WilderShares, LLC

Q2 2021 Quarterly Report: WilderHill Clean Energy Index®, June 30, 2021

The Clean Energy Index® (ECO) started 2nd Quarter around 200, and ended Q2 around 195, falling about -3%. After a strong +203% gain in 2020, when this decarbonization story rose by 6-fold in about best performance of most any Index or Fund anywhere, a sell-off was maybe overdue. Thus it wasn't so surprising after ECO had dropped by one-half Q1 2020, to see that after rising, it once again fell by one-half to a first half 2021 nadir. Volatility here is partly due to the 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 about +390%.

As we emphasize, ECO, global NEX and OCEAN passively capture volatile risky themes, so can & do at times 'drop like a rock'. Big gains may occur, bigger drops too. Yet fresh attention *may* continue to be paid here: solar will soon be best-priced electricity *anywhere, anytime in human history*. Just potentially, it *may* create vast demand ahead in the US, Europe, Asia. If infrastructure & new jobs, equity & social justice – perhaps overlap with climate change solutions - there may well be more volatility ahead. Not just in solar, perhaps too in wind both onshore and offshore, electric vehicles, batteries, energy storage, hydrogen, fuel cells, ESG thinking, and the deep decarbonization of everything – unlike anything before.

Last 5 years, this Benchmark ECO Index® live since 2004 and 1st to capture climate solutions is up +400% to late Q2. This over a period when any energy gains stand out. For in these same 5 years, CO_2-heavy oil & gas have dropped by some -50%, while over last 10 years those dirty fossils are down -80%. That's in stark contrast to decarbonization as an organizing theme uniquely in ECO, NEX, & OCEAN Indexes, showing strongest 5 year returns in energy.

First *global* clean energy Indexing theme is the New Energy Global Innovation Index (NEX). Live since 2006, it is up +200% last 5 years to late Q2, starkly beating fossil fuels: there's now a tracker in Europe (GCLE; London). Both ECO & the NEX have outperformed too vs. a younger, independent, other global clean energy Index most every sizable period: Year to Date, past 1, 5, 10 years, since inception etc; differences in weights, purity help explain long divergence. In sum for 15+ years WilderHill themes have been benchmarks. And energy, long dirty taken from underground and burned – is increasingly being captured in disruptive & sustainable ways – coming to us cleanly, freely and renewably from up towards the Heavens.

The Clean Energy Index® (ECO) live since 2004 is first for the clean energy theme. It has the longest track record, is Benchmark, and has often outperformed coal, oil & gas. The ECO Index® plus too global clean energy NEX Index live since 2006, best capture climate solutions: solar, wind, electric vehicles, batteries, hydrogen, fuel cells, and decarbonizing everything. WilderHill® Indexes are all volatile with notable performances, and useful non-correlation to fossil fuels. They're innovation leaders, transparent, naturally informed by sustainability and ESG thinking, and can help to build a diversified portfolio.

Source: NYSE.com

Much is happening in clean energy & markets of late, here the first half (1H) 2021.

Some of it is very hopeful. President Biden's aim to cut US carbon dioxide (CO_2) emissions by 50% by 2030 - is needed & doable. Renewables grew fast in 2021. But a thorny matter is, the rate of growth is still nowhere swift enough today, to achieve 50% cuts in CO_2 by 2030. Solar & wind alone are readily capable of doing it - but on current trends we won't reach 50% emissions cuts until 20 years later, 2050. Partly it's because renewables aren't yet growing fast enough to displace natural gas, oil, coal. Conversely, it's also because of a global inertia in dirty fossil fuels, that aren't yet being shuttered or even slowed nearly fast enough.

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

No surprise then they're expanding! Solar power's growth was about +39%/year last decade: roughly doubling capacity every 2 years. Wind's growth 17%/year, maybe an offshore and onshore wind boom ahead could remarkably raise that strong wind growth higher still.

Clean energy's potential is rather eye-opening. Sub-Saharan Africa for instance, might generate 1,000 times its current energy demands from renewables alone. Australia, Chile, Morocco, generate 100 times their current energy demands. Even voracious China, the US, Europe, and India, could generate more than all their energy needs by renewables alone.

Despite Covid, US residential solar grew by +30% YoY in 1H 2021. US offshore wind from a zero start, could see substantial growth this decade. President Biden's infrastructure & climate efforts can further decarbonize. But as for 50% CO_2 targeted cuts in this decade – to avoid climate crisis - all is still falling far, far short. That ought Not dissuade. Clean energy has the potential to bring about abundant, affordable, healthier power – right away. Deeper, faster change could happen, sooner than foreseen. Electric cars for example, may go from 2% of US new car sales 2021, to nearer 50% in a decade! In the meantime, the US lags China & Europe on EVs. As in clean renewable power generation, Europe again already leads the way.

Europe 1H 2021 was expanding its percentage of clean renewables faster than any region. As its wind & solar grow, they're displacing declining coal in Western Europe. Soon natural gas too will be constrained there; long backed as a transition fuel, it's fast becoming last pariah fossil: later this decade maybe as socially unacceptable as say coal, or cigarettes. Europe's new Climate Law is making matters better ahead for renewables, via a border tax on imports of CO_2-laden products. Yet while solar/wind are clear winners now, electric cars on a cusp, heating for buildings has no immediate fix. Replacing gas boilers in U.K. & Europe with heat pumps, is much too costly. Using renewable natural gas blended with green hydrogen (H_2) is still a few years away. As are ships, planes running on green H_2, even green ammonia (toxic, so to be handled carefully) along with other liquid, gaseous, solid fuels ahead.

Latest climate science strongly indicates CO_2 is one fulcrum today, and thus action by China. It's growth of renewable zero-CO_2 energy is one-side of the climate coin: other side is its CO_2 - and arguably there has got to be real movement in this decade on dirty coal.

Coal is lately falling fast in wealthy Western Europe & US – where it's being displaced by clean energy (and gas) - but they're outliers. Elsewhere as in China, Eastern Europe, India, even Japan, coal continues terrifying growth. China uniquely is growing renewables (great!) – yet is strongly expanding its dirtiest fuel, coal, at least in 5 years 2021-2025. Notably China 1H 2020 already added 11 more Gigawatts (GW) of coal – a big 53 GW more coal plants maybe in pipeline. Of all of the world's new coal power added 2020, China made up 90% of that.

Not just China, is at issue: 33 of world's 60 largest Banks grew their fossil fuels funding. Hence on coal alone, any & all hopes to decarbonize the world in the 2020s are blown apart. In 2021 world carbon emissions spiked by some 1.5 billion tons(!) due mostly to coal. And 2022 looks to be worse yet. Instead of immediate drawdown needed, according to the best science, to truly decarbonize – coal is still expanding globally the next 5 years at least.

There's happy words. A US commitment to cut emissions by 50% from 2005 levels by 2030. The COP 26 meeting in Scotland in 2H 2021 bringing more glowing words too. But look closer. Each Paris Accord nation sets its Nationally Determined Contributions (NDCs). Some are lax, like from China, Japan etc. And games played with numbers; the UN baseline is 1990 – not a later 2005 - when emissions were higher. So pledging say '50% cuts from 2005' really is more like a 43% reduction. Worse, the US early in 2021 was on track to only make an actual cut of 12% below 2005 levels by 2030 – nowhere close to even that 43%. Plus, games like counting *not*-cutting trees, or the oceans as net 'carbon sinks', makes a mockery of reductions. Some words inspire, others mislead or forestall action. And because global air traffic & shipping are kept out of emissions tallies(!) like methane, facts are even worse yet. Airplanes, like ships, are serious and very large CO_2 sources, and ought not to be pretended away.

In sum there's a growing gap between the big-*promised* cuts to 2030, vs. the data. The data show fast-*growing* CO2 emissions worldwide over 2021, and again 2022, led mostly by coal.

Meanwhile, even pledged cuts 'round the world' are themselves nowhere near enough.

Consider: the UN in 2021 tallied NDC pledges from 75 of 191 nations signing the Paris Climate Agreement. Excluding China & the US, it found even fulfilling those commitments – would only reduce global emissions by 1% from 2010 levels to 2030. So even if NDC targets from many countries were met, there still wouldn't be big enough reductions.

Yes, the Paris Agreement met with fanfare over supposed agreement to limit heating to 2 degrees C (3.6 degrees F), or better yet, to 1.5 C (2.7 degrees F). Assuming the science is to be believed, then CO_2 emissions need to be cut *in this decade* by far more than now: by nearly half or 45% to 2030. Given that ambitions and commitments worldwide are still nowhere close to 45% required reduction, Paris arguably is already out of date. And more immediate, more dramatic actions by the world's 3 biggest emitters, China, US, and Europe are essential.

To be clear-eyed, fanfare over the 1.5 C target really wasn't deserved. Not when a Paris Agreement lacks mechanisms for enforcing necessary cuts to achieve it. Not when there's no real Plan to meet a 1.5 C target this decade. Seen against vast scale of what best science says is needed for 45% cuts from 2010 levels this decade – vs. the lack of real action, more distant aims like 'zero' 'net' greenhouse gases by 2050 aren't yet worth discussing.

Or, squint just a bit to see some hope. In 2020, the plainly better economics of renewables meant 80% of new electric generating projects worldwide were clean energy. It just makes dollars and cents/sense. This led to a 10.3% rise in carbon-free electric generation globally. Nice to see: 91% of new renewables recently were wind & solar. Wind power had risen to 58 gigawatts (GW) by 2019; it then doubled 2020 to 111 GW. As a percentage of total global electricity production, clean sustainable energy grew 2 percentage points, going from 34.6% of the power generation total in 2019 – to 36.6% in 2020. Yet that's far from 100%.

Overall given the world's electricity demand pie is growing, thing of it is, coal's growing too. While coal is vexed from mining through waste disposal, more new coal power is being built – along with new financing abroad. Thus, even as renewables' share of electricity is growing, overall, total greenhouse gas emissions continue to grow as well. We'd note: there hasn't been a single year yet, of *falling* global coal capacity… ever! This says nothing about use of coal for other high heat industrial processes like making cement, steel, aluminum. That in turn, is an added embedded CO_2 that's being exported to the US, Europe, and worldwide.

Ill-defined happier terms 'net zero', 'climate neutral' are increasingly bandied about. But they're Not same as zero-carbon. Proclaimed widely, the former 2 seek to let emissions be 'offset' in bit of a shell game, counting disingenuously trees, forests, the oceans' as natural uptake etc. If coupled with distant target year like 2050, they can/do become meaningless. Unlike robust zero-carbon – instead net zero or carbon neutral demand less. So words can inspire – or may forestall stronger action. What's needed is to *decarbonize now*, in tandem with ending potent greenhouse gases: methane, black carbon, hydrofluorcarbons etc. Those super-pollutants are more climate forcing than carbon dioxide. While shorter-lived, they are far more potent at trapping heat so nearer-term drivers of global heating this century.

Science in short, requires an unprecedented and genuinely rapid transition to clean.

Instead, we hear words, more words that dissemble. Some ambitiously call for end to coal – yet the gap vs. today is vexed. Huge gains in renewables are necessary, yes; but alone are not sufficient, alone won't do the trick. The shift away from CO_2 must include global capital markets to decarbonize. Capital, like blood in the veins worldwide. Not passive, nor static – arguably market forces shape energy choices and truly matter most – along with government policies. Once, market pricing & policy had helped make coal the King of energy. Later, oil became exclusive choice for fueling transport. Then they made abundant natural gas so common late in the last century, that gas came to dominate making power and heat.

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

We turn now to clean energy and green themes in US & global financial markets.

Recent Q2 and 2021 Year to Date:
Clean energy and markets arguably are best-seen in ECO & global NEX. Below to start with rather some granularly is the first half (1H) of 2021, from January to June.

1H 2021 to June:

Source: finance.yahoo.com

To start out 2021, the WilderHill themes at first rose in January. ECO, NEX, OCEAN up +22%, +10%, +10%, outperforming S&P500. After peaks in late-January – all 3 started falling very hard, ending January/February at +5%, -3%, +2% YTD, so near S&P500. (OCEAN Index isn't shown simply as no tracker just yet). March/April the plunge deepened, thus crashing early 2021 rather like early 2020. By April, ECO was around -10% YTD, GNEX was around -3%, and Decarbonization/Sustainability OCEAN near nil; mid-May was a low, then a mixed June. And notably in this year, fossil fuels were *gaining* strongly 1H 2021 – coming off deep lows. In prior years our green themes usually had done far better than fossil fuels; that changed 1H 2021 when oil & gas - admittedly coming off of their own dismal deep lows, clearly well jumped.

For fossil fuels once down dramatically, 1H 2021 was quite a reversal. Oil for instance had dropped historically 2020 on Demand Collapse due to pandemic. World oil industry needs oil prices at least to be >$50s, >$60s. Nearer to $50s/barrel punishes indebted shale producers. Oil near $50 foretells much misery ahead for producers, even for whole countries relying on reserves. Equities are inherently forward-looking, so oil's vexed theme 2020 hadn't seemed an attractive destination for capital. But following big supply cuts to be discussed ahead, both oil & natural gas gained unusually well early 2021. Such higher prices 1H 2021 for natural gas, might however in time make clean energy yet even more relatively competitive.

A key point, to be repeated, is *Costs for solar/wind electricity by contrast, can go very low at times, naturally*. This variability is a characteristic, indeed a core trait of the renewables. Oil instead, faces 'make or break' price floors, beneath which industries suffer. Past oil busts meant near-term lost capacity, collapsing jobs, non-producing wells shut in, price hikes. In 2020, oil hadn't enjoy a firm floor, changing dramatically in 2021. **Demand destruction** was thus recently key there, versus renewables; meanwhile electric cars are accelerating.

'Happily', for Oil, it rebounded 1H 2021 back to $70s. But that was only after big self-induced supply cuts by Saudi Arabia/OPEC, plus on hopes of renewed demand and expected inflationary growth 2H 2021. Otherwise, were prior 100m barrels/day still supplied, it would have kept that market in collapse. Coal (no longer tracked by ETF) also lagged in 2020: no new US coal plants are being built, regardless of who's in the Oval Office. Coal's dismal economics in the US swamped even firm political will; thus US producers look overseas to where coal's still being widely burned: Asia has had much of the world appetite in 2021. Yet the fact that America's own domestic coal supply had once been the last century's cheapest, dirtiest, most stable source of electricity, suddenly is no longer much in its favor.

At start of a Q1 2021 plummet it was unknown of course if clean energy & so ECO might take a harsh backslash shape only/all down as "\" for Q1 - and Q2? Maybe "L" shape, for down then sideways? Or, given January's rise – maybe go hard back down in an Inverted "V", like an ^? For 3 reasons then, latter Q1 & 1H could see headwinds: *1) There's no clarity yet on prospects for a Climate Bill passing in 2H 2021; 2) *China's new 5-year plan might push big coal cuts to latter in this decade so post-2025; and 3) *Europe seeing a pause then by US & China, might refrain too from starting as aggressively early 2020s as was recently hoped.

To those 3, add 2 more: *underlying green stocks hit High P/E multiples in Q1; plus the strong advent of *Inflation Risk. Perhaps then early Q1 was a soft ceiling? Maybe for a downwards sloping "M"? Hope for a stimulus Climate Bill, succor; if one's optimistic then an Infrastructure Bill for climate *could* better justify these rich Price targets ("P" in P/Es). But Q2 is maybe an interregnum – a pause between Q1 hopes - & clarity 2H on this key Bill. Given Inflation fears there could be big falls, should a great inflation arise; maybe 20% over few cumulative years, Fed willing to let run hot >2% inflation targets. Capital unsurprisingly reflexively moved fast in 1H from growth stories - to value. Yet that was ironic as well. For longer term, the same volatile green growth stories might again re-attract capital. Once traders get re-accustomed to seeing (possibly) much higher, and yet historically more typical interest rates.

In that case, valuations above a 25x EBITDA (Earnings Before Interest, Taxes etc) might be again common. But in 2021, in a risky growth theme, few dividends, little/no positive "E" earnings – matters swung bearish. Both global NEX, and the ECO with its US listings, fell hard – rather as one might expect on 1H macro-picture. Such classic sell-off was maybe overdue: the NEX & ECO had already spiked upwards by 4 fold & by 6 fold in Q1 2020 to Q1 2021.

Recall Q1 2020: ECO had crashed -by 50%. So down again 1H 2021 also -50%, was not so surprising, from intraday 286 peak in Feb. 2021, down -50% to 145 mid-May. Given rapid 2020 gains, this only returned it to levels seen not long ago: ECO was 145 as recent as Nov. 2020. NEX if down say half, was 315 as recent as Sept. 2020. Bigger drops may be envisioned.

Somewhat interestingly, Q1 2020 had seen -50% decline from around 90 to near 45. That -50% had proved a resistance level and rebound from Q1 bottom. A fall again of -50% from February to May 2021, also coincidentally marked a 1H resistance level (and bounce) for ECO. After intraday Q1 peak 286 on Feb. 10th, ECO touched 1H low (to June) of 145, May 13th. Somewhat notably then, it *coincidentally* again fell near -50% to in retrospect, a 2nd (near-term) nadir. Then bounced – at least through the Q2 2021. Twice a fall of -50%, and then a rebound.

Q2 2021 as expected, proved something of interregnum. Rough patch filled with uncertainty: clean energy's theme spiked up late Q4 2020 & early Q1 2021 on Presidential race results and surprising gain of both seats by his Party in Senate in January … followed necessarily by this Q2 pause. A pause that being weighted down by high P/Es, by fast-growing inflations fears – and by an uncertainty over whether key Infrastructure reconciliation could pass in 2H. There was 'empty air' in Q2: little to support valuations twixt a Q1 Senate outcome – and better clarity ahead in Q3 or Q4 on whether key Infrastructure Climate reconciliation might pass.

Without doubt, ECO in 2H 2021 may fall quite more. Or perhaps, may also rise. If P/Es are a metric (useful) & if Price targets in January had been high, then prospects for passage soon, or not - of an Infrastructure package in latter 2021 - may soon be sizably impactful.

Inflation worries grew in Q2, across 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 polsylicon 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.

Above nicely reflects Q2 '*crash*' and fears that summed much of the clean energy sector. And a useful May 11th piece too, from Roth, also highlights supply-side constraints & inflation risks impacting sustainability's theme then stating: *"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 go on to point to e.g. polysilicon tightness, rising costs for steel, freight, & labor; margin challenges and potential demand destruction. Both good analyses, they helpfully pointed to challenges in Q2.

