicates that the least rise comes from Antarctica, even in the RCP8.5 highest heat scenario 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 are of greater concern. Scientists understand a crucial fraction of airborne carbon already emitted from the industrial revolution, plus from 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 halted in 5 decades ahead, may have committed the world to great inertia seen 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 the 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 pulling all kinds of climate levers, releasing CO_2 and potent other greenhouse gases at rates not seen before. A global reshaping is what we're talking about. So put aside for a moment, noisy political debate. Ignore too other impacts, say, the new diseases, heat, storms, famines, droughts, collapsing ecosystems, follow-on impacts spreading out like ripples on a pond. Just the impacts of seas directly rising, is enough.

Climate & ocean inertia is something that we've written about - see eg Scientific American, Oct. 19, 2016 - observing for example how problematically models projecting scenarios of climate change forecast only out to a year 2100, at times just to 2050. As a result the public discussions have been mostly framed as "X degrees of warming" or "Y feet of 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 an artificial, specific time horizon. https://blogs.scientificamerican.com/guest-blog/exposed-the-climate-fallacy-of-2100/

The population of, like politicians representing Miami & State of Florida, no doubt intend for these places to exist beyond a mere few centuries. Same for New York City, Boston, Washington D.C., London, Shanghai, Amsterdam, Mumbai and so on. Yet leaders oft discount staggering losses these places *may* face ahead. That's due to a nearby 2100 horizon.

Anything like sea level rise going potentially for centuries, or thousands of years, essentially means "forever" on human time scales. These new data imply that 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, CO_2 >410 ppm and rising fast, think maybe Pliocene. About 3-5 million years back, when hot Earth had a forested arctic. We might reach such climate in just a couple centuries. Of course, it will 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' temperature change. Those millions of years ago, CO_2 changes occurring naturally took many 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 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 a couple million years of hot Earth before humans appeared, PPMs and temps fell; down off of 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 CO2 out of the atmosphere over very, very long periods of time by Earth's natural 'rock thermostat'. Specifically, CO_2 was absorbed for example by rocks over millions of years. And taken up as by calcium carbonate and oceans

That long cooling after Pliocene, lowered CO_2 allowed 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 has taken to go from hot Pliocene, are being explosively undone. In just 250 years of fossil fuels, we've dramatically been destroying cold. Vanquishing so many 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 climate crisis, emergency with no fix.

Because of this, pulling CO_2 from air (& oceans) may soon be a necessity. Different from clean renewable energy done in first place to prevent pollution, there's a variety of potential (not so awful) ways that this might happen – and if done right – it very sadly may make sense. Of course, it mustn't be done in ways extending fossil fuels. And cannot be done say, by treating the deep oceans 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 these Indexes. But in 2021, no such technologies existed. None are ecologically benign yet, 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.

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

An international panel 2013 gave scenarios for rise this century mainly on a straightforward expansion of warming oceans. They had only allowed then for a small influence from new runoff 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.

The report presented an optimistic lower-end CO_2 scenario that assumed strong actions would be taken later on in this century to reduce CO_2 emissions, and predicted on that an estimated just 1 foot of rise (0.3 to 0.6 meters) by 2100. The high-end estimate, based on current trends continuing and little strong action this century to reduce CO_2, led to about 3.5 feet of rise by 2100, with the rate increasing rapidly to between one third to over half of an inch (8 to 16 millimeters) per year, during the last two decades of this century. 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 and 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:

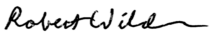
The Clean Energy Index® (ECO) started 3rd Quarter around 195 and ended Q3 around 160, down some -18%. After a big +203% gain over 2020 when this decarbonization story rose by 6-fold, about best performance of most any Index or Fund anywhere, a fall in 2021 was maybe due. So it wasn't surprising after ECO had fallen by ½ in 2020 to 50, a big rise afterwards to 280 - to see it again fall by ½ in 2021 to a nadir so far near 150. Such volatility is partly due to the very big and pro-clean energy policies, increasingly now happening for this theme worldwide. Or since the start of 2017, when ECO Index® was at 38, it's now up +340%.

The first-ever *global* clean energy Index is New Energy Global Innovation Index (NEX) live since 2006. The NEX is up +160% last 5 years to Q3 also starkly beating fossil fuels: there's now a tracker in Europe (GCLE; London). Global NEX has also outperformed vs. a major, younger independent global clean energy Index most every sizable period: Year to Date, past 1, 5, 10 years, since inception etc; equal weights here & greater purity help explain that divergence. In sum the WilderHill themes are firsts and benchmarks. And energy long taken from deep underground and burned – increasingly is captured in disruptive & sustainable ways – coming to us cleanly, freely, and renewably from up towards Heavens.

6 Additions to ECO Index for the start of Q4 2021 were: Enovix, EVgo, Joby Aviation, Li-Cycle, ReNew Power, and Standard Lithium; and 2 Deletions to start Q4 were: Broadwind, and Flux. At the Global NEX Index for start of Q4 2021, 7 Additions were: Abalance (Japan); Acciona Energias Renovables (Spain), EVgo (US), FREYR Battery (Norway/US), Joby Aviation (US), Li-Cycle (US), REE Automotive (Israel/US); and 7 NEX Deletions there for the start of Q4 were: Arise, Everfuel, HydrogenPro, Invinity, PNE, Proton Motor, and Solarpack .

As always, we welcome your thoughts and suggestions.