Stepping back, let's next more broadly on to 2020 too in ECO/NEX. Given both had stood out over 2020 as top performers worldwide, with ECO up +203%: why have they both done so 'well' in 2020? Several factors, enumerated next, may help add a bit of colour.

One may be our use of Decarbonize as an organizing principle has stood out. Another may be *Market Inefficiencies: our Indexes hold small-caps & mid-caps not well known to mainstream analysts; fewer analysts in cutting-edge innovations like electric cars, Li-ion, green hydrogen, fuel cells, solar IP – could add sizable pricing inefficiencies. On fewer analysts in zero-CO_2 (and those that are, do excellent work!) with a flood of new attention & price discovery, 'animal spirits' in tow there's scope for gains. A 3rd factor is all-too human: *sheer Disbelief! Difference of opinion is what makes a market; deep skepticism here - even shorting - vs +12,000% gains in an equity here are impactful. Our thematic focus on clean energy has been very consistent 15+ years; that it's coming into such favor maybe is good fortune.

We'd seen a bit similar at ECO 2004–2007 as green energy so long unknown drew a spotlight – for sharp rises in tiny solar firms, electric car startups, li-ion batteries, storage, H_2 fuel cells. Stubbornly-held (dis)beliefs maybe broke down perhaps just a bit - or not. Views often heard in 2004 included that: Electric cars could *never* be as fast as 'real cars'; nor reach 200 miles range, nor ever be as pretty or any fun to drive. Views were oft stated that solar & wind 'weren't real' - vs. 'always cheaper' coal & gas. Future earnings estimates, based on short-term valuations, resisted penciling anew. Importantly, valuations were based *on only future promise in 2007. Clean energy then was much too costly*. All soon crashed on global overcapacity, higher relative cost, and being just 'promise only' around 2007-2015.

So re-think 2020s what's maybe possible this decade, and it *may be* more promising. Possibly: 5-million-mile batteries; whole regions competing on building renewables & electric cars; solar-electricity costs falling to <penny a kilowatt/hour, perhaps cheap green hydrogen – all may cause new look at valuations. Closing past inefficiencies in equity pricing. To more accurately see truer prospects is never a bad thing, disruptions narrowing gaps is an engine of growth. Clean & new displacing dirty & old. Over & over so many ways, closing gaps from 'state A' – to 'state B' – propels. This is a force, quantum-level scales on to our own macro and visible, and up further to our own small solar system and local galaxy.

Or think financial sphere. Melt-ups redux. In our ECO Index® there'd been 10 components all up by 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. Perhaps this helped explain ECO rising then 6-fold+.

So note *Speed by which clean energy became the least-cost option, *Force by which governments were embracing zero-carbon, & maybe soon the biggest item, *Climate Change. It's this last factor, how much CO_2 can we afford: that's new to our species. Maybe most vital limit of all. 2050 goals near meaningless. Instead, what must be done to decarbonize Now?! All this squarely fits within our theme. The above helps explain jumps here 2020.

The Good

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

Another Good driver of delta: ***unprecedented commitments*** by 3 great economic blocs, China, Europe, 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 fleshed out post-Spring 2021 when a seminal new 14th 5 Year Plan publicly would be released to much anticipation.

Did that mean, all greenhouse gases? Methane/CH_4, HFCs too, to be climate neutral - or just CO_2? How much disagreeably, may current state of art, carbon capture & storage (CCS) play a role, CO_2 only temporarily 'stored'? Monoculture reforesting? Sleights of hand like 'carbon intensity' allowing an increased use of natural gas - to be regarded as an improvement(!), as by 'CO_2 per unit of GDP growth'? All that could the distort true numbers around 'net-zero'.

So it was a Big disappointment when its 5 year Plan preliminarily released in March 2021 did Not take big steps early to end coal. The world needs coal to peak before 2025; for biggest user China to commit to peak-coal first half of decade. It did not! Instead it saw CO_2 peaking post-2025, presumably steeper CO_2 cuts later. In a fudge, ocean & land seen as 'nature-based solutions', or CO_2 sinks. Meanwhile, its lugubrious inertia-bound bureaucracy isn't likely to jump there to draw down coal, given jobs. This push-off to post-2025, ought to have been resisted. CO_2 sinks for example, could fast become sources, even an Amazon Forest. *Instead, its Renewables were always the 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 just to gain confidence. China's own ruby red/gold solutions, its new energy solar/wind/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 declines in coal for electricity - and heat – plummeting from >70% – to <5%. To instead slowly cut coal, later post-2025, requires sharper cuts 2030. Far better, would have been to aggressively start to Decarbonize, Now. Immediately on a straighter pathway would have been so preferable, to so many, worldwide. China instead may ramp up its nuclear fission first, rising from its 46 plants that were making 50 GW in 2021.

Regardless, China's new energy costs may top $15 trillion! A greater spend than 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 technologies like maybe green hydrogen for zero-CO_2 high heat for steel and cement. The changes shall still be colossal.

Consider batteries: both for electric vehicles & energy storage. Apart from just Tesla in 2021, China is most seizing opportunities, as are also Japan, South Korea, and 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 some reason for big 2020 delta upswings in ECO/NEX/OCEAN! Demand helped push battery costs down 80% in 8 years, maybe ahead going to <$100/kWh by 2023. Battery demand may grow 5-fold.

America's leader in 2020, Tesla had ~35 (gigawatt/hours) GWh lithium-ion battery capacity, maybe 100 GWh in 2022; it aims for 3,000 GWh (or 3 TWh) by 2030. That 3 TWh, give or take, was about all world battery manufacturing capacity in 2020. Change is happening! Thus rising demand was another reason for valuation deltas 2020. To make all vehicles electric, may mean >10,000 GWh new battery manufacturing(!) each year next 15 years. Twice that + for all energy storage. Better batteries, storage innovations for renewables to replace fossils. Beyond lithium-ion, much may lay ahead: solid-state lithium metal's far faster charging; zinc deeply discharges on less thermal management with better longevity and cheaper to boot, vanadium flow batteries for a grid that may fundamentally resist degrading, etc.

China's early focus on batteries was fruitful for it. 2020 it had 80% of world refining material capacity: it could manufacture 77% of battery cells, 60% of components, had 72 GWh battery demand; no one was close! Europe's fondness for diesel had once held it back, no more! EV incentives there are moving it forward. 2020 Europe EV/hybrid numbers were >300,000, fast pulling ahead of US. A century ago, Des Moines Iowa was a world capitol for electric cars. 30,000 EVs were registered in the whole US in 1912. The US let its world-lead slip away, something China and lately Europe too, seem very intent not to let happen to them.

All this opportunity can = green jobs. China recognizing this, has its foot on the accelerator. Yet coal persists; China's 53% share of global coal in 2020, was even more than its 44% in 2015. Yet other side of ledger, is much clean energy growth. In 2019 China added 30 gigawatts (GW) of solar, and 26 GW wind, for solar/wind capacity of 204 GW/210 GW respectively. Then in 2020 China added 48 GW solar, 72 GW wind; maybe 60-70 GW more solar came 2021. Hopes for over >100 GW/year were dashed early 2021, on a latest NEA draft @60 GW. But thinking of what's needed, given CO_2, some **Climate** models given CO_2 levels >400 ppm are calling for even 10x-100x that: thousands of GW global solar/wind ahead, on climatic concerns.

Or look West. Faster-moving Western Europe's new European Climate Law is enormous. It lays out being 'carbon neutral' by (a too distant) 2050, but better yet with teeth getting 55% there *this decade* by 2030. Little-discussed in the US (like a China 5 Year Plan), it's still seminal. To be fleshed out, soon, it's a first legally-binding net zero Plan of these Big 3. Perhaps a 2030 target of 60 GW offshore wind, 5-fold increase from 2020; 300 GW by 2050. Plus unlike China, Europe is beginning vitally to start *very soon* - not years ahead. (China's green growth can become fastest in the world, in areas to which it does commit, where it focuses).

It's voluminous. European Decarbonizing is not just in energy: industries too, infrastructure, water, agriculture, buildings etc; all subject to consideration and change. Broadly an EU Green Deal may mean carbon tariffs and/or carbon taxes. Trillions of Euros spending, carbon border adjustment mechanisms on embedded carbon, affecting trading nations. Those details just 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. Actions may include whole government approaches, strong unitary executive, good-paying green jobs targeting areas hardest hit by coal, oil & gas losses. Tougher, is a carbon tax, a national renewables standard, ending fossil tax breaks - though watch for maybe breaks for clean power, alternative fuels, and 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 faster electrify the US. Better yet to do so with little or no embedded coal/carbon. In US, more EV charging, Building Back Better, good paying jobs in grid, in transmission weatherization, distribution etc. Arguably many Good reasons indeed for that upwards volatility seen 2020.

The Bad

Perhaps 'bad' factors too lay behind rises in 2020. Bad, in a sense the drivers, to some, didn't yet warrant such exuberance; Hydrogen (H_2) & fuel cells 2020 come to mind. Not that they won't or can't, one day, possibly sooner than expected - be key too. It's more that 2020, they perhaps hadn't yet justified hype, not until some 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 these 3 basket/s outperformed 2020. An H_2 still burdened by sparse CO_2 avoided, low efficiency, and yet H_2 may become increasingly green/relevant. If made from 'rock gas' (natural gas drilling) so inextricably tied to rock fossils, then it is not a worthy solution. 'Blue' H_2 from fossil fuels & sequestration only passes a low bar. Big Oil may embrace that blue chimera, seeing the subsidies too for H_2. But blue H_2 may be cheaper & competitive with green H_2 in this decade only. And neither that blue H_2 and sequestration, nor a past brown/grey dirty H_2 made from rock fossils, will be both clean/green and renewable.

Far better, is a *green hydrogen* that's renewably & cleanly made as 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 looking here too. Different, is capturing a potent greenhouse gas methane (CH_4) spilling from landfills, dairies, etc and making 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 – *capturing spilling CH_4* and using it – 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 is starting to tout H_2. Maybe green ammonia (H_2+Nitrogen = NH_3) easier to handle than H_2, maybe made on site as by offshore wind. (Blue ammonia undesirably, uses rock gas). Visuals of wind/solar making a 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 if tangential – highlight how better are the green energy solutions. Take a present dismal state of the art in CO_2 Direct Air Capture (DAC). So energy intensive it's now a non-starter, requiring gobs of power, so more CO_2, & so on. But… if DAC gets economically sensible + low-energy – then *that* could be huge. Even less fetching on present technology, yet touted by fossil industries, is Carbon Capture & Sequestration (CCS). CCS might extend fossil fuels' use by decades. It could inject some captured CO_2 back underground briefly, to help produce yet more oil. But then a question must be asked, which is Why??!! When burning *even-less* oil & gas is where we ought now to be fast-headed, in the first place?

There's matters too that they don't discuss. What if CO_2 leaks centuries hence, or sooner?? At Lake Nyos in Africa, a CO_2 'burp' killed a thousand people. Far better, a stable CO_2 storage or mineralization mechanism is needed. To be inert, safe, permanent. And as solar is cheaper than coal anyway, adding CCS to coal is No Answer. Capturing CO_2 + pumping it underground renders coal 4x too costly! It's why we'd seen 'clean coal' in ads only – but not for real.

A compelling DAC or CCS would *Remove CO_2 from air & seas, *Permanently, in *Practical, *Economic Ways, *Scalable to Gigatons, with Carbon *Benign, Stable, be *Carbon Negative – not carbon neutral. The impotence of technologies to do this 2021, boosts green equities.

Uglier still is 'Geoengineering'. (Seriously, try to dim our planet's air, or dump CO_2 massively in deep oceans without knowing effects??!). Such of course should be rejected. Yet even that hydra-headed monster, is overshadowed by an immediate real threat of climate crisis. In the 2020s, global heating fundamentally is altering our once-cool planet. This last specter concentrates the mind: how do we better 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 so many past ***wrong*** views about what's possible – helped propel clean equities up. 20 years ago conventional wisdom held EVs, like solar & wind power, were just costly toys at best, seated at a kids' table. Regarded unseriously. Rather than 'listening to the sea' or thinking holistically – electric cars were dismissed as being slow silly golf carts vexed by smallest hills, their range forever under <100 miles, a sad joke.

How wrong! From those 'facts' 20 years ago – sleek electric cars have become vastly better: they were fated to do so! Foreseeing that fate can favor the bold. Closing gaps between state "A" (old beliefs) – and "B" (true physical limits) – is disruptive innovation making useful work. Clearly, that can make a 'delta' in equity valuations – maybe too 'alpha' in financial terms. Foreseeing these gaps, even just a little early-on, may potentially be important ahead.

It's very non-linear. Think tremendous falls back in 2008/2009, and early 2020 as green themes plummeted (They certainly could do so ahead again). Back a dozen years ago, profit margins went non-existent, stayed down years. There's non-Euclidian curved geometry to the world. Like disjointedly 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 most every way. Think of heat engines, unfathomably still around us: spark plugs' explosions in cars push pistons for power. Coal plants, make electricity by heat difference too. Nuclear = world's costliest boiling water. Delta is in hot vs. cool. What's needed is differing states, temperature gap of "A" vs "B". Using difference but in heat engines it is brutal & inefficient - unlike nature herself.

Mr. Babbage captured it in his difference engine. Mr. Turing's work led to computers; but in pure mathematics. Here, nothing is so certain. Razor-thin solar margins, may crash. Equities again may plummet boom/bust, like a bear decade ago. Or, growth *may be* possible on new demand – on affordability – or on a top issue of all, perhaps: physical CO_2 limits.

This factor is so significant it stands alone *sui generis*: Climate Change. Potentially, it may devastate humanity, whole 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 we humans might beg, bargain with or badger nature. On most topics, scientists will counsel calm. Soothingly, they'll remind us things aren't as bad, nor as extreme, as non-scientific laypersons paint them.

Not so, on climate. Singularly, researchers here are shouting. Perhaps it's thus Conservative to heed scientific consensus – unconservative to reject it. It may one day hit us not in spirit of gladly looking towards smarter solutions, nor boldly advancing our better natures. Instead, it may mean hastily saving what may still be saved: remember Summers lasting only 3 months? Sandy Beaches? Winter? Coral Reefs? How better to prevent this as a future we needlessly bequeath. Especially as Sustainable, No Regrets paths can make us healthier, happier, richer, safer, more secure. Save us from spiraling blood & treasure, bearing diseases and despair. That may mean our intentionally acknowledging ahead: Prevention Rather than Cure.

NEX/ECO/OCEAN themes may capture & track much here. Decarbonizing, electrifying everything, EVs, low-carbon fuels, efficient heating & cooling, greening industry, etc etc. Some new delta may emerge in areas of particular strength, in certain themes, or regions. Consider for instance, 14 of the most volatile upside constituents seen in NEX mid-Q1 2021. They were most up for that past 52-weeks to early 2021, as the 14 biggest gainers.

Late January 2021, NEX was nearer highs, figures then much higher; we'd thus avoided looking at that time. Instead, here they are in March 2021 as NEX components like most growth & innovation equities, globally, were instead in steep falls. Hence these % up figures are moderated by looking here March 3rd amidst a then so far -25% YTD plummet. Here worldwide is much like ECO's story, where we'd noted biggest gains were over +1,000% from their lows last 52 weeks to early March 2021. These were thus rich gains globally. 14 NEX components to Q1 2021 all showing gains of at least +600% from their 52-week lows were:

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

In sum 2020 concluded with large gains in all 3 Index themes. Then, Q1 and afterwards Q2 2021 saw a correction mid-May as there were falls in ECO, in NEX, and in OCEAN. To end of June 2021, ECO has touched a recent low near 145, NEX fell near 400, OCEAN near 350. Should a hoped-for Infrastructure and Climate reconciliation package fail in this Q3 or Q4 of 2021 – then arguably all 3 Index themes could plummet much farther, swiftly.

Seeing 14 components in NEX, or in any Index theme with Gains over +600% the past 52-weeks off lows, may again be a bit remarkable. Maybe it helps explain a big NEX 4-fold rise from March 2020 to January 2021. And a perhaps rather unsurprising crash in 1H 2021, so far.

The above gainers were remarkably diverse. Some in new energy innovation are scalable and 'on offense' against climate change, like solar & wind. Names in solar upstream include poly & ingot/wafer/panel manufacturing - to downstream inverters, sales, and installation. There's advanced Li-ion batteries, materials. Plus, much in highly speculative hydrogen & fuel cells, biofuels too given that new energy innovation reflects a range of dynamics.

There's 'defense' too on climate. Smaller steps, extant infrastructure. Capturing methane – otherwise indifferently released into air like a sewer. Renewable natural gas; extant systems render that a CO_2 once-combusted, so a less potent greenhouse gas. There's low CO_2 or better still negative-CO_2 liquids from renewables like for aviation fuel, gasoline, diesel.

Still, past equity gains like 2020 in no way foreshadow gains again ahead. Indeed big rises may auger sharp/er falls 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 that past dominance by once-magical fossils now waning - mean what's bad for fast-fading coal, oil, gas - is bad for humanity. We'll all be far braver and wiser, setting out to return life once more to a more climate-stable, broad sunlit uplands: this choice is seminal.

20 years ago the path was less clear. Solar seemed likely viable, yet passive or active? Wind, sure, but will vertical, or horizontal axis turbines win out in red in tooth and claw competition? Electric vehicles: probable too but *when* may they succeed? Might green hydrogen *ever* come to be? If so, fuel cells ever robust & low-cost? All were obvious questions – no obvious answers. Questions barely imaginable then, now lay ahead: which electric jets will be best; is green H_2 or ammonia better for ships; how to make DAC green; can scalable sequestration render carbon inert like mineralized rock? So much ahead this decade. All open to debate. Inherently, unknowable. We well recall this like end of the last century, only some 25+ years ago.

To passively pool diverse clean energy ideas in an Index basket had made great sense then – & still does now. Victors are unknowable among technologies competing to win the day. Mitigating against individual risk is compelling too: probably even more so, now! One can't know which components in fast-changing storage, solar, wind, green H_2, fuel cells, electric vehicles, decarbonizing and more(!) may survive ahead. Which equities all risky – shall fail – which may survive, perhaps thrive. This vexed question always bedevils and makes the passive Indexing approach like seen here in ECO/NEX/OCEAN arguably rather compelling.

A differing beast, is volatility. We can say with great confidence that oil prices will doubtless jump at times ahead. Coal, oil, gas may be in long-term decline, yet events happen: accidents, attacks on infrastructure, drought, floods, hot days, bitter cold snaps – overthrowing, decimating energy. To not weatherize against extreme heat & cold – given climate crisis - means price jumps ahead. Unpredictability, is very predictable, in that sense. Drought threatens gas, coal, nuke power. Stratospheric heating due to global warming, may be seen one month, weakening jet stream, allowing super cold arctic air to dip South freezing energy infrastructure soon after. A slowing Gulf Stream might ironically, dramatically cool Europe, or alter current patterns. Oil & gas may be in lugubrious decline longer-term – yet we'll certainly be seeing many upwards price spikes along the way.

Maybe foreshadowing weather extremes ahead, one deadly disaster hit Texas in 2021 when a freeze took down its electric grid. That blackout showcases battles going on now in messaging: just what will make for a better, stronger, more reliable grid going forward. Fossil fuels, especially natural gas that's been so dominant – lately is finding itself on its back heels.

Amidst that crisis, an argument was hastily put out that a State blackout was due mainly to clean energy, to wind turbines freezing! Whether promoted by uninformed, or by more politically motivated renewable critics – that tale was widely circulated especially by certain media outlets. The image quickly spread of a helicopter and vat hovering above a frozen wind turbine – accompanied by claims this was a recent photo of flailing attempts now in Texas, to use chemicals to try to unfreeze wind power. They claimed this as proof that wind power was ***the main cause*** of these terrible grid outages in a freezing Feb. 2021 in Texas.

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

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 2021 was not mainly powered (yet) by renewables; but instead by natural gas. A sizable 52% of its grid power was running on natural gas in 2020 – vs. about 39% that's on gas nationwide. What's important is how well forecast energy Supply – matches Demand. During that week, the Electricity Reliability Council of Texas (or ERCOT) expected 82 gigawatts (GW) of power would be available then, in Winter. Greatest expected supply percentage was from natural gas: a huge projected 50 GW availability.

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

Many plants didn't – couldn't - find enough natural gas at any price, anywhere. While early criticisms were made against wind power by both Governor – and Texas Railroad Commission – they clearly were barking up a wrong tree. Hence that fascinating image and fun tale of a 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 went offline. From peak pre-freeze to worst on February 15th wind dropped 8 GW. But, importantly, very low wind output was forecast for the time of year: dead Winter regularly near wind power lows. ERCOT's models expected just a puny 1.89 GW from wind. Thus, when wind's output went as low as 0.65 GW nadir, that wasn't very far off forecast models. (Wind soon spools up enormously later months).

Moreover a relatively small underperformance, vs expectations for wind, was narrower than coal: latter was off a larger 5 GW from where it 'should have been' due to freeze. Even a supposedly unflappable nuclear, was down by roughly a like amount to wind – off 0.7 GW.

So each source of electrical power was hit. The truth was, wind power shortages were but a tiny fraction (about the smallest of all!) during that crisis of those 3 vexing days.

Core in this shortfall was natural gas. It suddenly fell short, by huge 20 GW less than expected – a gap 16 GW lower than the 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 a warm, even hot place; much equipment was left unweatherized, and tanks that divert oil, water, and gas, became solidly blocked off.

Unfrozen, they could have spooled up enough to 'oversupply' natural gas-fired electricity to 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, they 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 in turn give elsewhere) at ridiculous prices like $200/BTU. On a trading Exchange where gas prices hadn't gone to $200, they'd added a digit. Nearby wealthy Dallas the price of natural gas (right in heart of super-gas-abundant Texas!) suddenly went to $1,000.

Power plants needing continuously supplied gas – to sell electricity - 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 the chaos of needing to find gas right away at any price, their prices that they'd charged soon shot up for each MWH – from $24, to in some cases a crazy $9,000!

Power producers needing gas to make electricity, were competing with gas producers needing it to meet contracted obligations for available unfrozen supplies. All getting hurt. That gas trading expert describes how the differences in trading normally are just concerning 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 drilling *more* natural gas would have solved nothing. But *winterizing - or better yet *weathering for Summers too at key gas facilities & infrastructure can make a difference. Texas has a long history preferring a very light regulatory touch to its electricity supply, natural gas are 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 in deeply-freezing places, because facilities have been built with freezes in mind. Winterizing just 1 well might cost $100K, and as only 0.06% of annual Texas gas production may freeze off in a year, so not all of it need be winterized. There's 100,000 Permian Basin wells, 250,000 active in the State; many are just marginal of little consequence. Hence there needs be balancing. Or, the State could continue being fully hands-off, like before (with such consequences).

More *storage was suggested – but natural gas, for in Texas' crisis the *gas Storage* was a Hero; it didn't freeze off like gas production did. Another idea, *winterize power plants. A multi-billion-dollar nuclear power plant going down due to a pump freezing (inexpensive to prevent in first place) is a no-brainer to fix. Gas facilities to be *critical infrastructure so powered in a crisis. Harder is to *protect against drought: thermal coal, gas, nuclear may *have to* shut on missing water. For Arizona, Texas, much of the West, a drought threat is worsening.

If most all above for gas feels like playing at edges of a teetering system, one bound for scrap heap next few decades, it's probably true. And what is shows too, is what actually went wrong in a February 2021 Texas crisis. It wasn't due to small loss of wind! Wind turbines can readily be winterized; that may add 5%-10% to costs per turbine, but is readily done around the world. Wind works fine in Arctic, or US Upper Midwest far colder than Texas; in fact it prefers cooler heavy breezes. (Natural gas too prefers cool, but no claims to contrary are made about gas – as they are for wind power!). Months after Texas' freeze, matters came to light including concerns the blackout might paint gas in a poor light. A campaign had then been fast mounted to call renewables 'unreliable' – and deem fossils as 'reliable energy'. Even though it was natural gas, by producing far below expectations, *that was most responsible*.

Consider too: Texas' disaster, bad as it was, was minutes away from being far, 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. Lack of infrastructure resilience is a very big deal.

It boils down to: How ready we are for a changing climate? Honestly, not at all. A major oil fuel pipeline from Texas to US East Coast, if shut – could paralyze Southeastern US. Glance at a weather app like Ventusky, showing swirling arctic polar vortex every Winter. Bitter arctic air drops at times in Winters towards population centers, yet remains just North of the US, and Europe, Asia. We're saved by the historic wind patterns. Those can change. Sudden stratospheric warming for instance, 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 farther south. While it may not sound especially harsh, to the ear, consequences surely would be. Drought too increasingly imperils big thermal plants.

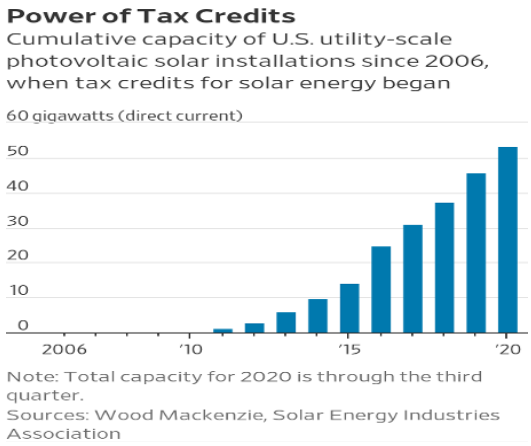
Perhaps 'Climate Change' or 'Global Warming' are too benign as phrases for maybe Calamity. 'Global Heating' may be better, 'Climate Crisis', Emergency, or even 'Global Weirding' for decades, centuries, or longer ending in a much hotter Planet. Equator not far differing from warmed Poles. That does Not mean getting there is incremental. Or that we'll experience just linear, pleasant, 'nice' warming on the way, gradual and gentle changes only.

A slowing Gulf Stream *could* paradoxically mean bitter cold. Trace a finger on a globe from lovely Britain and Northern Europe, either westward or eastward. Quickly it becomes frozen barren places away from North Atlantic warmed by Gulf Stream. Should non-linear global heating cause warm Gulf current to cease, changes could end so much we know today. Science is still very unsure: will it be cooling or warming; but it's unlikely to be no change at all!

For Texas 2021, gas was its weak link. Nuclear, and coal too are vulnerable to heat, cold, flood & drought. With solar & wind, instead, Storing abundant electricity is what's needed. Generating electricity will grow cheap ahead, thanks to cleaner, better renewables. Storing that power, somehow, is where we now also need focus and grow. It can and it will be done myriad ways, but it's clear that ***Storage*** is where much attention is now turning.

So what to do 2022/2023/2024? Changing tack, let's briefly look at possible Tax incentives for new energy storage. Back in 2020, proposed tax changes for storage had passed in House – but not in Senate, nor were they supported by a President who then opposed green themes. In 2021 things were different. Budget-reconciliation in Senate allows for 51 votes, so consider that tax credits like which had once earlier on been so crucial to starting up solar – could again, possibly, become similarly vital to storage and batteries maybe from 2021 onwards.

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



Sources: Wood McKenzie & SEIA

Tax credits for Storage had required links to solar – so was 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 megawatts of deployed storage – we'll need hundreds, thousands of gigawatts. No doubt we'll scale storage with right policy. Repeat for batteries & all storage - what recently happened in fast-growing solar – and 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 thatare cheaper to boot. Where naturally hot lithium brine occurs, geothermal power from the hot brine could make lithium hydroxide without wasting water; freed from intensive evaporative ponds like lithium today (and no sulfur). Co-locate battery & EV makers – like build polysilicon plants nearby solar panel makers - and to decarbonize as organizing principle promotes *both* lower-costs/efficiency & ever better zero-CO_2 solutions.

Key tax changes are perhaps possible 2021/2022. Desirably, they might extend solar ITC credit for 5, 10 years at 30%, a direct pay option @85%, plus on storage alone, add 10% credit where construction jobs satisfy specific labor goals. Wind PTC extended at 60%, better than annual threats of termination; ITC @85% for parties not able to avail of Tax Credits like a cash option so useful in 2009. 10% added credit with Labor Dept targets met as on prevailing wages. 44 current tax benefits, replaced by maybe 3 in clean power, transportation fuels, efficiency. Perhaps possible in 2021/2022: equity & inclusion, rural job programs, environmental justice, all top line priorities in new energy policy (line items, W. Virginia?!). We'll consider farther ahead advanced battery design and materials; there's strategic needs there.

2021, 2020, 2019: A Last Few Years

Let's look briefly back at one striking 12 months period March 2020 to March 2021. ECO was then up +250%; NEX up +150%: far outpacing fossil fuels and Indexes like S&P500 and Nasdaq. ECO/NEX showed a vivid non-correlation too vs all dirty energy, what a fine example of diversification! While oil & gas stories were in free fall over 2020, clean sharply rose. 1H 2021 they next showed a non-correlation as well; clean ECO & NEX again marched to a different drummer; their roles reversed as clean *fell* sharply – and dirty rose, first half 2021.

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

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

It is slowly greening, at a snail's pace. An electric car maker was added to the 500 late 2020 – so late it was already a 4th biggest US company – and regarded curiously in that Index as in 'consumer discretionary'. Enphase was added 2021. As for energy, in general, we'd noted 2020 that (dirty) energy then had made up just 2.5% of the S&P500. Once, it was far bigger: it was 7% in 2015, 11% in 2010; 16% in 2008; and in 1980 dirty energy was 7 of S&P's top 10 by market cap, 25%! By contrast a 18% in 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, in say Q3 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, a US oil & gas behemoth: Exxon. In 2020 the Dow Jones Index announced it was dropping Exxon from its leading 30-stock Dow basket. Why? Apple was splitting 4-1, so price-weighted Dow needed to find new component/s to keep up with other baskets. (Dow significantly lagged performance of late). New representation was chosen - but Not from anything in old-dirty energy in oil. Instead, they added 3 technology-heavy names. Dow Industrials deleted an Exxon that, in various incarnations, was in since 1928. Once a longest-serving component of Dow, no more. Only Chevron, among oil stayed. Reflections of a prior decade perhaps when dirty energy fell fast – despite tirhe bounce up 1H 2021.

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

And real-world Returns for clean energy last many years have hardly been 'non-pecuniary'! In a Past 12 months chart to say, late May 2021, 2 top performers again are ECO/NEX trackers, very nicely non-correlating vs all. ECO/NEX are positive some +150% & +110% to mid-Q2 2021. Thus they did far better than old energy that were instead just +66%% (oil) or *down* -10% (gas). Better too, than S&P500 and Dow both up 'just' +40% - far beating those comparison bogeys. Hence maybe no surprise to see billions of dollars flowing into ESG, breaking all records. 2020 ESG assets had more than doubled those of 2019, reaching $246 billion end of Q1 2021. In Q1 2021 inflows then reached $55 billion, vs. $41 billion in Q1 2020. For backdrop, assets in ETFs and ETPs topped $6 Trillion for a first-time end of April 2021. As ESG in particular has grown in its space and far outperformed at least in 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. for being deemed 'non-pecuniary', then that's a bit curious given the glaring Performance facts:
Past 12 months to late-May 2021:

Source: finance.yahoo.com

In a recent window March 2020 to March 2021, ECO had ranged from 46 - 286, rising 6-fold! Global NEX had ranged 150 to 630, up 4-fold! Like nothing in old energy. As was said of clean equity gains in 2020 by a brilliant man, "How strange…. Well, back to work". Doubtless more big falls like 1H 2021 lay ahead. Start of 2021, China aimed to go from 11% solar/wind power generation – to 16% by 2025. Wind developers had jumped on a spurt of activity due to expiring subsidies – they'd installed 72 GW of wind 2020, 3x 2019 (solar up 60%). But, because that government's fund to pay subsidies had Q1 2021 reached cumulative shortfall of 320 billion yuan (near USD $50 billion), its government briefly proposed write-off some owed sums. In response one big wind developer's stock swiftly fell -30% in 4 days. It soon rebounded afterwards once the proposal was dropped. Regardless even with such big drops, and ongoing wild volatility, decarbonizing has begun to figure more prominently with good reason.

Global change matters. Drought in Taiwan 1H 2021 has meant semiconductor chip shortages. A Western US drought has meant more wildfires, power outages ahead. Over a full 2020 & 1H 2021 smitten by diseases, wildfires, temperature extremes, blackouts, we increasingly can see mounting evidence the economy is wholly owned subsidiary of the environment. On the other hand, if a US Infrastructure & Climate package does Not pass Q3 or Q4 2021, so a key hope gets yanked away – then ECO & NEX themes could well fall *much* farther ahead!

Let's assume for a moment a Bill does pass: what might be in it? In 1H 2021 one item receiving much attention was 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 US lawmakers therefore is: how to shape US innovation policy so American battery production may then begin to compete, having fallen so badly behind these past many years.

One problem 2021, was the US lags in making enough lithium, nickel for batteries; also in producing rare earths minerals (which in fact are not very rare) needed for motors & strategic uses. As Senator Manchin observed mid-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 seeing critical demand upstream in manufacturing batteries, for both electric cars and grid.

This 'ain't our first Rodeo' seeing the US fall badly behind, when it needn't have done so. We saw solar manufacturing decamp out of Japan, the US & Germany - into China past 2 decades; by 2020 the 3 biggest solar manufacturers were all based in China. A problem is, it looks like that may be happening again for crucial batteries. This needn't occur. But in 2021, the US had only 3 big battery factories. Tesla's few Gigafactory/s is/are vital for US manufacturers: yet there may be only 10 total big US battery factories in all in 2030. (Should be many more). And here the 'US' would include South Korean-owned factories, merely built in the US.

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

All underlines need for action now pre-2025 in: **Cutting CO_2 emissions where US & world are failing badly; **Building Back Better in the US, and B3W globally where US+Europe can lead. The US has fallen behind not just China, but a more committed Western Europe too.

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

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

Yet for all of that, mining clearly means a range of environmental and social impacts to be handled solemnly. Some ideas, like say green lithium made using hot briny waters on zero-carbon geothermal power – are better than the water-intensive evaporative ponds & sulfur. So too to avoid mining company bankruptcies that upend cleanup. Ecologically sensitive places surely must be 100% protected from all mining. Meanwhile, some US states such as West Virginia welcome sourcing minerals from ample extant wastes and mines.

Senators Manchin, Capito, Murkowski have introduced legislation to derive rare earths from their own coal wastes, of which they've rather a lot. Recent studies show more greenhouse gas methane may be coming from Appalachia's old coal areas – than from Texas' many active & abandoned oil/gas fields! Places unemployment is high, like past coal country, arguably should merit special attention in jobs locally for strategic minerals. Legislation considered in 2021 included incentives for US solar & semiconductor manufacturing, proposed LIFT America Act that could include domestic battery-making incentives and years of support ahead for US-sourced critical supply chains. But given where China is now, and how much faster Europe is moving, it's doubtful the US can get to what's needed in batteries, minerals, rare earths without a big change in direction. Sadly, US likely may remain dependent on importing these strategically-vital materials, often mainly from a more ambitious China.

Possible changes could lay ahead like cutting subsidies bizarrely still given fossil fuels. A 2017 Report found $20 billion in subsidies were given 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', has Master Limited Partnerships for fossils. The G20 advocates eliminating ALL dirty energy subsidies; a study estimates their 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-19 relief bill had $8 billion in tax breaks for 77 fossil companies. Given it's all from the public purse, and public health burdens of fossils massive, it is 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%. An IEA funded partly by OPEC nations predicts per capita earnings there, may fall from $1,800 in 2021, to $450 mid-2030s as fossil fuel use is slashed. No surprise, several oil-heavy nations and entities are calling such IEA findings "fantasy" – and not realistic.

IEA also criticized 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 vague too, along with oft very distant target dates.

The IEA says annual low-carbon investments must more than double from $2 trillion/year, to $5 trillion by 2030. It expects 30 years hence, 2/3rds of power from renewables. It sees in next 10 years EVs going from 5% - to 60% of vehicles on the road [China's massive boom in vehicle making is mainly electric]. Planes running on biofuels, ships on ammonia [hopefully ***green*** H_2, NH_3, biofuels]. Carbon pricing worldwide [with China, to be effective], subsidies ended for fossils [including US to be effective]. Green hydrogen used for high heat industry.