Sincerely,



Rob Wilder
rwilder@wildershares.com

Appendix I:

ECO Index (via independent tracker PBW) Descending Weights in latter-Q3 on 9/14/2021, or about ~2 weeks before the rebalance to start Q4 2021, 67 Stocks:

Name	Symbol	Weight
Lithium Americas Corp	LAC	2.65
First Solar Inc	FSLR	2.52
Albemarle Corp	ALB	2.43
JinkoSolar Holding Co Ltd ADR	JKS	2.41
Livent Corp	LTHM	2.31
Array Technologies Inc	ARRY	2.26
Quanta Services Inc	PWR	2.09
Sociedad Quimica y Minera de Chile SA ADR	SQM	2.07
Daqo New Energy Corp ADR	DQ	2.05
Tesla Inc	TSLA	2.04
MYR Group Inc	MYRG	1.97
Ormat Technologies Inc	ORA	1.95
Maxeon Solar Technologies Ltd	MAXN	1.88
Canadian Solar Inc	CSIQ	1.85
Gentherm Inc	THRM	1.83
Azure Power Global Ltd	AZRE	1.82
Ameresco Inc	AMRC	1.75
Shoals Technologies Group Inc	SHLS	1.74
MP Materials Corp	MP	1.74
Willdan Group Inc	WLDN	1.69
Infrastructure and Energy Alternatives Inc	IEA	1.67
Sunnova Energy International Inc	NOVA	1.67
SolarEdge Technologies Inc	SEDG	1.65
XPeng Inc ADR	XPEV	1.64
ReneSola Ltd ADR	SOL	1.64
FTC Solar Inc	FTCI	1.60
Woodward Inc	WWD	1.58
Universal Display Corp	OLED	1.51
Enphase Energy Inc	ENPH	1.51
Cree Inc	CREE	1.51
NIO Inc ADR	NIO	1.49
TPI Composites Inc	TPIC	1.49
American Superconductor Corp	AMSC	1.43
ESCO Technologies Inc	ESE	1.43
Sunrun Inc	RUN	1.42
SunPower Corp	SPWR	1.41

Arcimoto Inc	FUV	1.40
Piedmont Lithium Inc	PLL	1.39
Gevo Inc	GEVO	1.38
Kandi Technologies Group Inc	KNDI	1.36
Ballard Power Systems Inc	BLDP	1.36
QuantumScape Corp	QS	1.33
Advent Technologies Holdings Inc	ADN	1.32
Advanced Energy Industries Inc	AEIS	1.31
Itron Inc	ITRI	1.30
ElectraMeccanica Vehicles Corp	SOLO	1.29
Beam Global	BEEM	1.26
Blink Charging Co	BLNK	1.26
Fisker Inc	FSR	1.24
GreenPower Motor Co Inc	GP	1.24
Renewable Energy Group Inc	REGI	1.23
Eos Energy Enterprises Inc	EOSE	1.23
Bloom Energy Corp	BE	1.20
Canoo Inc	GOEV	1.19
Sunworks Inc	SUNW	1.14
Plug Power Inc	PLUG	1.12
Lion Electric Co/The	LEV	1.09
Lordstown Motors Corp	RIDE	1.07
ChargePoint Holdings Inc	CHPT	1.05
Stem Inc	STEM	1.04
Workhorse Group Inc	WKHS	1.03
FuelCell Energy Inc	FCEL	0.95
Romeo Power Inc	RMO	0.94
SPI Energy Co Ltd	SPI	0.43
AYRO Inc	AYRO	0.43
Flux Power Holdings Inc	FLUX	0.39
Broadwind Inc	BWEN	0.35

There's strong representation at top from *Lithium & materials for batteries, *Solar Power, *Electric Vehicles, *Grid, *Electric Vehicles, and *Geothermal.

Starting March 2021: Effective First Quarter 2021 quarterly Rebalance announcements for WilderHill Clean Energy Index (ECO) occur after close, sixth index business day prior to last index business day of month - March, June, September, December: Announcements made by New York Stock Exchange. (Only later are those data posted on our website – the following month).

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

INDEX (ECO) SECTOR & STOCK WEIGHTS FOR START OF Q4 2021. 71 STOCKS.
Each stock freely floats according to its share price after rebalance.
*Stocks below $200 million in size at rebalance are *banded with a 0.50% weight.

Renewable Energy Harvesting - 17% weight (11 stocks @1.50% each +1 *banded)
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 is in EVs.
TPI Composites, TPIC. Wind Blades; also light-weighting for transportation.

Energy Storage - 26% sector weight (18 stocks @1.44% 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.
GreenPower Motor, GP. Large EV, electric transit buses, transit, school buses.
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.
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 - 24% sector (17 stocks @1.38% each + 1 *banded)
Ameresco, AMRC. Energy saving efficiencies, net zero CO_2, decarbonization.
American Superconductor, AMSC. Wind, grid conditioning; superconductors.
Arcimoto, FUV. EVs, smaller very low-cost 3 wheeled electric vehicles.
**Ayro,* AYRO. EVs, compact fleet vehicles university & corporate campuses.
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, EVs and fleets.

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.
Shoals, SHLS. Solar, electrical balance of system (EBOS), wiring, combiners.
Universal Display, OLED. Organic light emitting diodes, efficient displays.
Willdan, WLDN. Efficiency, in distributed energy, renewables, engineering.

Energy Conversion - 20% sector weight (14 stocks @1.42% 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.
Cree, CREE. Power electronics, electrifying EV power, SiC, converters.
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.
Li-Cycle, LICY. Battery Recycling, closed-loop of lithium, other materials.
MP Materials, MP. Rare Earths, domestic U.S. source Neodymium, NdPr.
Plug Power, PLUG. Small fuel cells, for eg forklifts; drop in replacements.
SolarEdge Technologies, SEDG. Inverters, solar optimizers, inverters.
Woodward, WWD. Converters, controls for wind power, energy storage.