Change is afoot. 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, subject to pricing attack. So when nearest front-month contracts 'broke' to contango 2020, near tank tops limiting storage, that oil index went far down fast unlike the futures farther 12 months+ out for oil. It amply proved there's a floor beneath which oil prices cannot fall – very unlike solar & wind power.

We'll discuss it ahead, but a point is that oil's crash had proved a crisis – until rebounding 1H 2021 to $70s/barrel WTI. June 2021 OPEC restored 2 million more barrels/day production. By contrast, green themes like solar - can & do move very, very differently. And prognosis for clean is thankfully different. Drivers differ for Solar, where there's been good 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 seen as a benefit: before it made panels, and installed/serviced them. Split by spin, newly specialized, the parent could refocus downstream selling North America solar. It's a big market albeit thin margins, storage allowing premium branding, and it can also get bigger. In-country work can't be outsourced, nor done overseas by cheaper or commoditized competitors based elsewhere. (In 2021, a concern for solar instead became fast-rising input prices and thus inflation).

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

Upstream, the spunoff premium PV panel maker had enjoyed China patent protection & pricing power early 2021 (2-4 cents/Watt commercial, ~4-8 c/W residential). But margin pressures are unrelenting; so shipping cells, rather than completed PV panels, shaved costs. There's huge commoditization across PV upstream ('just get good panels, least cost') with module pricing ~80% from 2012. Module capacity was maybe growing >60% from 210 GW 2019, to say 340 GW in 2022. Downstream, sales of e.g. the spinoff's premium P series may help to hurdle thin margins. It will be interesting to see how both do as performances unfold. One, a 'new' premium solar panel maker - the other now handling just solar sales & installs.

Hence a roller-coaster 2020/2021 proved exhausting & thrilling. Stock chart was remarkable too; nothing like it, and 100 dense pages in this ECO Report. Overshadowing all 2020/2021 was the pandemic. Job losses jumped in a Great Lockdown. Markets cratered in many themes 2020 – they may do so again ahead. Oil imploded to places not seen in 100 years, then bounced up 1H 2021. Attention paid in 2019 to climate and clean energy solutions –initially derailed briefly by pandemic – again resurged from 2021 especially on new weather extremes.

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

Given 2016 declines, as 2021 scrolls ahead, the past 5 years by mathematical coincidence can improve – even if ECO ends flat for 2021. Should ECO/NEX happen to even gain a bit second half/2H 2021, then a past 5 years chart could really rise. It'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* most past 5 years charts, in prior Reports of 2010s, has shifted. A once monolithic 2010s that only saw 'All energy (clean too) far down' - lately has been changing early 2020s, a lot.

Striking in a 5-year Chart below, is *clean ECO/NEX leaving a down 2014-2016. It also *reflects positive up years 2017 & 2019/2020. Gains in ECO, NEX, OCEAN were big in absolute ways – plus relative to major Indexes too. With clean ECO up +300% below, it had left dirty fuels / and major Indexes 'in the dust'. Past 5 years to May, the ECO tracker is strongest of all stories here up over +300%; 2nd best is global new energy NEX is up +175%. There's then a huge gap down after the two highest themes – to next performances by 'bogeys' Dow and the S&P500 each up about +100%. Normally anything up +100% over 5 years is a 'Win'. So in absolute sense, yes: those 2 bogeys did well. Just relative to the clean & decarbonize themes characterizing ECO/NEX/OCEAN, have the major Dow and S&P500 so foundered. Farthest at bottom, the two dirty oil and natural gas themes, each are far *down* by some -50%!

A separate independent, younger global clean energy Index, not ours, trails ECO/NEX here; that other global clean energy theme has underperformed vs NEX most every sizable period, Year to Date, the last 1, 5, 10, 12 years and since inception etc. It and 2 other relevant Index themes, an excellent solar-only story, and active alternative energy mutual fund, are seen next in charts ahead for their stories the past 10 years, 12+ years, plus. Those three, serve to replace the Dow, S&P500, and an all country world theme for visual clarity in Charts.

Clean can plunge at times; so after tremendous gains 2020, a drop 1H 2021 wasn't surprising! On the other hand, clean's gains may at times also outpace broad Indexes, even up more. Consider August 2020: the Dow then 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 August by +20%, NEX was up +15%, & OCEAN was up +12% (nor were those their greatest monthly gains in 2020: November and then December of 2021 next saw larger gains).

ECO/NEX trackers vs. Varied fossil fuels themes and major Indexes a Rolling Past 5 years, May 2016 to mid-May 2021. Once, a past 5 years was 'very tough' for all of energy; here it's Differentiated – Clean ECO/NEX up at top greatly outpaces Dirty energy:

Source: finance.yahoo.com

Next page, the 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's changed? From a strict charting sense, it's partly due to leaving steep declines long ago, late 2000s and early 2010s. Those were near final legs of steep plunge then, in renewables. So including any bit of those years, had bent performance downwards. Clean relatively outperformed vs. dirty at times. Still - clean also had plunged back then too, and this fact warrants attention. Thus next is a rolling chart for the rough past 10 years from May of 2011 - to May 2021.

Past 10 years, *global* NEX is here up the most by +95%, while ECO is up +66%. This period starts leaving behind a Great Recession that thunderously dropped all in 2008-2012. That had put in bottoms for many *non-energy* stories, some moving well up afterwards. But not so energy: it got hit harder, stayed down longer. As seen here especially among dirty themes, much in energy went on falling far into 2010s, with no immediate rebounding up.

That 2010s decade was rough as well in clean energy. The story is well captured by ECO/NEX, so note ECO tracker start of 2010 was 55 – ending 2019 at 34 - well down. Global NEX tracker in 2010 was 16 - it ended 2019 at 14 - also down. Early 2020s volatile as well, unsurprisingly. Yet clean vs. dirty energy is diverged - lately happily by a lot! Long-term clean energy back history is immersed in a prior decade, as China's manufacturing solar, wind scaled up and drove down costs. That would come to accelerate solar & wind installations; it also meant lots of new supply and badly crushed margins. Biofuels spiked in 2000s; but are constrained by limited supply; prices for soybean oil like corn bushels, inflate badly with new demand.

Solar has moved somewhat past that prior overcapacity & commoditization, thin margins. Globally, NEX is positive +100% for these 10 years as noted. ECO positive too for 10 years to May 2021. Then, next is a big gap down to a separate global clean energy Index (not ours) telling a very concentrated story; it's here up but only +33%. An excellent, focused solar-only story here is up only +5%, near nil, below an active-managed alternative energy fund that's +15%. Meanwhile oil & gas are plumbing depths very far down some -85% to -90%. A tale of two cities: Big Declines for Dirty energy – vs Clean Well-Up - that's trending for some time. Recent 1H 2021 gains in oil & gas *might possibly* begin to create a new narrative, ahead.

Perhaps ahead 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'. Looking at the next chart below, a passive Solar basket was down last 10 years, but it is far better since lows last decade. A trailing active-fund shows, yet again, that it's always tough to beat the passive Indexes.

So very highest is Global NEX, and then ECO. They far outperformed vs. other energy themes here – yet trail broad Indexes not seen like S&P500. On other hand, clean ECO & NEX clearly did 'best' here last 10 years – vs. other energy stories. As time rolls past earlier tough years, then these *could* begin perhaps telling a different story. As seen next how this NEX theme captures global clean new energy is no backroom matter; it is very consequential.

Rolling Past 10 Years from May 2011 to May 2021:

Source: yahoofinance.com

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

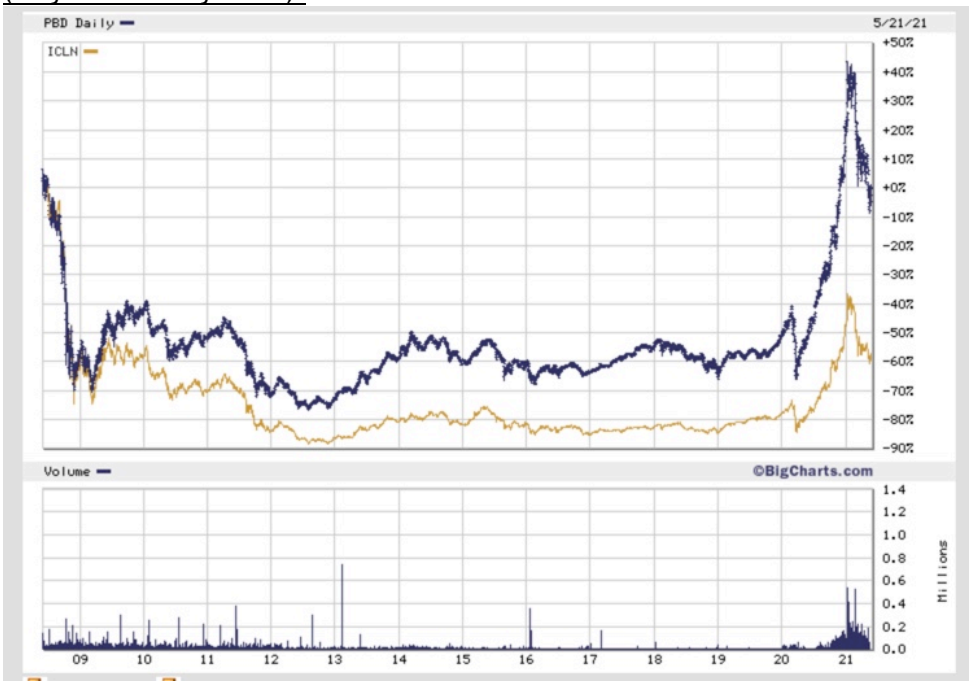
NEX is steeped in innovation, so is unlike past classifications in an old CIGS (Global Industry Classification Systems) nomenclature from 1999. One result was that the other global Index basket had long fallen more heavily in what CIGS calls "Utilities". To underscore: if one had been aiming for only a narrow concentration, just a few only biggest names, fewer themes /countries, and no energy storage – then that other basket was maybe a better choice.

Consider too their Biggest divergence: Performance. Briefer periods, the NEX vs. other Index traded leadership back & forth a bit. Shorter-time-horizons one Index might lag the other, or other lead for brief periods. So on 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 their live trackers for the past 12+ years, May 2008 to May 2021. It's interesting to see how divergent performances are for these two Indexes/ tracker funds. In sum **global NEX tracker (bold)** has long clearly shown much better performance capturing the global clean energy story worldwide:

NEX (bold) for Global Clean Energy theme since 2008 – vs a separate Index in this global theme (May 2008 – May 2021):



Source: Bigcharts.com

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

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

Nothing was wrong with that *per se*. Also, it meant a good contrast between 2 clean energy Indexes. For other differences, between global NEX – vs. that other global clean 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 has for years since its inception held just 30 components until 2021: arguably just 30 meant clean energy scope; it isn't possible to well capture very many stories across EVs, hydrogen, fuel cells etc etc.

Weighting styles matter greatly. That other basket on market capitalization, was modified by a 4.5% cap, at times far exceeded. Generally, at any rate just top 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 dominant names. So concentrating that way had 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 - vs NEX has differed at times trading leadership back and forth - over most all longer periods, the NEX does significantly better. NEX equal weighting much greater 125 names (and may grow), in start of Q2 2021 far wider reach. And helpfully, the equal weighted style allows more & smaller names to be included and heard; each has a 'voice'. Given such big difference in performance, it seems equal weighting *may be* allow a passive NEX (& tracker) to better capture more - especially the smaller and mid cap stocks, inherently purer plays. *Please note, Neither approach is 'right': they're simply differing methodologies.* Varied ways for clean energy stories to be captured. One is very concentrated – one is wider-ranging.

Both have trackers now in US & Europe. Other basket as a practical matter has moderately lower expense ratio trackers (although swamped by performance difference). And heavily-traded funds helpfully mean liquidity. Overall, 2 differing takes on this fast growing theme. An Equal weight - vs. Market cap skewing to Top few, for a variety of choice. Perhaps quite useful in real world ways, having 2 such differing baskets for this fast-emerging story.

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

After conducting a useful public consultation, in April 2021 the other Index made numerous understandable changes: Q2 2021+going forward. After a long set 30 names exactly, it was adding 52 more – and might go on towards 100 plus, total now unlimited. (With new unlimited ceiling it was again becoming more like NEX, which makes sense as this story itself may grow ahead; this allows that other Index too to better reflect what's happening over time).

Among additions, however there now are & can be Non-Pure-plays outside global clean energy – when <100. As noted that may 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*, for a major new difference between that other Index post-Q2 2021 – and the NEX. That other Index before, arguably held close to clean energy theme. Generally for example, before it had little in fossil fuels, say, natural gas.

But this change meant it now holds/could go on holding non-pure names. Just 2 examples: that other Index added a big natural gas utility that's 'not as clean' - so it cannot be in NEX. Besides its own natural gas generation & sales, plus with 3rd parties, it's also in nuclear power – which is excluded from NEX (and nuclear is soon being shut by California mandates).

Second, it added another electric utility, again ineligible for the clean energy NEX. That 2nd name is still generating much electricity from burning oil, even diesel (among the last few Utilities in US to do so). In 2020, only about ~35% of the Utility's power was from renewables, even though 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 deeper look next at such matters, plus ESG. For folks who eyes glaze at the thought, we'd suggest please skipping to a section ahead – for Rolling Charts vs. Fixed charts.

As a technical matter, some years back as small caps grew more popular, big inflows made it hard then for active fund managers to hold smaller equities, say <$500 million, even <$5 billion(!) market cap. There was liquidity risk from inflows. Defining '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 diluted out of the target concept – no longer pure.

A ramification of fast-rising popularity was it got harder to hold smaller caps, as inflows grew. Whether active managed Funds – or passive Indexes. Consider now, ESG thinking; green goals have seen tremendous interest too lately. There's been an upswing of activity, of interest, of 'net creations' especially in ETFs with focus on ESG themes. Interest grew to near one-quarter net creations in equity ETFs in 2020, went higher 1H 2021. Much interest in ESG likely aims at purportedly *clean energy* - so one may assume – truly non-fossil fuel names.

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

In a rush to ESG, perhaps towards clean energy too may logically follow. Arguably then, a priority here should be on staying tightly green/clean. Not being pushed out into brown. Otherwise, a consequence of addressing volatility or liquidity, may be that a prior focus on the desired target (say, zero-carbon clean energy) may get pushed somewhat off-theme.

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

It's nothing of the sort! But carbon-intensity can give false numeracy. 'A Greenwashing'. And lend seeming quantitative rigor - while it's opposite. Left side of equation, is correct: carbon footprint can be measurable, tons of CO_2 Scope 1, 2, 3. But right side of equation, 'intensity' grafts on 'value'. Dollars, Renminbi, Euros; the atmosphere cares not how/why CO_2 molecule was made – whether more *profitably*, or less so. Upshot is, fossil fuels are given a pass.

What carbon intensity does do, is lend a fig leaf. Seeming quantitative, it lets highly polluting firms claim that green mantle by transitioning partly from oil or coal – to gas. Useful in marketing, fossil producers may even join in some 'clean' funds or baskets – even for ESG – by using that otherly-conceived notion of profits, or revenue per tonne/CO_2, 'intensity'.

Perniciously subtle. Consider a startup solar firm, tiny CO_2 emissions, few sales, negative revenues; it won't score well for its carbon intensity. By contrast, a big fossil fuels producer that massively increases its gas sales, gobs of gas revenue, scores well. Big CO_2 is eclipsed by swelling revenues, for a 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. The smaller pure plays in NEX, inherently purer, room to grow, may thus be relevant to NEX outperformance; consider a Chart below.

These 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 right: when Equal-weighted, it nicely doubled going up fast from 100 in 2020 to over 200 - so up over +100% … vs a market cap weighted version that instead went up 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 arguably makes a good, relevant point: it's surprising to find 'brown' names with such fossil fuel exposure in ESG funds - or inside any clean energy funds at all.

In a small note, **Volatility** here isn't particularly due to *Global* aspect to this theme. Look at *global* NEX vs *US-listings only* ECO. The 2 Indexes have longest track records in the industry here (15+ years, 13+ years) - so put aside a moment that other, separate, global clean energy Index. Glance at NEX/ECO, and a few thoughts come to mind about their sizable volatility. One is US listings only basket, ECO, *may* be more volatile. We saw that head-to-head, day to day in e.g. first 6 weeks 2021: NEX tracker had sizable 14 days with 3% or more change per day to March 15. Tracker for US listings ECO had more: 24 days of 3%+ change/ day. Global NEX may have some leveling via its more nations, more stories, 2x higher cap floor.

Hence *global,* by itself, doesn't confer volatility. But *new energy innovation* may somewhat. In Q2 NEX had e.g. risky names in H_2 & fuel cells – rather like other clean energy baskets. Europe, fast greening its industry *may* seek to move relatively soon towards H_2. Continental Europe lacking gas infrastructure (it's no Texas) must import gas. It may also seek green H_2 on climate concerns too. Says nothing about how equities here may perform (maybe down like 1H 2021, maybe up like 2020): it just may reflect Europe's interest in greening of late. These nonetheless remain very risky, volatile, uncertain: mere innovation *possibilities*.

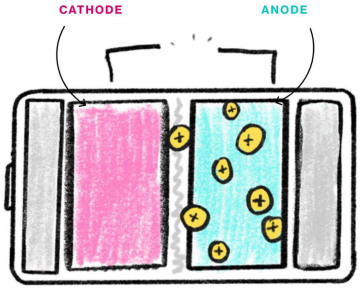
In 2021 the International Renewable Energy Agency (IRENA) reported a startling $131 *Trillion* is needed for clean energy by 2050 to avoid heating >1.5 degrees C. Coal & oil may virtually go away, natural gas might peak 2025. Global electrolyzer capacity may go from puny 0.3 GW – to 5,000 GW. Green H_2 may also be a feedstock for green ammonia, or methanol (CH_3OH) as liquid fuel. Europe, potentially, *might* become a world leader here. China may choose to instead ramp nuclear power – while only slowly reducing (if at all) coal use to 2025.

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

As for storage, the world arguably needs far more, ever 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 global NEX Index). Excerpting from their useful nicely-visual piece, we post several good illustrations below.