Greener Utilities – 10% sector weight (6 stocks @1.58% each + 1 *banded)
Beam, BEEM. EV Charging, rapidly deployable portable PV powered utility.
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 – 3% sector weight (2 stocks @1.50% 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-Q3 via independent tracker (PBD) 9/14/21, ~2 weeks before Rebalance to start Q4 2021. 125 stocks:

Name	Symbol	Weight
Ecopro BM Co Ltd	247540 KS	1.59
West Holdings Corp	1407 JP	1.39
RENOVA Inc	9519 JP	1.31
Lithium Americas Corp	LAC	1.29
SK IE Technology Co Ltd	361610 KS	1.17
Flat Glass Group Co Ltd	6865 HK	1.13
Solarpack Corp Tecnologica SA	SPK	1.11
First Solar Inc	FSLR	1.10
Livent Corp	LTHM	1.10
Alfen Beheer BV	ALFEN	1.10
Ganfeng Lithium Co Ltd	1772 HK	1.09
Nibe Industrier AB	NIBEB SS	1.07
Xinjiang Goldwind Science & Technology	2208 HK	1.01
Array Technologies Inc	ARRY	0.99
Falck Renewables SpA	FKR	0.98
Verbund AG	VER AV	0.97
Kingspan Group PLC	KSP	0.97
VERBIO Vereinigte BioEnergie AG	VBK	0.95
JinkoSolar Holding Co Ltd ADR	JKS	0.95
Xinyi Solar Holdings Ltd	968 HK	0.93
Sociedad Quimica y Minera de Chile SA ADR	SQM	0.93
Ceres Power Holdings PLC	CWR LN	0.93
SolarEdge Technologies Inc	SEDG	0.91
Koninklijke DSM NV	DSM	0.91
EDP Renovaveis SA	EDPR	0.91
Sunnova Energy International Inc	NOVA	0.90
BYD Co Ltd	1211 HK	0.90
Iljin Materials Co Ltd	020150 KS	0.89
Vestas Wind Systems A/S	VWS DC	0.89
MP Materials Corp	MP	0.89
Shoals Technologies Group Inc	SHLS	0.89
Ameresco Inc	AMRC	0.88
SFC Energy AG	F3C	0.88
Nordex SE	NDX1	0.88
ITM Power PLC	ITM LN	0.88
Xinyi Energy Holdings Ltd	3868 HK	0.88
Enphase Energy Inc	ENPH	0.88

Hydrogen Refueling Solutions	ALHRS FP	0.87
Prysmian SpA	PRY	0.87
SolTech Energy Sweden AB	SOLT SS	0.86
Grenergy Renovables SA	GRE	0.86
Maxeon Solar Technologies Ltd	MAXN	0.86
Samsung SDI Co Ltd	006400 KS	0.85
Acciona SA	ANA	0.85
Hannon Armstrong Sustainable Infrastructure	HASI	0.85
Orsted AS	ORSTED	0.85
Sunrun Inc	RUN	0.84
Caverion Oyj	CAV1V FH	0.84
Ormat Technologies Inc	ORA	0.84
Enlight Renewable Energy Ltd	ENLT	0.84
Greencoat UK Wind PLC/Funds	UKW LN	0.84
Sino-American Silicon Products Inc	5483 TT	0.83
Mercury NZ Ltd	MCY	0.83
Voltalia SA	VLTSA FP	0.82
Novozymes A/S	NZYMB DC	0.81
2G Energy AG	2GB	0.81
Landis+Gyr Group AG	LAND SW	0.80
Azure Power Global Ltd	AZRE	0.80
Terna - Rete Elettrica Nazionale	TRN	0.79
Canadian Solar Inc	CSIQ	0.78
Boralex Inc	BLX	0.78
Neoen SA	NEOEN FP	0.78
Meridian Energy Ltd	MEL	0.78
Willdan Group Inc	WLDN	0.77
Encavis AG	ECV	0.77
Daqo New Energy Corp ADR	DQ	0.76
Greenlane Renewables Inc	GRN	0.76
PNE AG	PNE3	0.76
Solaria Energia y Medio Ambiente SA	SLR	0.76
XPeng Inc ADR	XPEV	0.76
Doosan Fuel Cell Co Ltd	336260 KS	0.76
TransAlta Renewables Inc	RNW	0.75
Invinity Energy Systems PLC	IES LN	0.75
Hexagon Purus ASA	HPUR	0.75
Universal Display Corp	OLED	0.75
CropEnergies AG	CE2	0.74
Innergex Renewable Energy Inc	INE	0.74

American Superconductor Corp	AMSC	0.74
Cree Inc	CREE	0.74
AFC Energy PLC	AFC LN	0.73
Motech Industries Inc	6244 TT	0.73
SunPower Corp	SPWR	0.73
Gencell Ltd	GNCL	0.73
Ballard Power Systems Inc	BLDP	0.72
GS Yuasa Corp	6674 JP	0.72
PowerCell Sweden AB	PCELL SS	0.71
CS Wind Corp	112610 KS	0.71
United Renewable Energy Co Ltd/Taiwan	3576 TT	0.71
Eolus Vind AB	EOLUB SS	0.71
FTC Solar Inc	FTCI	0.71
Gevo Inc	GEVO	0.70
Siemens Gamesa Renewable Energy SA	SGRE	0.69
Signify NV	LIGHT	0.68
ReneSola Ltd ADR	SOL	0.68
NIO Inc ADR	NIO	0.67
Hydrogenpro AS	HYPRO	0.67
SMA Solar Technology AG	S92	0.66
Arise AB	ARISE SS	0.66
Bloom Energy Corp	BE	0.66
Plug Power Inc	PLUG	0.66
Arcosa Inc	ACA	0.65
TPI Composites Inc	TPIC	0.65
Piedmont Lithium Inc	PLL	0.64
Itron Inc	ITRI	0.64
Fisker Inc	FSR	0.64
Gurit Holding AG	GUR SW	0.64
QuantumScape Corp	QS	0.62
Cell Impact AB	CIB SS	0.62
Aker Offshore Wind AS	AOW	0.61
Sunworks Inc	SUNW	0.60
GreenPower Motor Co Inc	GP	0.59
Scatec ASA	SCATC	0.59
Everfuel A/S	EFUEL	0.58
NEL ASA	NEL	0.58
Stem Inc	STEM	0.57
Renewable Energy Group Inc	REGI	0.57
ChargePoint Holdings Inc	CHPT	0.57

Xebec Adsorption Inc	XBC	0.55
Eos Energy Enterprises Inc	EOSE	0.54
Proton Motor Power Systems PLC	PPS LN	0.52
Lion Electric Co/The	LEV	0.52
Canoo Inc	GOEV	0.51
Lordstown Motors Corp	RIDE	0.50
McPhy Energy SA	MCPHY FP	0.50
FuelCell Energy Inc	FCEL	0.49

Among the best performers in NEX the period above, there's clear representation from *Lithium & Battery Materials, *Solar Power, *Biofuels, *Efficiency, *Wind Power.

Appendix IV:

WilderHill New Energy Global Innovation (NEX) - for start of Q4 2021. 125 Stocks.

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

Name	Description	Sector	Curr.	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 tech.	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 Supercond.	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
Canadian Solar	Solar, vertically integrated solar manufacturer, China.	RSR	USD	CANADA
Canoo	Electric delivery vehicles, configurable, multipurpose.	EEF	USD	US
Caverion OYJ	Energy efficiency, buildings, infrastructure, Europe.	EEF	EUR	FINLAND
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
Corp. Acciona Energias	Renewables, one of world's biggest: wind, solar etc.	RWD	EUR	SPAIN
Cree Inc.	Power electronics, electrifying powertrains, SiC, GaN.	EEF	USD	US
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
Encavis AG	Solar, large solar park operator, also wind, Germany.	RSR	EUR	GERMANY
Enlight Renewable	Solar & wind power, energy storage infrastructure.	RSR	ILS	ISRAEL
Enphase	Inverters, micro-products for solar panels, storage.	RSR	USD	US
Eolus Vind	Wind power, also consulting services for wind.	RWD	SEK	SWEDEN
Eos Energy	Batteries, zinc chemistry for stationary grid storage.	ENS	USD	US
Evgo	EV charging, an early leader in fast charging.	EEF	USD	US
Falck Renewables SpA	Renewable wind, biomass, WtE, solar, Europe.	RWD	EUR	ITALY
First Solar	Thin film solar, CdTe low-cost alternate to polysilicon.	RSR	USD	US
Fisker	Electric cars, electric SUVs, w/ contract manufacturer.	ENS	USD	US
Flat Glass Group	PV panel glass, solar plants engineering & construction	RSR	HKD	CHINA
Freyr Battery SA	Batteries, decarbonization includes cell manufacturing.	ENS	USD	NORWAY
FTC Solar	Solar, ground mounted trackers; also PV software.	RSR	USD	US
FuelCell Energy	Fuel cells, high temperature and hydrogen.	ECV	USD	US
Ganfeng Lithium	Lithium, production of compounds, metals, 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
Greencoat UK Wind plc	Infrastructure fund, invested in U.K. wind power assets.	RWD	GBP	UK
Greenlane Renewables	Renewable natural gas, lower-carbon liquid fuels.	RBB	CAD	CANADA
GreenPower Motor	Electric vehicles, transit, school and charter buses.	ENS	USD	CANADA
Grenergy Renovables SA	Solar and wind, batteries, Spain, Latin America.	RSR	EUR	SPAIN
GS Yuasa	Battery technologies, also lithium for EVs, Japan.	ENS	JPY	JAPAN
Gurit Holding AG	Composite Materials in wind, lightens cars, planes.	RWD	CHF	SWITZERLAND
Hannon Armstrong	Energy efficiency, capital & finance for infrastructure.	EEF	USD	US
Hexagon Purus AS	Hydrogen storage, whole systems for FC vehicles.	ENS	NOK	NORWAY
Hydrogen Refueling Sol	Hydrogen refueling, turnkey systems for heavy trucks.	ENS	EUR	FRANCE
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
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
Maxeon Solar	Solar panel manufacturer, a spinoff.	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
Nibe Industrier AB	Heating & cooling, sustainable technologies, Sweden.	EEF	SEK	SWEDEN
Nio	Electric Vehicles, design, manufacture, premium EVs.	ENS	USD	CHINA
Nordex SE	Wind turbines, based in Germany/Europe, worldwide.	RWD	EUR	GERMANY
Novozymes A/S	Biofuels, enzymes used in partnerships, Denmark.	RBB	DKK	DENMARK
Ormat	Geothermal, works too in recovered heat energy.	ROH	USD	US
Orsted A/S	Sustainable wind, also biomass, thermal, Denmark.	RWD	DKK	DENMARK
Piedmont Lithium	Lithium, US-based source for battery-grade lithium.	ENS	USD	US
Plug Power	Small fuel cells, e.g. in forklifts; drop in replacements.	ECV	USD	US
Powercell Sweden	Fuel cells, transportation, marine, stationary uses.	ECV	SEK	SWEDEN
Prysmian SpA	Cables, renewable power transmission, global.	EEF	EUR	ITALY
Quantumscape	Lithium metal batteries, solid state, quicker charge.	ENS	USD	US
REE Automotive	Modular EV platforms, efficiency in wheel arch.	EEF	USD	ISRAEL
ReneSola	Solar, project developer and operator, worldwide.	RSR	USD	CHINA
Renewable Energy Grp	Biodiesel, natural fats, oils, grease to biofuels.	RBB	USD	US
Renova	Wind, Solar, Biomass, power generation in Asia.	RWD	JPY	JAPAN
Royal DSM	Biofuels, reduction of CO2 and methane emissions.	RBB	EUR	NETHERLANDS
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
Sunworks	Solar installations, 1-stop for commercial & residential.	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
TransAlta Renewables	Renewables, operating wind power, some hydro.	RWD	CAD	CANADA
United Renewable Ener	Solar, also energy storage, hydrogen and fuel cells.	RSR	TWD	TAIWAN
Universal Display	Organic light emitting diodes, efficient displays.	EEF	USD	US
Verbio Vereinigte Bio.	Biofuels, manufacturer supplier to Germany, Europe.	RBB	EUR	GERMANY
Verbund AG	Electricity supplier, hydro, a large provider for Austria.	ROH	EUR	AUSTRIA
Vestas Wind Sys A/S	Wind, wind turbine manufacturing & services, Denmark.	RWD	DKK	DENMARK
Voltalia SA	Renewables, biomass, wind, solar, also carbon credits.	RBB	EUR	FRANCE
West Holdings	Solar, Japan-focused residential and commercial PV.	RSR	JPY	JAPAN
Willdan Group	Energy efficiency in infrastructure, engineering.	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