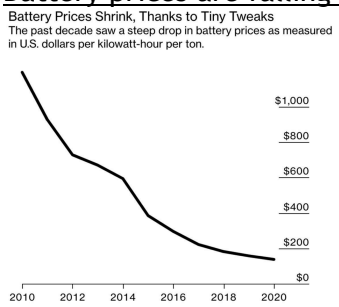
First, lithium ion is a constellation of battery types and all need materials besides lithium – such as Nickel, Manganese. Meanwhile there's considerable efforts to use less, or even no cobalt, as differing chemistries favor varied goals. All batteries basically consist of *Cathode, *Anode, *Separator, *Electrolyte. Anode's largely settled: graphite & some use of silicon. Cathode has instead a few varied chemistries dominating; each applies to particular uses where certain characteristics are favored. Traits to be balanced include: cost, energy density, calendar longevity, cycle life, fast charging, and temperature range. Favoring one like say an improved energy density, may come at cost of trade-off of reduced cycle life.

a) 4 basic battery parts:



Source: Bloomberg Businessweek

Battery prices are falling hard:

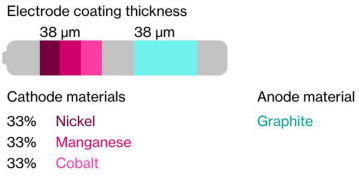


Source: Bloomberg Businessweek

b) Nickel Manganese Cobalt (NMC) in Zoe:

Source: Bloomberg Businessweek

NMC Composition in 2012:

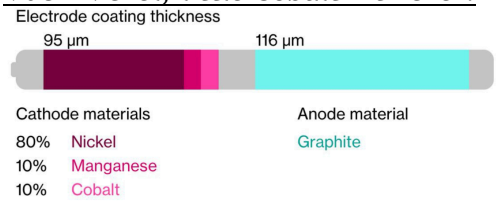


Source: Bloomberg Businessweek

c) NMC as seen more recently in a Nio:

Source: Bloomberg Businessweek

Much Nickel, little Cobalt = thicker:

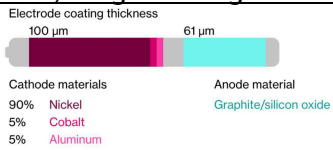


Source: Bloomberg Businessweek

d) Tesla 3 using a new NCA:

Source: Bloomberg Businessweek

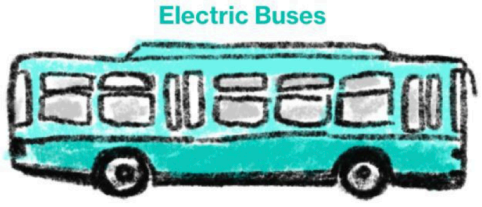
NCA, a light strong battery, no manganese:



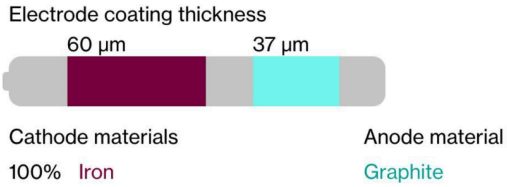
Source: Bloomberg Businessweek

A use may favor cost, over performance. LFP iron battery won't have high performance of say, an NCA cathode, but it's less costly. (We had an early electric bike here in 2000s that used an LFP chemistry). On less cobalt, more manganese helps too. 2 iron LFP examples might be a bus as short range and weight's a non-issue – or a price-conscious modern EV sedan:

e) Electric Buses using LFP lower-cost iron:



Source: Bloomberg Businessweek



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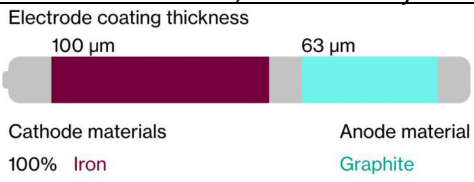
f) Modern LFP, a bit less-energy dense:

Source: Bloomberg Businessweek

Thicker Electrode, is less costly using iron:



Source: Bloomberg Businessweek

Efforts continue on better cathodes, with chemistries suited to particular uses like cell phones vs. ebikes vs. EVs. Depending on say if energy density - or lower cost, is most needed. It is certain that battery cathodes will continue to evolve, with new improvements ahead. For example, nickel is costly; thus given a desire for less cobalt, attention's being paid to improving energy density via less-costly iron phosphate (LFP) batteries – or spiffy NCA. The world's largest LFP supplier is based in China, a leader (where else?); as a new LFP competitor there is adding leverage to EV makers considering iron for less-costly EV models.

Adding a bit more silicon at anode, while avoiding swelling, also shows some promise. Farther ahead, much better, metallic lithium batteries could be - would be so impressive. Their fire risk is untenable on 2021 state of the art; 'dendrites' can penetrate electrolyte. But idea of a new-generation solid-state battery mid-2020's is tantalizing. There's a drumbeat of wistful hopes ever-on the horizon. Meanwhile a solid-state battery still elusive, may be getting closer. Notions of non-incremental, bold advances like a solid-state may make one hopeful.

For instance, recent research shows a new hierarchy of interface instabilities, self-healing, *may* fortify separator at cathode/anode, ensuring no puncture, replacing liquid electrolyte with solid-state core. Plus allow ultrahigh current density. With a fire-safe boundary, energy/ power density improves significantly while bringing down charging times dramatically. Lithium metal anode, paired with $LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$ cathode – has shown 82% capacity retention after 10,000 cycles! Not long ago, a standard was 80% capacity loss (at which point Li-ion battery is 'dead' for EV purposes) after just 500 cycles. Thus early electric cars strove for 200-mile range, given 500 charge/discharge cycles of 200 miles range – delivered 100,000 miles life for an electric car battery. Afterwards it might have 2nd life uses such as maybe stationary storage where less than 80% is acceptable. Should a 10,000 cycle (or well short of that!) solid-state battery *possibly* enter production mid-decade, then like going from vacuum tubes (we recall once building radios with) – to solid-state transistors, and then to wondrous computer chips – a solid-state step up *might* be game-changing.

Please be aware, some recent phrases may mislead a bit: 'carbon intensity' isn't actual CO_2; a strong 'E Pillar' ESG score doesn't correlate to low-CO_2 emissions; a big oil & gas producer may promise 'low emissions' for its own operations (scope 1) but not scope 3 emissions or might regard energy efficiency as a responsibility of buyers); 'carbon credits' may be used in ways that game true emissions reductions; and 'net zero' like a 'carbon sequestration' phrase, or too-distant-2050 promises, may divert from today's much-needed true zero-carbon.

Lest that disappoint, consider such dissembling oft as last gasps of a dying past. Solar, Wind & Electric Vehicles arguably have already won as superior technology ahead: this decade will fill in the blanks. Mid-term, natural gas likely faces stiff competition from batteries/ storage enabling renewables to be firm power. Longer-term, maybe green H_2 perhaps – and more economical ways to provide clean heat in buildings, and industry.

A last point about Charts. One small problem with **rolling** Charts, past 1 year, 5 years, 10 years etc, is in a few years they *may* show Very strong returns ahead here for ECO & NEX. Once charts leave a huge fall 2008-2012, and tough 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 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 12+ years & growing, this *non-rolling* chart shows past Very Big energy declines. Unsurprisingly, fossil fuels again lag green, sizably. But, relative to a rolling 10 years, one vibrant difference is a global crash back in 2009 has been highlighted, forever preserved. What energy will do ahead, in the 2020s, will doubtless be of interest as these years scroll forward. What was once viewed as tough times for all energy last 12+ years - *may* instead ahead perhaps show as very tough for fossil fuels mainly … Or perhaps, Not!

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 from 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', 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 & a deep mire afterward stretching across clean and dirty energy, for years, is brightly preserved below forever.

Starting from the bottom we see 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 had just 30 components so differs greatly vs. NEX. Tied with it is an actively managed alternative energy mutual fund. 'Above' those steeply rising yet still near nil after dramatic falls 2008/2009, is ECO. Clearly 'highest' among energy baskets here is global NEX though near nil, +2%. Broad Indexes outside energy (not seen here) did do *far* 'better' yet differ sizably: energy a sliver there. Plus since 2017, clean energy has shown quite some upwards volatility too, which *may* yet change many things ahead:

<u>Roughly Last 12 ½ Years starting from a Fixed June 1, 2008 to early 2021:</u>

Source: yahoofinance.com

Side note is a clean energy plummet in Spring 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 losing -12.57%, closing at 47.37. So this basket dropped by ½ in early 2020, from a 93.65 high, intraday on Feb. 20 (closing @92.53). In just weeks, ECO plummeted -50%!! World markets were crashing too amidst fears of a 2nd Depression like unemployment. All seemed on brink that moment. Lest we over-emphasize negatives, spotlighting falls like Q1 2021, or those seen long ago in 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 March 24th nadir, a 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, fears of 25% unemployment & Depression, the Index went on to 55.87 on March 24, closing at 55.74 on hopes of $2 Trillion stimulus. Focused green support wasn't expected in a new stimulus in 2020; and as expected, that help didn't come – since it was opposed politically. Yet clean energy's growing cost-competitive - even *without* subsidies ahead (unlike fossil fuels and nuclear, that so need continued support).

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 S&P 500 & Dow rose some +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 upside: ECO rose +19%, while volatile NEX gained over +12%. Broadly they were rising themes.

Compared to Top 10 in a market cap 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 component in fuel cells had risen to some 10% of it, Q1. When that 1 sharply fell in March, it pulled that other Index down by a sizable amount. Not so much, in NEX/ECO.

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

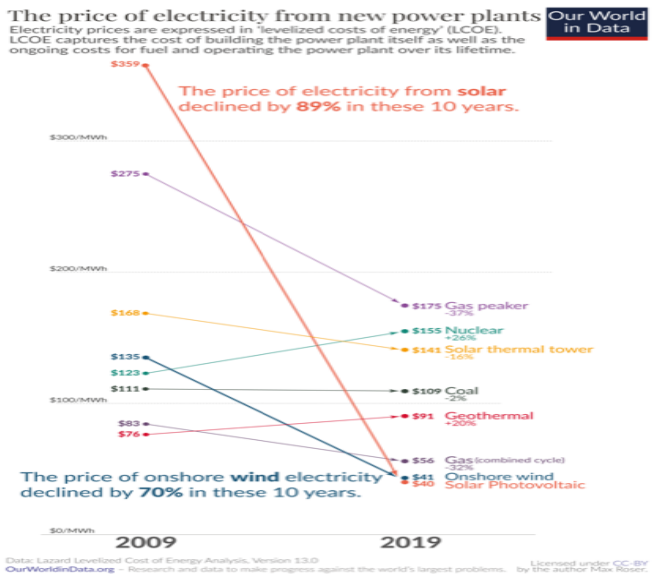
Solar & wind, and EVs, are different. They'll more likely grow, vs. far less certain green H_2. That said there is growing interest in H_2 and easier to transport green ammonia (H_2+nitrogen) as liquid (like propane), and even green methanol – moving hydrogen like an energy currency. Where super-hot furnace temperatures are needed, making steel, cement, aluminum, clean electricity from solar PV/wind can't normally accomplish that. But adding a step, could. On electrolysis by cheap green electrons, green H_2 from water (H_2O) – makes high temperatures. One firm is looking at a >90% efficient electrolysis, no membrane needed, <$1/kg! Green ammonia, or methanol as liquid (neither one blue from rock gas) being energy carriers.

Applications immediately show themselves if green hydrogen is under <$1. Making say 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 project in Sweden aims to instead release only 25 kilograms CO_2 per metric ton of steel – vs. 1.6 tons today. An affordable green hydrogen ideal often talked about for decades could just possibly, advance H_2 & fuel cells.

Flip side of America's starting from zilch 2010 - is that where we are on renewables now, is *Awful*. Even in 2020 US offshore wind 'should already' have been in hundreds of GWs; instead it was near non-existent. Solar in 2020 made up only 3.4% - and wind 8.1% of US electricity. When solar & wind should have been meeting 100% of electricity demand. Electric propulsion in cars, trucks, ships, jets is still but tiny rounding error. So it may feel we've come a ways – but it's only given how pathetically we began. The World Economic Forum observed on 'Our World in Data' (OWiD) figures that 2019, fossil fuels made up fully 79% of energy production worldwide. Unsurprisingly that had come about because they for so long had bested all on costs and reliability, relatively speaking. And on firmness, But not much longer.

Solar is forecast to wallop dirty ahead, given price plummet of 89% last 10 years. Costs of solar, like wind & storage, continued dropping hard 2020. Coal, oil, gas suddenly are becoming instead relatively costlier - they always must pay for fuels. Fossil fuels are always bound to be expensive to operate, they must pollute, and they seem powerless to reduce their cost follies much further. Unsustainably, they're creating 87% of global emissions of CO_2. Estimates are their air pollution alone has been causing 3.6 million deaths every year, which is 6-fold more than all the annual war deaths, terrorist attacks, and murders combined!!

This Report focuses on energy, but it is a broad topic that my include heat and other uses. Coal, most harmful energy source, still generates 37% of our electricity and with it, the most CO2. Natural gas, 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 due to fracking – costs there turned back up in Q1 2021. Yet changes there are dwarfed by wondrous-solar: costs down by -89% and by onshore wind where costs are down -70% as seen here:



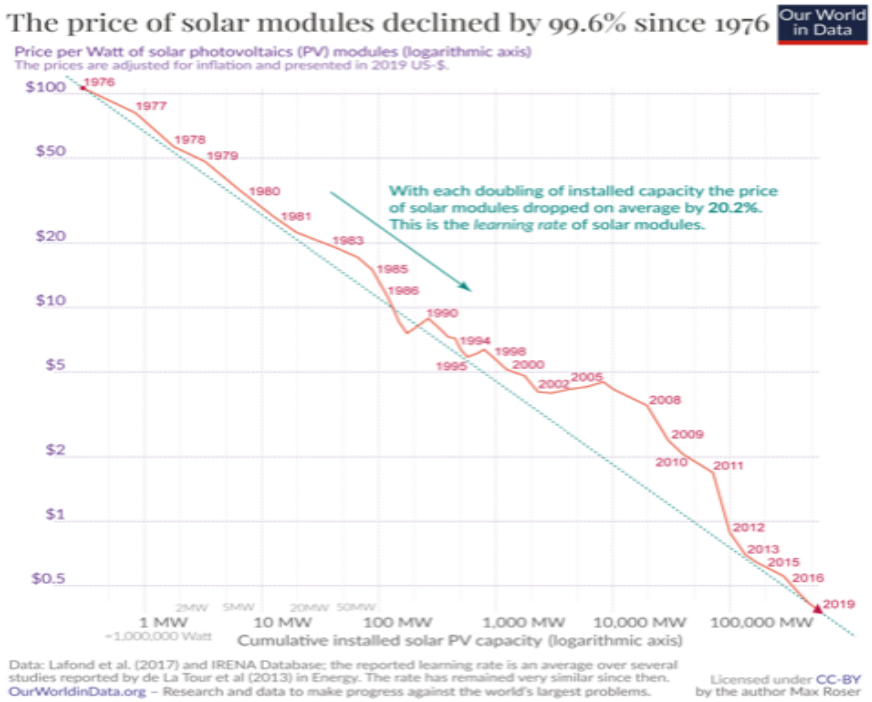
Source: Roser, Why Did Renewables Become So Cheap So Fast? Our World in Data (Dec. 2020).

So fossil fuels & nuclear are poorly situated as ways in 2020s to make electric power. Think about it: they are vexed by *high costs of Fuel, & what about their Wastes (nukes must store it for centuries, millennia after shut-down!), and by their *High Operating Costs with hundreds+ of employees; those costs won't decline. Every new, non-standardized US nuclear plant costs yet *more* to build(!) – the exact opposite of better solar/wind.

At a coal plant, fuel costs may eat up 40% of operating costs. Natural gas fuel costs declined 10 years to 2020, but Not in a long-term trend; in Q1 2021 it is Not going far lower.

Renewables solar & wind instead enjoy *zero costs for fuel. Relatively-speaking *close to zero Operating Costs. How horrible it must be, for the fossil fuels & nuclear to compete with that! Only by amortizing sunk costs at already-built coal, gas, and nuclear, can they reduce costs significantly until extant plants age-out. Comparing like for like, new renewable solar/wind are simply much more affordable on levelized costs/LCOE – so often better than the rest.

That OWID Report identified an early solar cost in 1956, $1,865/per watt(!). So just 1 typical 300-watt solar panel today, installed on a person's rooftop would cost over $500,000 at that rate. Of course, that was unaffordable back then. Advanced nonetheless for say, space applications, solar went on getting better, prices came down very fast. *So with solar it's all about the Technology*. Similar to integrated circuit chips in computers, we grew far better at cramming in lots of performance ever more cheaply. It's a virtuous circle, similar to computer chips which enjoy ever greater new deployments = prices falling more = more competitive new markets = and so demand increases: repeat that over and over and over!



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

Solar module prices fell so enormously -99.6% since 1976(!) as it's all about Technology. And the Executive Branch may reduce or repeal existing tariffs, so China PV becomes cheaper. Fossil fuels – by contrast - are Not all about technology; they may be doomed. Declines seen above like 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 learning curve? They can't, if economics is a metric. But fossils have great inertia, much influence, capital, lobbying, and will deploy that (more on it later). No doubt they won't go gently into that good night. Still no wonder solar & wind make up most new power construction. Now, in a clean energy index, storage has got to be significant. And how an Index is constructed – is as we note – very significant as well.

Meaningful are the initial choices by Indexes, which shape them. Their early vision, impacts performance mightily. Though passive, this literally shapes the 'mind's eye' of a basket.

Take a well-known 'FTSE 100'. In the UK and oft called 'Footsie', this Financial Times Stock Exchange Index is made up of the 100 largest blue chip firms listed on the London Stock Exchange. A bit of a prosperity gauge for UK economy, it's also the most widely used measure of how well the British stock market and firms domiciled there are doing.

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

But, not much, really. Initially its 100 companies first had market value about £100 billion – with Index starting at 1,000. By end of January 2021, it stood around 6,400. That was an annual gain over 37 years of just 5.1% (7.6% annually including net share issuance).

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

Much stronger growth was seen 1984 through 2005. It had shown a better return compound average growth of 12.5% (real terms 8.5%). But then 2005 through January 2021, annual growth rate has become much slower and only 2% ahead of inflation at 4.7%.

This over a period lately when the US technology & innovation equities positively boomed.

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

As a market cap weighted Index, it might automatically adjust for awful returns in CO_2 heavy old school oil & gas. Once-big firms decline, losing Index prominence, that allows much faster-growing smaller firms to take up the leadership positions. Problem is, the rest of that Index by definition (remember, literally 100 largest firms listed) have similarly been in slower areas like mining (now is 8, but had been 12), in retail, or tobacco. Not in innovation or technology. It's thus not so similar to an S&P500 (recently adding its first EV maker). And surely it is not at all similar to innovation-heavy Index like say, popular Nasdaq 100.

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

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

As pointed out in MoneyWeek, part of FTSE 100's issue is absence of organic growth among its components. Sage plc has grown enterprise software, as Next plc did clothing retail. But much also entered top 100 by mergers & acquisitions – not a good long-term ramp for growth. An innovation & technology thesis in Nasdaq 100, the Nasdaq Composite - or an S&P500 are different. As noted in MoneyWeek, the S&P had 19 technology stocks in 2005 – while FTSE 100 had only 1. Early 2020s, more technology names joined FTSE 100 than before. Still by contrast, US Indexes reflect considerably more tech themes. The mid cap and smaller cap FTSE 250 enjoys more momentum and more innovation-equities, than the FTSE 100. Seeing this chart below – clearly performance farthest at bottom these past 5 years is FTSE 100 in light blue that's 'up' only very little in this period (to mid-February 2021) some +11%.

Next up mid-cap FTSE 250 in purple does sizably better, +30%. A technology-rich barometer, S&P500 in pink doubled here. Tech-and-innovation-heavy Nasdaq composite in gold is far up, at 200%. The **NEX Index in blue** is up +275%. To be sure, innovation and technology themes are very risky: at times they'll drop hard & fast. While a conservative theme is less risky, over recent periods at least technology and thematic areas (like new energy innovation) has outperformed by far. So much so, one must be very wary of a bubble here – and recall too the NEX - like ECO & OCEAN - can and will at times 'drop like a rock'. Here it is:

Past 5 years to mid-Q1 2021; FTSE 100 is at bottom pink, **S&P500** middle, and **NEX** at top:

Source:YahooFinance.com

With hindsight one can obtain better performance than a FTSE 100 of late in UK markets. One might for instance rely on a differing, mid-and smaller cap FTSE 250. In some ways the 250 is similar to 100 – yet other ways quite different. As name implies it's the top 250 by market cap also listed in London. From 1985 through January 2021, it had returned a more significant +8.5%, putting is well ahead of the large cap 100 (that's been up 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 perhaps be mildly notable: like emphasis or not on older themes of the past. (Big/conservative maybe better in down years). Or a potential pool of components tending to skew, or not, towards tech innovation. In the FTSE 100, older style energy is rather large at 9% and there's much mining (materials) 13% - so together 22%. By contrast in US those two are 5% of market; in Europe they are 10%. In the US: technology makes up 28%, healthcare 14% of the S&P500; in a Europe-wide Index (ex-UK) it is roughly 10% and 16%. By contrast, they're just 1.3% and 10% in the UK. In sum the rules and construction of an Index can be thought of as shaping the theme; they really matter. Next, let's look at some possibilities ahead in a world fast changing.

A Recent Past under Covid-19 – & perhaps some possibilities ahead:

New President + bare Senate majority *might 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' ever contemplated.

A glimpse of what may be sought 2021+ after is seen in a 500 page Select House Committee on the Climate Crisis Report from Summer of 2020 and 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 on in this decade towards decarbonization, are be a big change.

This Plan is no small beer. It's far more ambitious & aggressive than was contemplated back in early 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 unmoored *hype* like before in hydrogen fuel cells (since called 'fool cells' by many) – then big drops may be more likely. Plus, expectations may shatter as big changes like a national renewable energy standard, or carbon tax - require legislation & so Senate - home to compromise, inertia, realpolitik.

Consider as well, how little was truly done for US clean energy mid-2020. Summer of 2020, federal pandemic aid for fossil fuel-heavy sectors reached some $68 billion; yet 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 will change soon in the 2020s).

More directly fossil interests got $3 billion in forgivable small businesses loans back mid-2020. Contrasts with little support specific to clean energy. Impossible to know if we're in calm before another pandemic wave 2021 and after. But, solar has re-gained momentum, Utility scale up some 43% in 2020 to 19 GW. Costs dropped 5%-8%, as many big installers re-reached pre-Covid expected levels. Early 2021, even US residential solar grew by 25%-30% in 2021 YoY! Europe expected to do well too, plus on fewer inverter supply challenges.

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 tripled the world's figure first half of 2019. Major offshore wind array decisions in 1H 2020 had included a 1.5 GW Vattenfall project off The Netherlands and it was largest to date at $3.9 billion; a new 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 600 MW Guandong Yudean that will cost $1.8 billion.

One big driver lately was huge declines in offshore wind costs – plus looming subsidy cliffs. Unlike solar based so strongly in semiconductors (like cramming ever more memory capacity into semi chips), wind is more about advances like in heavy fabrication, and ever-bigger blade designs. Since 2012, levelized offshore wind costs dropped 67%. Unlike onshore-based wind rubbing up against limited availability, oceans are immense, often windy spaces for placing massive turbines far from view. Big wind farms have been providing desirable, reliable, returns on capital. Thus, renewables investments here rose 1st half 2020 to $132 billion, vs first half 2019 at $125 billion. Much of that offshore wind fast growing worldwide.

Even with Covid-19, 3 nations experienced especially strong new renewables investments in part thanks to their offshore wind early 2020. China was up some +40% over 2019; France had tripled, and The Netherlands gained by 2.5 fold in 1H 2020 - vs 1H in the prior year. Let's take a look at one particular offshore wind development early 2021 that stood out. This was oil giant BP's winning bid, £924 million for the option to develop 2 offshore wind sites off North West England and Wales. Their winning Bid in 2021 has perhaps said several things.

One maybe: BP with its big money is 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'll pay the British Crown Estate near £231 million per year, over 5 years for each of 2 sites end of which they'll 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 to Crown ocean property by Cobra Instalaciones y Servicios alongside its British homegrown offshore venture partner, Flotation Energy. That well surpasses too £83,000 MW/year paid by a joint venture of Total & Macquarie to another site. And it's more than £89,000 MW/year & £76,000 MW/year in 2 bids won by the big German company RWE for big wind farms at Dogger Bank.

It hammers home that BP rather late to offshore wind is paying high prices. In a sense its hand was forced: it promised to go carbon neutral by 2050. But there's a cost to coming late. Its shareholders have seen higher-returns once earned from older oil exploration & production. So BP may feel some considerable pressure to earn something like high 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 has shown poor returns for years. US behemoths too like ExxonMobil have shrunk considerably. And past-high times hard to match. 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 industries or jobs that could match what fossil fuels once paid, and allowed workers to stay in the same one place their whole lives. Today in green energy, a worker in wind with years of experience and training can make good salary around $80K/year, a better-paid geothermal around the $80Ks, solar with some years of experience in the $70Ks. Unionization rates have dipped everywhere, including aspects of fossil fuels production. But in areas like pipefitters, unionization rates are relatively higher and with it comes sizably better Wages and Benefits.

Wind farms once built 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, perhaps likely to be enjoyed by first-moving risk-takers. Otherwise, lumbering fossil fuel giants like a BP, or supermajors following others' leads, may instead experience lower returns nearer say to 5% - than 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 green energy. Leader Orsted, even 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 old still fossil fuel-centered business models. All perhaps non-starters, as is reflected in market cap trends.

Consider 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 (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 spending at BP for its renewables and clean tech might not be terribly inspiring. However, ExxonMobil in US is spending much less: under 1%; same 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 in Europe shows biofuels, biomass, wind, solar, hydrogen leading – plus as one might expect much around varied treatments of carbon. And shareholder actions are likely to be increasingly successful soon in prioritizing climate action.

Backdrop to it all, post-2021 gains after output cuts by OPEC+, is that Big Oil & Gas valuations mainly declined past 5 years etc. That's important: perhaps the more that fossil behemoths especially in the US resist change, more they *may* head longer term towards smaller market caps. Those most wedded to highest-CO_2 models – may possibly (Ahem, no polite way of saying this): move towards Irrelevance 25, 30 years from now. Like coal & steam before them.

Take for instance, 1 year to mid-Q1 of 2021. Here's **BP, in blue**, a Big Oil example at bottom, down -45%. (It did rise on announcement of its billion £ wind project). A bit above it, though also well negative is carbon-heavy **ExxonMobil, in gold,** off about -15%. In contrast, Orsted, in light blue (once was in oil & gas, but sold that & instead embraces clean renewables like offshore wind) is up +40%. And a tracker for decarbonizing **global new energy innovation Index (NEX), in orange**, is at the top here to mid-Q1 2021 at least, up some +140%.

Source: GoogleFinance

Denmark's Orsted rather a posterchild for a once, oil & gas firm, transitioning truly to clean new energy - successfully, growing & becoming more profitable to boot. No half steps, nor dithering with 'carbon sequestration' to prolong fossils. Orsted robustly launched itself into wind, solar, bioenergy. Benefits are shown in rising market capitalization (above), increasing strongly - even as BP & Exxon declined. Benefits can be underscored in Scope 1, 2, 3 rankings, for emissions. Scope 1 means direct emissions by company's own operations, Scope 2 indirect by say its power suppliers; they can be reduced even as a firm goes on selling fossil products. Big Oil could thus stay put within its dirty fossil fuel lane, while reducing Scope 1 & 2.

But Scope 3 refers to customers' carbon footprint using the product/s; hence only a green transition (like at Orsted) to genuine sustainable energy will satisfy this measure. If US Big Oil is determined to stay in dirty energy, perhaps on facile CO_2 accounting like 'carbon offsets', marketing and like, then Scope 3 concerns still nonetheless grow ever-tougher.

Big Oil Europe is starting to embrace offshore wind, well ahead of the 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 the cash, experience, engineering knowhow – like BP partnering with Equinor of Norway for US wind. What's also needed besides wind - floating or otherwise – and potentially too in big oil's wheelhouse, is adding magnitudes more energy Storage. Big oil could accelerate storage: pumped air in existing caverns (not carbon sequestration!); weights for gravity storage, geothermal. As noted, geothermal power at lithium-rich hot brine could make clean power – and zero-carbon Lithium for batteries. Such zero CO_2 green lithium could displace rock mining, and the water-intensive evaporative ponds still using sulfur.

UK lessons learned in ocean wind can assist the US. In infrastructure like undersea cables, facilitating offtake of power in first-place. In this like much else, the US has badly trailed behind UK in offshore wind policy. In 2021 there was 'just' 10 GW in UK, which still ranks it as world-leader. The UK aims to quadruple that this decade - to 40 GW offshore wind - enough to power so many homes. Yet they could do much more. The US by contrast in 2021, had pathetically close to zero offshore wind, despite a vast country's even more vast shores!

Data from excellent Bloomberg New Energy Finance, BNEF (our long-time prior NEX partner) - and the US National Renewable Energy Lab, 2021, shows how badly America lags Europe and China on offshore wind. We could all use the same innovations – GE Haliade 12 MW turbines, Siemens 14 MW, Vestas 15 MW wind generators - so consider a big obstacle is US regulations. All of America early 2021, had but 2 small offshore wind farms at work, one a tiny 30 MW site so equivalent to just 2½ turbines! That will change – but it's much too slowly.

Breaking down the US Pipeline, initially there is a Project Planning stage (developer or Agency initiates site control), then Site Control (lease/contract), Permitting (building plan+ offtake agreement), then Approval (regulatory OK), Financial Close (sponsor investment), next Construction (build initiated), and Operating. This doesn't include myriad lawsuits in the way, political opposition, sparse infrastructure to offtake power, all halting offshore wind before it begins. Perhaps little wonder, wind power has been so absent thus far from US shores.

What's changing like 'pig in a python' are projects bulging near start. Projects in site control, offtake stage have increased +200% from a small base in 2018/2019. Start of 2021 some 28 GW various US projects were mostly early development stages. As slices of pie, now-installed US wind is hardly visible: 30 MW, or 0.1% of 28 GW planned ahead, a tiny 12 MW in final approval. But a new 6 GW of coming US wind is advancing towards permit offtake stage, 22%. It's a big ocean; some 60% of 28 GW pipeline or 17 GW, is still in earlier lease area/site control step. There's several years yet to go - but it is at least some small progress.

US states farthest along early 2021, all in Site Control/Permitting were Massachusetts with 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 final Construction in 2021; Virginia's 12 MW energized. Overall, the US is 'progressing' far too slowly, many years to unfold.

Confoundingly, all but 2 of 11 States in wind's pipeline 2021, were on the East Coast. Despite Pacific Ocean's great wind resources! One might guess there'd already have been tens of gigawatts, including Texas and Louisiana coasts - yet only California & Hawaii have potential projects, mere 1 GW in planning. Much is needed too like submerged power cabling. That said BNEF raised its estimated US offshore wind projections +70%, from 11 GW by 2030 estimated in 2018 – to 19 GW by 2030 just a year later, in 2019. And it is since growing.

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

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

A decade before the UK's steady growth had built most installed offshore wind: 8 GW. Germany started later, it grew faster. Then China most 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. China especially, goes from just 10 GW wind in construction 2019, to soon leading globe in offshore wind.

More granular facts get interesting; starting about 2024, US may be a significant player. Here what grows significant are *floating* offshore wind platforms. US offshore wind that's attached to seafloor is entirely still East Coast, where trailing edge margin means shallow waters. Deep US West Coast waters, would mean operating in waters of 1,000 meters or more.

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

Startling change is US ambitions on 2.3 GW proposed pipeline. Here, Castle Wind off California is a large 1 GW; it might go in deep 900 meter waters. Interestingly all 7 proposed US projects use steel semi-submersible platform. That's easiest of 3 main types of floating substructures. With a shallow draft they might be built by docks, towed out without heavy lift install vessels. That design now makes up 89% of substructures where a choice was made. And note for fixed wind, those new huge 12-15 MW wind turbines, the number of vessels able to install nacelle mass >500 tonnes, hub height >100 meters & rotor diameter 200 meters(!) is vanishingly small. So highly specialized vessels for offshore wind (WTIVs) must be constructed for monopile wind affixed to seafloor, for jackup depths >50 meters. Vessels (especially on Jones Act) & port infrastructure needed from scratch for hopeful growth of fixed & floating wind ahead.

Crucial to all offshore wind, is pricing. Like solar, it's falling dramatically – with onshore wind costs modestly more than solar. Yet renewables are all highly favorable - vs. costly nuclear, and dirty coal, gas – as old energy is unable to compete with price declines of their own.

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

Once offshore wind steadies its toe-hold, regulatory issues get better understood & fixed, *floating* wind may have far greater presence. America's 1st floating ocean wind project began late 2020. Meanwhile, China is creating much faster growth in its offshore wind. Solar too, advancing there. China confounded expectations for slowed solar manufacturing in 2020 due to Covid-19: instead, its solar manufacturing even gained speed. First half (1H) of 2020, China produced 59 GW of solar panels, that was about 15% greater than in 1H 2019.

Europe seeing decarbonizing gains in solar & wind. 1H 2020 the EU made more of its power renewably – than from fossil fuels. Note nations there, with **more* renewables - enjoyed **cheaper** electricity prices – obliterating a 'higher cost' argument oft leveled against green. Despite critics' dings that renewables 'suffer' from intermittency, there was strong electricity supply 2020 & 1H 2021 in Europe (unlike big power interruptions in California, Texas).

1st half 2020 among 27 EU members, wind, solar, hydro & bioenergy made 40% of electricity overall – fossil fuels, 34%. Latter April to June, renewables made 44%. Austria then made 93% mainly using its hydro from renewables, Portugal made 67%, and Germany 54%.

In Denmark wind & solar alone made 64% of its electricity; Ireland 49%; and 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 – on one perspective. From 13% EU electricity in 2016, to 22% 1H 2020. Yet from 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 has made much less progress. Renewables just 18% US electricity generated 2019, fossils 62%. Recall again how European nations with *more* renewables, often see *lower* *Wholesale* electricity costs, rewarding green areas. 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 extended 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 wouldn't yet get a credit unless bundled with solar. Nor was a $7,500 credit re-extended for GM or Tesla cars. But the future looks to be better. In 2020, consolidations continued, solar went on maturing. And 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 ways from few small solar listings possible for ECO and for global NEX we well recall back in 2006 or 2007, even 2010. In 2021, an issue was rising costs across solar inputs – and so projects pushed off.

Data & facts reveal an energy landscape changing so fast, it's challenging 'all we know' about energy. Clean energy overtaking fossil fuels on price. Even more compellingly, clean energy – *Without Subsidies* – soon *becoming more affordable than fossil fuels & nuclear!!* Economics more than anything changes everything. Carbon awareness still lags. Economics thus is vital – and trending smartly (if 'too slowly'). Especially given coal, oil, and nuclear shrivel without their more highly-needed subsidies. Not our Grandparent's energy world.

While coal prices had hovered near level for years - renewables (and gas) got more affordable – thus renewables plus natural gas suddenly became leaders. Especially on 2020 demand loss: Utilities turned 1st to their lowest-cost sources. Those were renewables on free sun & wind - plus natural gas. Coal left in cold. Gas is big, it is capable, flexible. Fracking brought a fuel price collapse (price spikes seen since, in 2021). Relatively firm equity gains in oil and gas in 2021, from off 2020 lows have been noticeable - but may lack prospects for sustainable strong decades of returns ahead – especially vs. cleaner decarbonize themes today.

So green themes may be flowering, in key cases like never before. Consider, Electric Vehicles. Here, Carnot's Limit helps explain why new electric cars were destined to outdo old-school oily 'gassers'. Today's very best gassers are inefficient, sadly archaic at their best. Their diesel or gasoline heat engines in cars & trucks only let them reach theoretical bests near 40% efficiencies. More typical car heat engines sadly just 20% efficient(!). Gigantic heavy SUVs, anchored further by lacking-in-torque heat engines, are relegated to be so slow, that they suffer from often silly model differentiation like on the number of cupholders.

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

Or consider, big thermal power plants today – and what Mr. Carnot observed in 1800s. Today's sad natural gas turbine steam plants only reach efficiencies in the 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 on time's arrow, given entropy, it 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 in discrete quanta; we've learned to harness photons in solar panels made ever better in 50+ years. On research in wavelengths, new solar panels may enjoy maximum efficiency ceilings far 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 well 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 that is profoundly pushing only-downwards on solar costs, often very rapidly.