% WEIGHT EACH COMPONENT for Q4 2021

125 stocks/100 =
Weight each: **0.800000**

7 Additions Q4 2021: Abalance, Acciona Energias, Evgo, FREYR Battery, Joby, Li-Cycle, REE.
7 Deletions Q4 2021: Arise, Everfuel, HydrogenPro, Invinity, PNE, Proton Motor, Solarpack.

125 Stocks for Start of Q4 2021.

NEX SECTOR WEIGHTS:	SECTOR	#	% Approx. Weight
Energy Conversion	**ECV**	**16**	**13%**
Energy Efficiency	**EEF**	**19**	**15%**
Energy Storage	**ENS**	**24**	**19%**
Renewables - Biofuels	**RBB**	**9**	**7%**
Renewables - Other	**ROH**	**5**	**4%**
Renewable - Solar	**RSR**	**32**	**26%**
Renewable - Wind	**RWD**	**20**	**16%**
		125	**100%**

NEX Index: notes ADT Value floor goes from USD 25k/day – to 250k/day. August 26, 2021:

Methodology Change | WILDERHILL NEW ENERGY GLOBAL INNOVATION INDEX | Effective Date 09/09/2021

Today, on the 26/08/2021, Solactive announces the following changes to the methodology of the following Indices (the 'Affected Indices'):

NAME	RIC	ISIN
Wilderhill New Energy Global Innovation Index (USD)	.NEX	US96811Y1029
Wilderhill New Energy Global Innovation Index (USD NTR)	.NEXUSN	DE000SLA47C1
Wilderhill New Energy Global Innovation Index (USD TR)	.NEXUST	DE000SLA4684
Wilderhill New Energy Global Innovation Index (EUR)	.NEXEU	DE000SLA4650
Wilderhill New Energy Global Innovation Index (EUR NTR)	.NEXEUN	DE000SLA47D9
Wilderhill New Energy Global Innovation Index (EUR TR)	.NEXEUT	DE000SLA4692
Wilderhill New Energy Global Innovation Index (GBP)	.NEXBP	DE000SLA4668
Wilderhill New Energy Global Innovation Index (GBP NTR)	.NEXBPN	DE000SLA47E7
Wilderhill New Energy Global Innovation Index (GBP TR)	.NEXBPT	DE000SLA47A5
Wilderhill New Energy Global Innovation Index (JPY)	.NEXJY	DE000SLA4676
Wilderhill New Energy Global Innovation Index (JPY NTR)	.NEXJYN	DE000SLA47F4
Wilderhill New Energy Global Innovation Index (JPY TR)	.NEXJYT	DE000SLA47B3

Rationale for Methodology Change

The Affected Indices provide exposure to companies that have business operations in innovative climate change solutions which include clean energy, renewables, decarbonization and energy efficiency. In order to meet liquidity requirements that properly reflect the current market conditions revolving around ESG, Solactive determined to increase the AVERAGE DAILY VALUE TRADED over the last 30 days prior to the SELECTION DAY from USD 25K to USD 250K on the next regular quarterly rebalance and going forward.

Changes to the Index Guideline

The following Methodology changes will be implemented in the following points of the Index Guideline (ordered in accordance with the numbering of the affected sections):

1. **Section 2.2. – SELECTION OF THE INDEX COMPONENTS**

From (old version)
[…]
AVERAGE DAILY VALUE TRADED over the last 30 days prior to the SELECTION DAY is larger than USD 25k.
[…]
To (new version):
AVERAGE DAILY VALUE TRADED over the last 30 days prior to the SELECTION DAY is larger than USD 250k.