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

In a metaphor, fossil fuels served us for centuries. We 'learned' in their 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, for avoiding waste we'd never build something that's 'too big'.

Like Newtonian Physics, what's long been 'known' may mislead. Semiconductors 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 still, weirdly different Quantum theory at first so bizarre to us, has increasingly explained reality for new understanding – so that weirdness is being usefully-harnessed.

It's 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 the same time. Einstein-Podoleky-Rosen paradox where 2 entangled particles though far distant from one another, 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 progressed as we learn. Space no complete vacuum; virtual particles may briefly snap in & out of existence. Photons may act in 4 possible ways, 2 actually observed, other 2 options simply cancelling each other out – so wonderful Feynman Rules of probability weirdly, profoundly deterministic - in what is the Hong-Ou-Mandel effect. (If interested in more, see e.g. the Quantum Centre at the UK University of Sheffield, https://www.youtube.com/watch?v=ld2r2IMt4vg).

A point being that in clean energy too, we're learning bizarre novelties, some at first 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. It's progress! Jarring yes, but leverage in how we advance – including in new energy innovation. Especially as we're moving ever-nearer towards zero CO_2 and towards softer, more natural energy paths.

Lashing lithium batteries to AC motors in electric cars were 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: 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; US dirty energies use 126,000 sq km. And if solar PV becomes super-low cost, then over-sizing solar may more than compensate vs. more costly added storage. 'Oversizing' solar – given fuel is free – may have not be issue or penalty we felt in over-sizing any coal or gas plant. Moreover that solar power may in time be shared widely via grid, or as surplus green H_2. Ever over-size say, a nuclear plant? 'Fuggetabouddit'!! That would be so costly, inflexible, vexed wastes stored for centuries or millennia, that it's been cul-de-sac of an idea for any fossil fuels or nuclear.

Yet intriguing, if solar grows super inexpensive. Electricity usually must be used immediately when generated – so we've learned to avoid it. But in a new world, to possibly waste some solar via overcapacity on sunniest days, might obviate need for (costlier) storage. Nothing like oversupplying dirty-brown electrons which has carried all kinds of downsides. If free and abundant renewable electricity is provided by intermittency, then the green H_2 & inefficient fuel cells once staggeringly 'foolish' 20 years ago, might just begin to make some sense.

Leaving these academic musings aside, let's return to decarbonizing now. ECO/NEX/OCEAN saw equity gains in 2020 - dirty oil, gas & coal flailed by comparison. Clean energy clearly 'beat' brown energy then. In a recent turn, clean energy bested major bogeys too in 2020. Yet solar, even with all its green credentials, like anything else may suffer unneeded potential undesirable risks. We'll address sadly a political risk next, that's so unnecessary of late; a possibility of unneeded/unwanted forced labor within one unique region.

An issue lately brought to light is allegations of forced labor in Xinjiang Uighur Autonomous Region of desert in northwestern China. Of note here, Xinjiang as a major source for silicon used in manufacturing solar panels: processed polysilicon is used in solar made worldwide, including in the US. 'Poly' prices have plummeted over many years, to where it's become a cheap commodity. 3/4s of 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 currently 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. 3 aren't in any of our Indexes; but 2 do have US listed shares and they are widely found in many US and global clean energy Indexes including ECO & NEX – they also are in a great many active funds. One is in 135 mutual funds, the other in 165 mutual funds. Indeed, one is a leading component by weight in a separate good global clean energy Index (not ours) & tracker. So this issue warrants attention. (None of those 5 are in the OCEAN Index).

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. is seeking to ensure there's no forced labor 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 to a Neutral rating on that possibility; again no evidence, but without clarity, the US Congress or Executive may soon act given this gravity. At present the 2 solar firms emphatically state they condemn forced labor, 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 has not (yet) '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's mining Rare Earth minerals was raised by that source elsewhere – but for far different reasons. (Besides too mining's myriad ecological challenges). Instead, given the vital role Rare Earth's have across clean energy's spectrum in solar, wind, electric vehicles, batteries etc, another of its reports looks at dominance of China in mining strategic rare Earths. 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 greatly impacts the oceans, http://fullmeasure.news/news/shows/the-battle-below

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

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

They note rising solar demand & capacity constraints pushed poly prices upwards 1H 2021. 2020 poly was priced $10/kg or $11/kg. Poly went past RMB 100/kg in 2021 (1 Renminbi=$0.15 USD), on to RMB 150/kg or $21/kg ex-VAT. They'd seen a risk of solar poly at 150 RMB in 2021, and it hit that on high demand. Wafer suppliers 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 a China (STAR) listing in 2021, may add capacity of 40, 80, or 100 MT. Given strong demand, Tier 1 costs flat a bit 2021 near RMB 30-40/kg or $5-$6/kg, there's scope maybe for margin expansion. Growth might occur in eg Inner Mongolia & Yunnan; and if prices rise quickly, that draws in idled Tier 2 suppliers. Generally, 2021 had seen rising demand for PV, and pricier solar glass, silver, and freight too. US Utility scale solar pricing was at around 25-27 cents/watt; closer to 29 cents/watt in 2nd half 2021.

Solar's situation back >10 years ago was so different! Then, pricing 2010 for *finished* modules was near $2.00/watt. Costs have dropped so hard since; from $2.00/watt (modules) in 2010 - falling last 10 years to just 0.20/watt by 2021! Poly commonly a key input in solar panels so costs are critical. PV poly in 2010 had cost some $55/kg, that spiked some on shortage in 2011 to $80/kg. But after that, it mainly has dropped considerably lower. By early 2021 poly was down to around $11/kg to $21/kg in 1H 2021. So perhaps the brief rises on demand, but a figure ~$11/kg in 2020 is now far less costly nowadays, allowing much cheaper solar.

Back when poly was very costly, different materials and designs had tried to avoid it. Over time poly supply located to China's low-cost regions, co-located with PV manufacturers. Increasingly too PV became an automated process - especially panel manufacturing. In future poly & solar makers may co-locate say in Europe, North Africa, Middle East. On automated processes, a renewables-powered Middle East could export say Green Hydrogen, zero-carbon green ammonia, methanol. PV too made from super-abundant sunshine and sands. Making it again a leading energy exporter worldwide - not of oil – but of zero-CO_2 green power!

By 2021, much world poly supply came from Northwestern China. It wasn't always thus. Here let's look back, to excerpts from our 2005 WilderHill ECO Index Report detailing notable poly shortages then, when surplus polysilicon was sourced from US semiconductor manufacturing:
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 into 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 then: back in 2005. At any rate it perhaps was interesting to recall poly/PV situation back 15+ years ago. Things are very different now, early 2020s. Having recalled that time, let's now look forward over various fronts towards the coming 2020s next.

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

Musing on 2021 dynamics, one little noticed but potential big change may happen ahead an Office of Information and Regulatory Affairs (OIRA) in OMB. On his first day 2021, the new President directed that OIRA reviews now promote the: "public health and safety, economic growth, social welfare, racial justice, environmental stewardship, human dignity, equity, and the interests of future generations." Including environmental justice is very welcomed. Goes beyond a (blinkered) cost-benefit analysis that had allowed horrific pollution in communities of color; this is a step forward. Plus that helps remove from the fossil fuel interests' quiver, poisoned arrow of "externalities" that has long discounted/promoted pollution.

Backdrops changing too. We'd predicted back in March 2020 at start of Coronavirus, that a then beginning pandemic – could become endemic. Becoming background threat like the flu – maybe evolving in variants going ahead. Especially given places & people sans vaccination, acting as reservoirs, as well as an ongoing spread among mammals etc.

There's some positive change. From a politics that was anti-science, proven so wrong on Covid (and arguably climate). A more recent embrace of science is much the better for it. Public opinion polling strongly supporting new emphasis on facts. Including on climate change, where science-based perspectives are starting to become embraced. Change may yet go deeper; $2 trillion and more *might* be spent on climate solutions. Infrastructure improvements that are deeply green. US large utility-scale solar, for example, could early on grow >100 GW/year. Battery storage could fast grow >40 GW/year; in time approaching today's installed electric generating capacity. Maybe a world flowering of new green growth. A robust carbon tax may arguably be the simplest direct way to get there, though politics continues to get in the way. But countless obstacles are ahead. So think about very low hanging fruit.

Cheap batteries are a hardy perennial – lodestones to improve intermittent renewables & EVs. Battery capacity may go from <300 Wh/kg to >400 Wh/kg. "Made in U.S.A." can & must = good-paying jobs. Solar manufacturing capacity ought to fast go to the 100s+ of GW/yr. Scary climate scenarios show a striking call for *Terwatts* more solar PV worldwide, fast.

So green stimulus is needed 2021 and there's precedent. 2009 ARRA boosted climate-friendly sectors by $90 billion of $800 billion. That helped triple U.S. solar/wind installs, grew U.S. clean energy jobs from a few hundred thousand, to 3+ million. In 2021 in Europe a Green Deal - and maybe carbon tax are being shaped. The 2020 US CARES Act had boosted carbon-heavy, older industries – a new package that's in focus April 2021 will potentially be far greener. Giving us great cost reductions, unlike in oil or coal. For as renewables *achieve cost declines, they hold onto & grow farther still;* they're stickier, sustainable and welcome.

In this decade, a laggard US *may* pivot towards carbon free grid, saving money to boot. It's now feasible! We'll look at freshening possibilities next. This *may* be a transformative decade in the US, in Europe, and Asia. Let's start with the US, to envision the possibilities by 2035. These lately go far, far beyond what even lately was thought possible.

Where is the US power grid now? 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 2019 accounted for a large part (though far from all) of US CO_2 emissions; it 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% from wind, 7% was hydropower; only about 2% came from solar, while 2% was from miscellaneous other sources.

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

Numbers above show what a huge slog is 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. Nuclear can't offer much help; unlike solar & wind each year getting cheaper & better – US nuclear instead is going up in price. Nuclear plants once built for 'just' <$7 or $8 billion each. Now, two 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 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 – make just 9% of US energy (2019) because they're non-firm; intermittent on still days, no solar at night.

So we started 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 recent, slow 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, triple the 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 new 1,500 MW (1.5 GW) of wind power in Oklahoma in 2019 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 this actual figure likely less. And renewables enjoy free fuel, so as next several pages show – this actually leads to an outcome of Americans paying *less* for their power in 2035 – than they did 2021! From there savings snowball. Factor in the 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 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 from 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 using 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 new nuclear, or sequestration). In contrast to this Zero Carbon path, the 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.

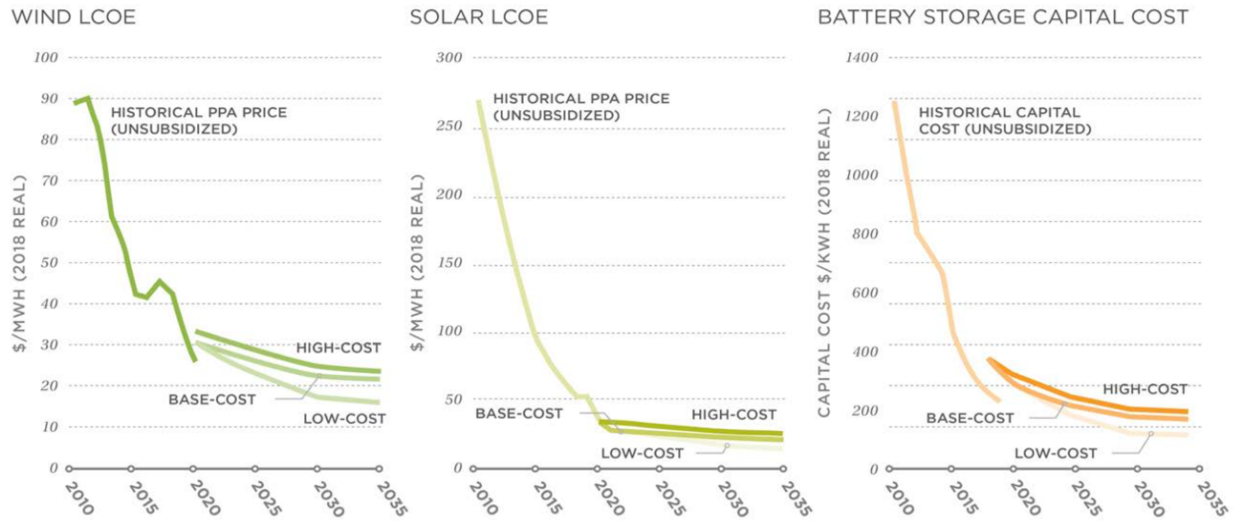
Happily, only modest new transmission or spur lines are needed to interconnect expanding clean power, so a less pressing need for costly, slow-to-build intergenerational lines. No tough overturning grid infrastructure, requiring longer lead times. But what changes, is composition of both generation and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

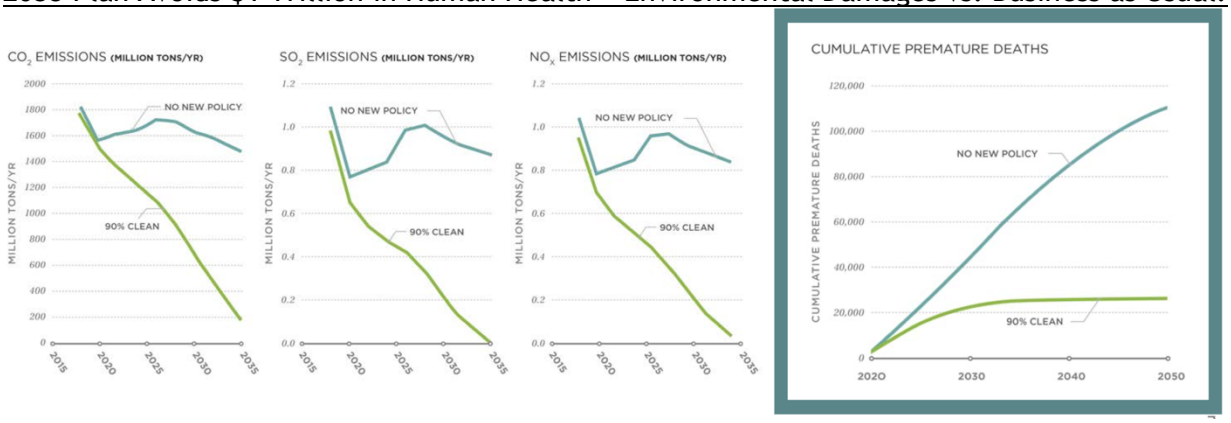
<u>Dramatic Declines in Costs Have Arrived 2020 Far Sooner than Expected:</u>



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(!).

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



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

So 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!)

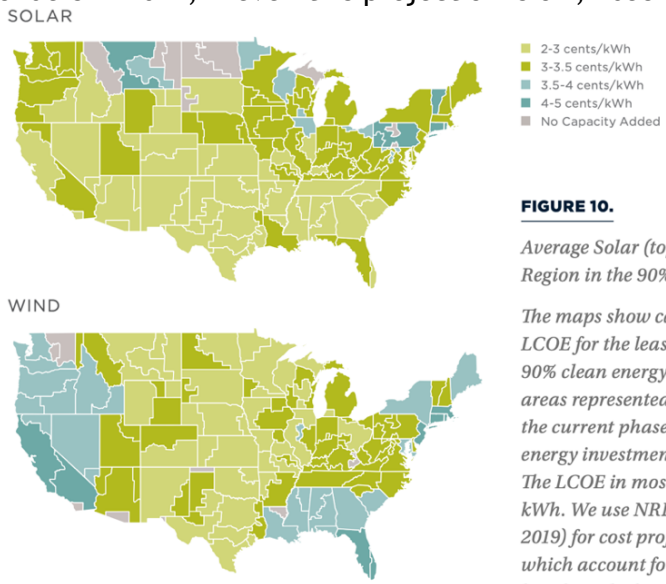


FIGURE 10.

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.

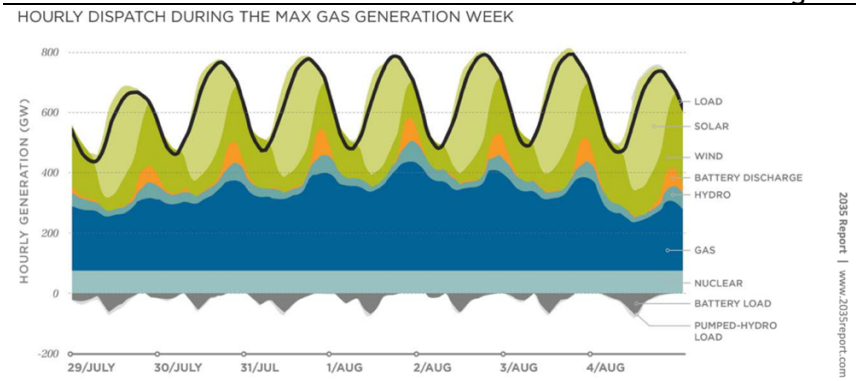
This Plan is so different from what's seen today, one may naturally ask: How is this done? We know solar is pretty binary, each 12 hours making zero power all night long. So what happens when high demand in evening – overlaps with little wind – drastically curtailing output?

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.

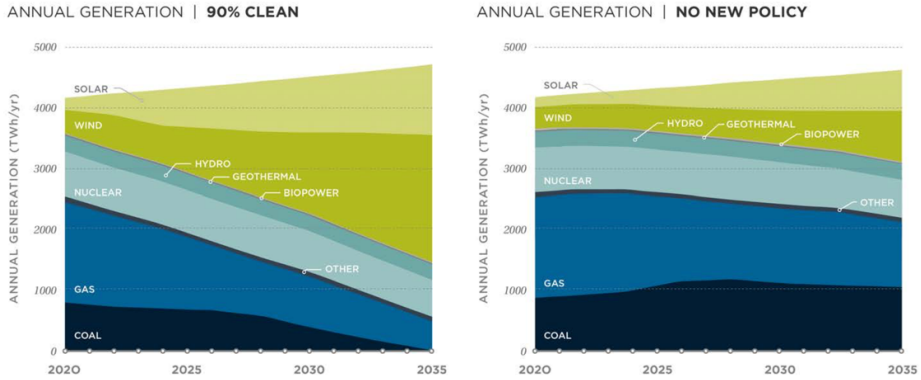
A Worst-Case Generation Period for Renewables: Still Moving Off of Fossil Fuels/Nuclear:



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).