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

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 Q3 2021, 110 components:

WilderHill (OCEAN) components	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
Advent Technologies	Fuel Cells, make core membranes assembly.	USA	PP
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, Ships.	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
CREE	Power electronics in EVs, Si-C.	USA	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
Eneti	Offshore Wind Turbine installation Vessels.	Monaco	GT
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
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
FuelCell Energy	H2 fuel cells, power ahead ports, shipping.	USA	GT
Geberit AG	Waste treatment, supply, piping.	Switzerland	WT
GenCell	Fuel Cells, hydrogen and ammonia.	Israel	GT
Green Hydrogen Systems	Electrolyzers, green H2 from renewables.	Denmark	CE
GreenPower Motor	Electric Buses and large transit vehicles.	Canada	PP
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
Hexagon Purus	Hydrogen, storage & systems in transport.	Norway	GT

Idex	Water, pumps, flow meters, fluid systems.	USA	WT
Innergex Renewable	Run-of-river Hydro power, Wind, Solar.	Canada	CE
Intertek Group plc	Cargo and Trade services, quality assurance.	Britain	PP
ITM Power PLC	Electrolysis for green hydrogen, zero CO2.	Britain	PP
Itron	Smart Grid Power and Water Management.	USA	PP
Kingspan Group PLC	Building Insulation.	Ireland	PP
Kuehne und Nagel	Shipping Logistics, clean cargo group.	Switzerland	PP
Kurita Water	Water Treatment, wastewater systems.	Japan	WT
Leroy Seafood Group	Seafood, with high FAIRR Report score.	Norway	SF
Maxeon Solar	Solar, higher-efficiency premium PV panels.	USA	CE
McPhy Energy SAS	Hydrogen, for decarbonization.	France	PP
Mercury NZ	100% Renewables by hydro, geothermal, wind.	New Zealand	CE
Meridian Energy	Power generation 100% from renewables.	New Zealand	CE
Metawater	Water purification, sewage treatment plants.	Japan	WT
Mowi ASA	Seafood, with high FAIRR Report score.	Norway	SF
MP Materials	Rare Earths, used in EVs, wind turbines etc.	USA	PP
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
Proton Motor Power	Fuel cells, and hydrogen production.	Germany	CE
Quantumscape	Solid state lithium-metal batteries.	USA	PP
Royal DSM Konink.	Algal omega-3 salmon aquaculture feedstock.	Netherlands	SF
SalMar ASA	Seafood, aquaculture with high ESG scores	Norway	SF
Samsung SDI	Li Ion Batteries.	S. Korea	CE
Scatec Solar ASA	Solar, developer across emerging nations.	Norway	CE
SFC Energy AG	Fuel Cells, direct methanol.	Germany	GT
Shoals Technologies	Solar, electric Balance of System for PV.	USA	CE
Siemens Gamesa Renewable	Wind turbines, and focus on renewables.	Spain	CE
Signify NV	LEDs, was Philips Lighting.	Netherlands	PP
Sino-American Silicon Products	Solar feedstock, wafers.	Taiwan	CE
SolarEdge	Solar MicroInverters	USA	CE
Solaria Energia y Medio	Solar, Wind, power from renewables plants.	Spain	CE

Sunnova Energy	Residential Solar and Energy Storage.	USA	CE
SunPower Corp	Solar, services plus storage.	USA	CE
Sunrun Inc	Solar, residential Installer.	USA	CE
SunWorks	Solar, one-stop systems 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
Voltalia	Renewables producer, also energy storage.	France	CE
Vow ASA	Wastewater treatment, in Aquaculture.	Norway	WT
Wartsila OYJ	Ports, Terminals, energy with sustainability.	Finland	GT
Watts Water Technologies	Water quality, rainwater harvest, flow control.	USA	WT
Xebec Adsorption	Hydrogen, generation and purification.	Canada	PP
Xinjiang Goldwind Science & Tech.	Wind, turbine manufacturer, also in services.	China	CE
Xinyi Solar Holdings Ltd	Solar glass, has spun off solar farms.	China	PP
Xpeng	Electric vehicles, connectivity.	China	PP
Xylem	Water Technologies.	USA	WT

For Rebalance in latter Q3 2021

Deletes: AMTX.OQ, ARISE.ST, EFUEL-ME.OL, GRN.TO, HYPRO-ME.OL, ALHRS.PA, IES.L, PNEGn.DE, SPK.MC, ****VGM-ME.OL.

****VGM-ME.OL had been briefly added intra-Q2 due to a demerger only.

Additions: ANE.MC, GREENH.CO, ORGN.OQ.

Equal Weight = 110/100 = 0.909090% each.

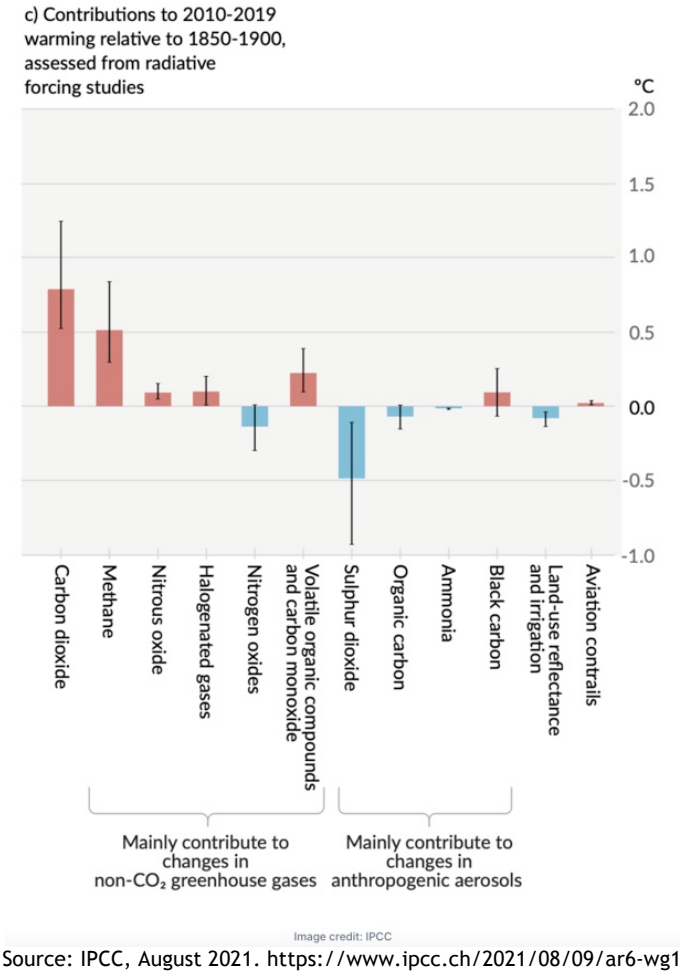
Cool Climate™ (OCEAN) SECTOR	#	Approx. Weight
GREENER TRANSPORT (GT) =	15	14%
CLEAN ENERGY (CE) =	37	34%
WATER (WT) =	19	17%
SUSTAINABLE FOODS (SF) =	7	6%
POLLUTION PREVENTION (PP) =	32	29%
TOTAL CONSTITUENTS =	110	

**Up to 10% of OCEAN Index Constituents that have received an ESG score, may have that ESG Score be under B-.
**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).

Big concerns over Global Heating will soon expand beyond CO_2 - to include leaking natural gas (methane) & other shorter-lived and yet potent Greenhouse Gases.

As for methane from human activities, about 40% comes from agriculture including livestock, 15% from landfills/organic wastes; some could be avoided or captured though it's a challenge. Methane however now seen leaking globally from oil & gas drilling, pipelines and coal mines - can soon be much more quickly & largely ended. Eliminating near half of that this decade by 2030, could shave close to 0.3 degrees Celsius off global heating by 2045.

Hence there's several fronts in this war ahead against GHGs to save a once-cooler climate. 'Carbon' aka carbon dioxide, or CO_2, was a short-hand way to refer to All greenhouse gases – letting methane go virtually undiscussed. But the shorthand now should be unpacked in detail. Carbon dioxide *has been* responsible for about 40% of heating in a decade to 2019 – and methane massively contributes too near 25%. There's other contributors as well - seen here as methane/natural gas is but one more clear target for action now:



Source: IPCC, August 2021. https://www.ipcc.ch/2021/08/09/ar6-wg1-20210809-pr

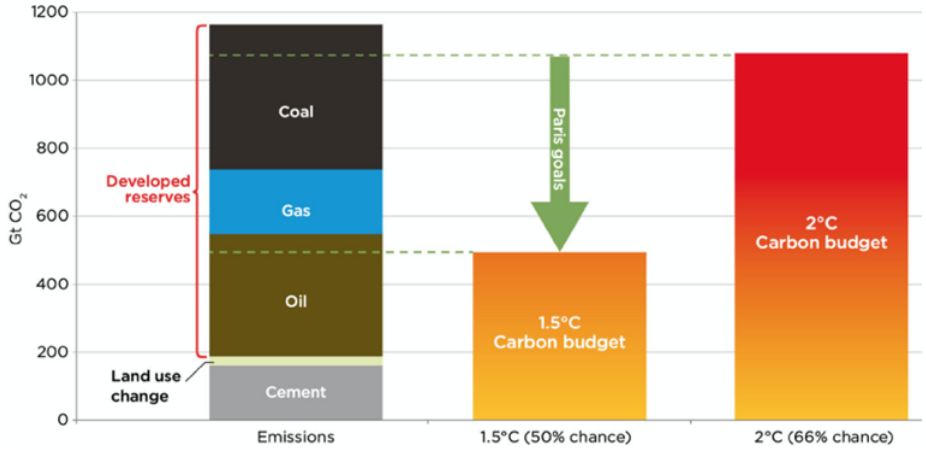
To paraphrase Bill Gates, we must get to near-zero emissions of All GHGs in a few decades, in all 5 types of human activities contributing most emissions: *how we make electricity, *how we make things, *how we grow things, *how we get around, *how we keep warm & cool.

For how Dire the CO_2 Facts & Trends may be in 2021: consider this Carbon Budget Chart by Oil Change International (OCI) next comparing what's likely to be burned of fossil fuel reserves coal, oil, and natural gas - vs Earth's possible carbon budget. These data imply, first, that for Paris' goals of 1.5 C warming to be achieved – ALL world proven fossil fuel reserves that are not now producing, would have to abandoned! No New mining or drilling!

That seems almost 100% certain NOT to Happen. While some European oil firms are thinking seriously of becoming 'energy companies', US majors and elsewhere are more intent on marketing & on promoting carbon capture, so relying on fossils. As for *developed* reserves, keeping to 1.5 C means all extant coal must be abandoned this decade, a Thanos-like snap of fingers – or we'll blow past 1.5 C. Only by halting all extant coal, plus most oil & gas in 2020s, may carbon budget see 'just' 1.5 C rise. It's simple physics & chemistry. Whatever oil firms might desire, nations or people may want to think, leaders are prepared to 'promise' about say a distant 2050, this budget if accurate, puts a hard ceiling on fossils *now*. Period.

Hence to say our Planet & Oceans will likely realistically blow past it in this decade 2020s is a hard truth. It scarily acknowledges where things are, early vital 2020s. And yet much might just possibly, look very different in 10 years' time near end of this seminal 2020s:

FIGURE 1: CO_2 EMISSIONS FROM DEVELOPED GLOBAL FOSSIL FUEL RESERVES, COMPARED TO CARBON BUDGETS WITHIN RANGE OF THE PARIS GOALS



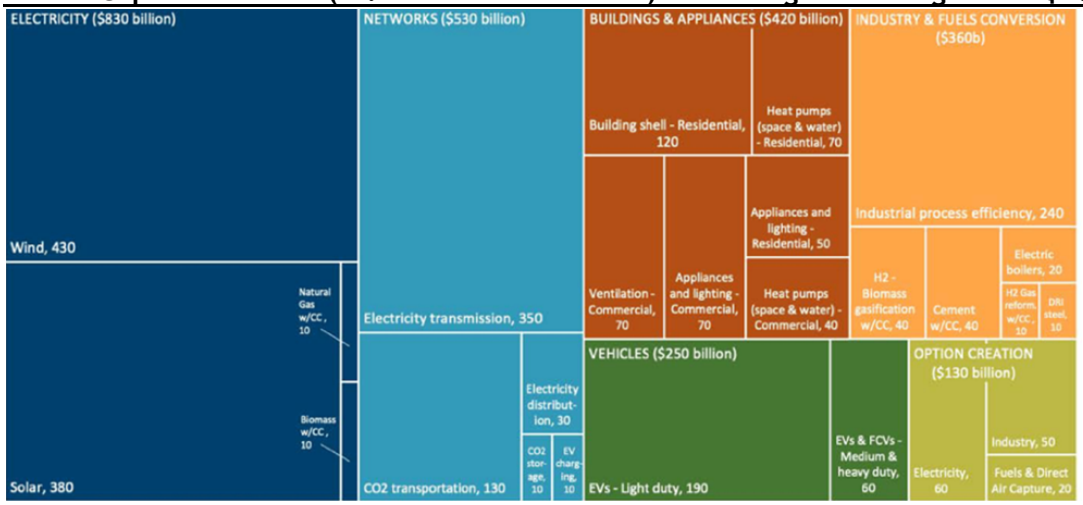
Source: Oil Change International (OCI), 'Big Oil Reality Check: Assessing Oil & Gas Company Climate Plans.' 2020.

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; some of these may be in the ECO Index and they are all held-very long-term only.

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

---

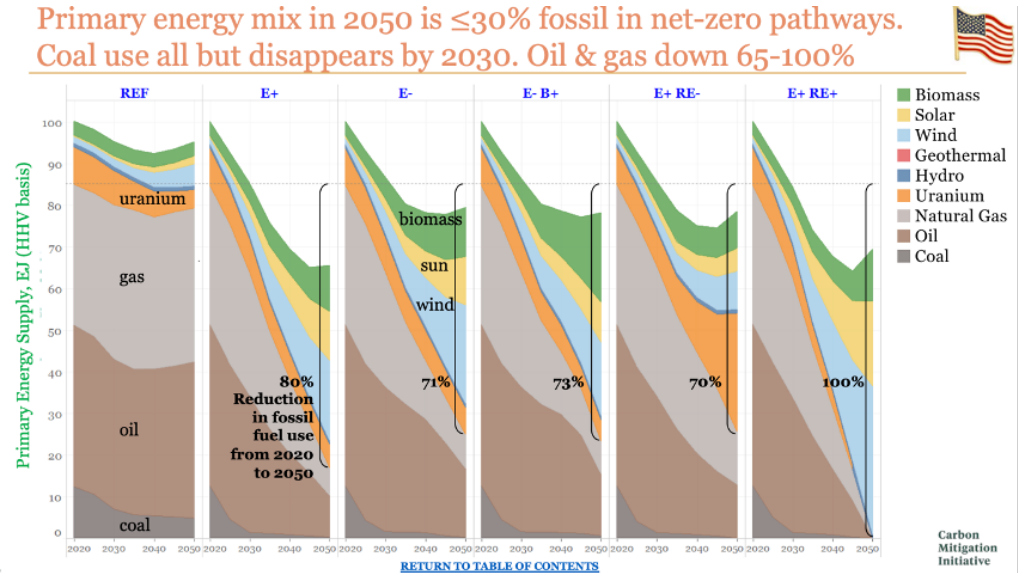
A Look at some important divergent Possibilities for Capital ahead in 2020s Decade: Added Capital Invested (vs. reference scenario) in coming 2020s might be >$2.5 Trillion:



Source: Oil Change International (OCI), 'Big Oil Reality Check: Assessing Oil & Gas Company Climate Plans.' 2020. Interim Report. Net-Zero America: Potential Pathways, Infrastructure, and Impacts. By E. Larson, C. Greig, J. Jenkins, et al. Princeton U., Princeton, NJ. December 15, 2020.

Total additional capital invested 2021-2030, by sector and subsector for a net-zero pathway vs. business as usual (billions 2018 $)

Source: Net-Zero America. High Meadows Environmental Inst., Carbon Mitigation In. Princeton Univ., Dec 2020.



Source: Net-Zero America. High Meadows Environmental Inst., Carbon Mitigation Inst. Princeton Univ., Dec 2020.