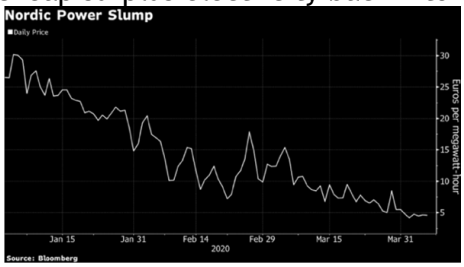
Moving on let's recall *applied* clean energy in 2020: when renewables' prices can and did fall swiftly – happening in good snowballing ways (unlike oil). Start 1st with Solar; costs hit a Record Low cost of *only 1.35 cents per kilowatt/hour* at a big 1.5 gigawatt solar farm going up in Abu Dhabi! True, 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 after in 2021 has vexed solar, from its poly inputs through PV installation – but that is not terminal.

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.

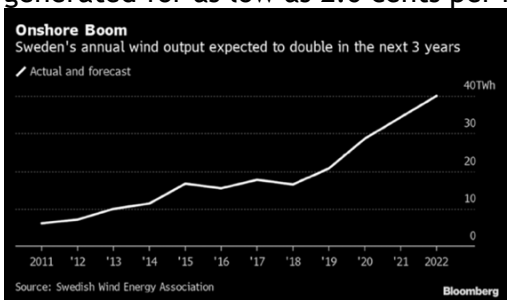
So yes, most renewables are intermittent. There's not always blowing wind, nor seasonal rains for hydro. At times other renewables too may be tapped; for instance geothermal, a renewable, might possibly grow more common as firm power. Especially if oil rig counts drop, then geothermal may become more 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.

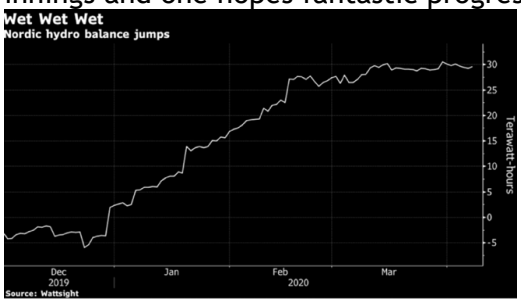
Recall dirty, cheap, coal in northwestern China attracted industries there, simply on low cost electricity; like Liuzhou's incentives for making EVs. Northern Sweden can do it one-better! Cheap/er clean power, can better make green steel, aluminum etc! Local industries welcome low-priced big hydro and 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 nuclear reactor output – yet solar is intermittent - unlike nuclear, coal, natural gas). By 2020 solar & wind had gone 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 a US 2009 meltdown. American jobs were lost at rates of half a million per month. In response a $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 have come under half the cost of nuclear power (and nukes will still have centuries of costly toxic waste to dispose of). Thusly are renewables clearly preferable to once-cheap King coal. Lower than 'cheap' new 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 become cheap power there by 2025, it's standing by coal. Unsurprisingly after a horrific nuclear accident, nuclear fell there from some 1/3rd of its power, to under 4%. Yet fossil fuels instead grew to 4/5ths. And its renewables are dominated by non-optimal, big hydropower. Plus it is exporting bad practices; only China gives more financing for coal plants overseas. There's airy talk of course 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, that major threats to oceans include climate change from CO_2 & the greenhouse gases like methane; overfishing; non-point source pollution; habitat destruction, acidification etc – all harmful to marine biological diversity. Each presents a daunting problem to overcome. Each locked-in, difficult to resolve to protect oceans.

Seemingly the most intractable, most vexed, and hardest of all to remedy: is CO_2 & climate. So it's surprising: the solution here is economically/ecologically sensible – it saves money! Key of course is more clean renewable power. Solar shines brightly, another option blows overhead, wind's story. The question is, how to get there, given inertia 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 wringing out costs, growing capacity, solar in 2020 was profitable. 2021 saw inflation here, while growing.

In 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 high costs.

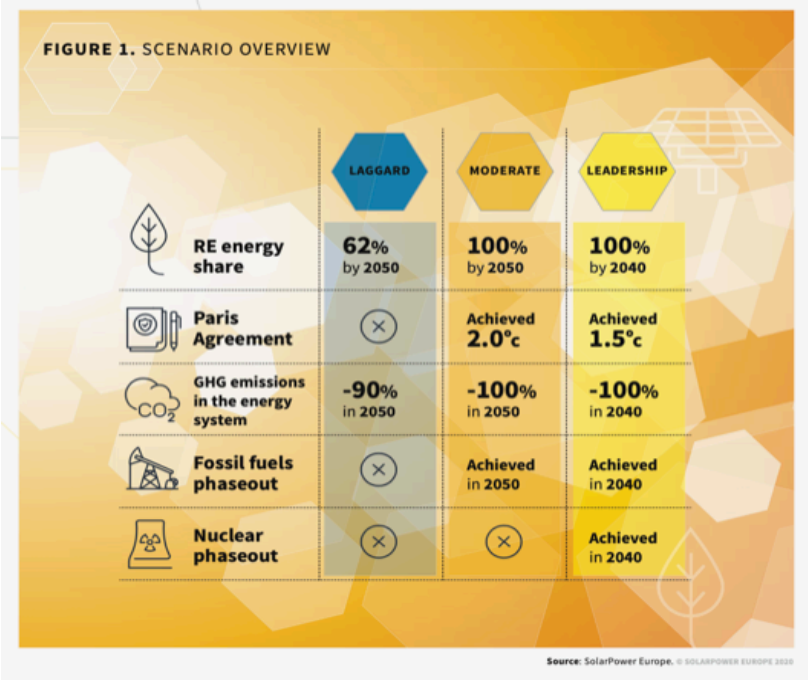
This Report recommends policy makers immediately begin by creating a new framework targeting installed 7 TW of solar power – plus 1.7 TW of wind reached well before 2040.

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.

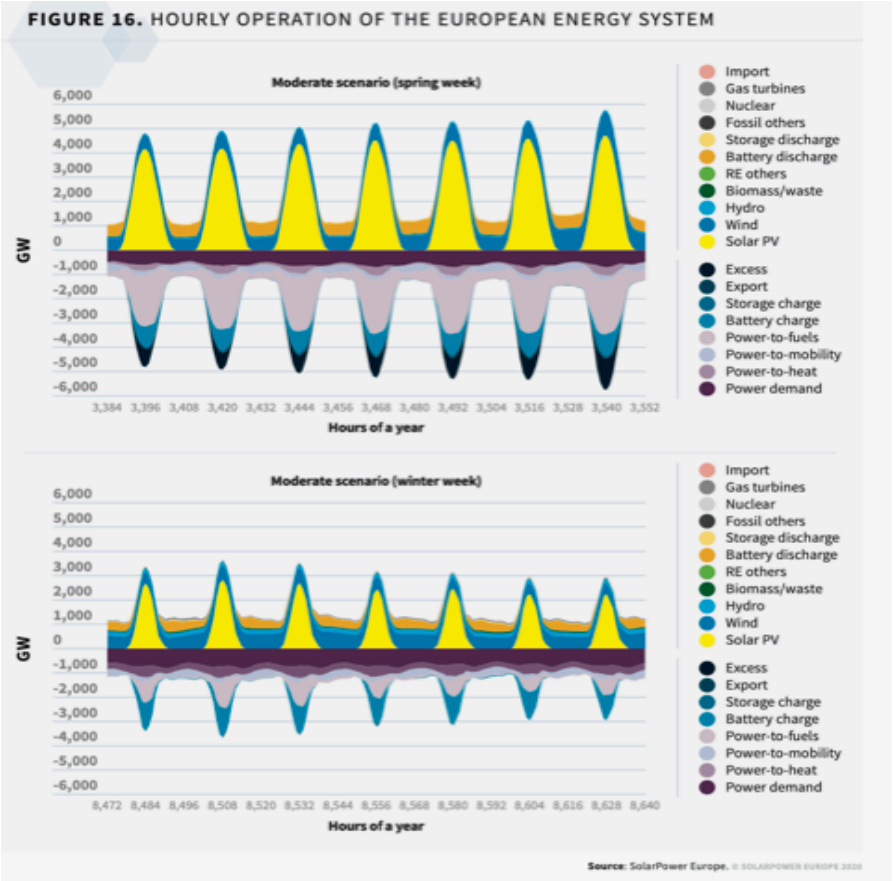
2 scenarios are presented, for a Moderate approach – and a Leadership one that's quicker. A former meets only the 2.0 degrees of warming goal under Paris. The latter meets the more robust, better 1.5 degrees goal. Again it's a matter of when ramp begins, and the angle of departure. But interestingly,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



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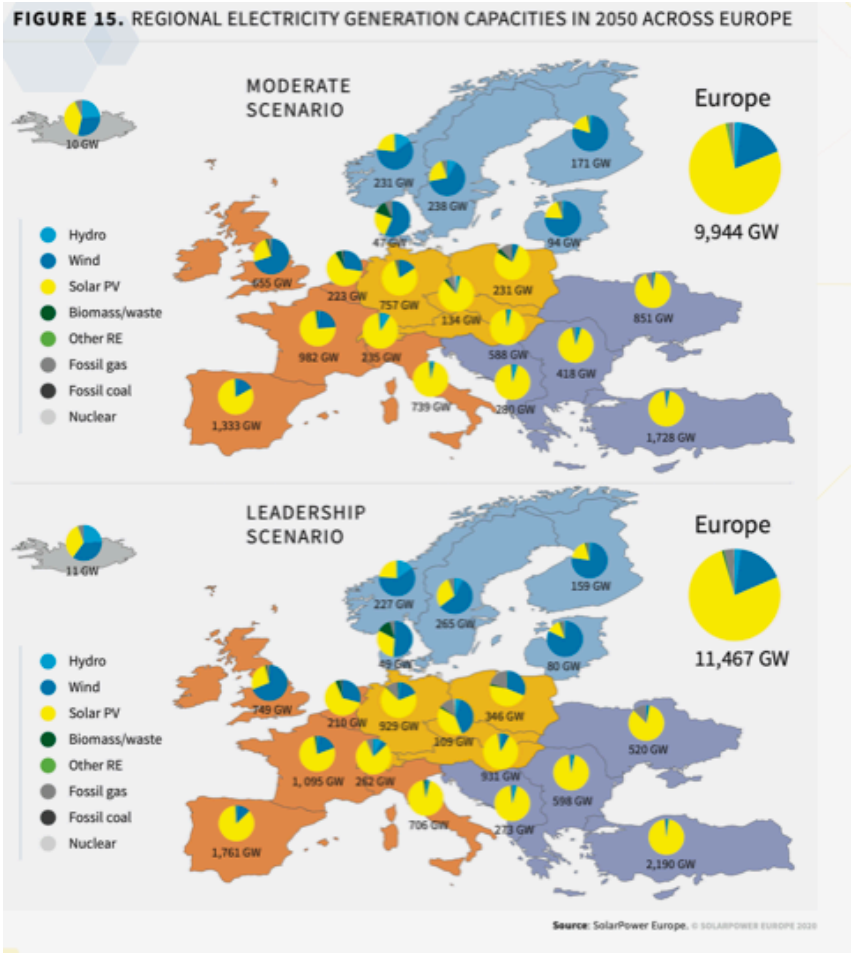
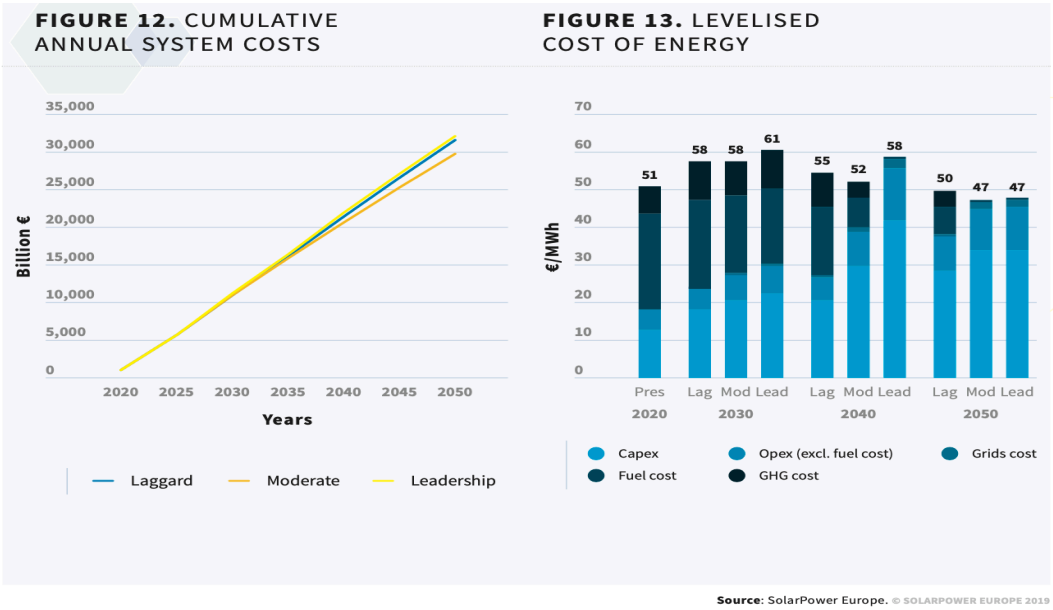
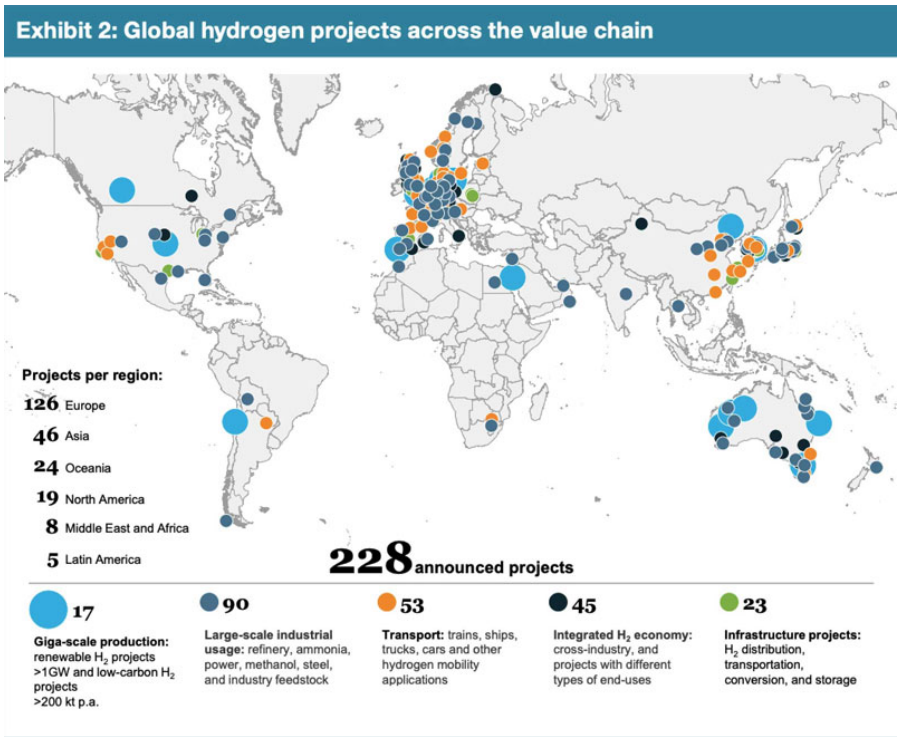


Source: Solar Power Europe 2020.



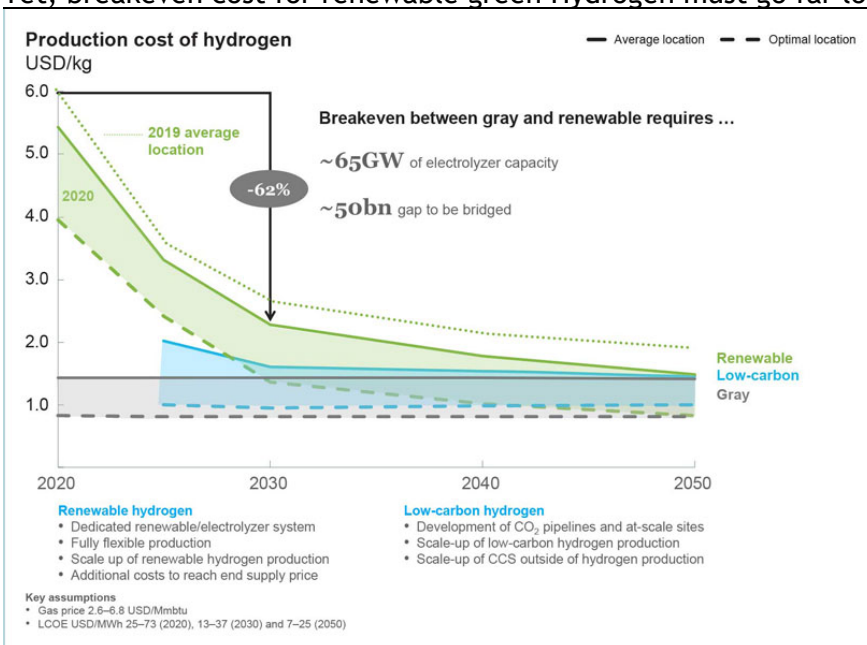
Source: Solar Power Europe 2020.

Taking a look at Hydrogen, Financial Times laid out a 2021 view (reproduced in Anthropocene Magazine) depicting 228 large, H_2 projects, with much 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 now is at issue – how deep/long is unclear. Given how renewables, above, uniquely thrive on ever-lower prices – let's contrast that next by looking instead at **Oil** in a remarkable Spring 2020. Oil 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 change 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, another big trend stands out in evolving energy 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 just beginning to unfold as clean renewables became the best bet. Even in that tough 2020, it was **due to, because of** tough conditions then, and given the superiority of solar & wind (and gas so cheap), that coal was jettisoned. Prospects for inflexible big nuclear had dimmed considerably as well.

For retail power consumers, how electricity is delivered matters. Recall nimble Texas: some things there it does pretty well, with lighter regulations. There's more competition; wind power can be plentiful at night costing under 9 cents/kWh. Texas residential power rates can be some 37% less than California, its commercial & industrial rates about 50% less. Other things are not as good there; Texas still makes ~20% of its power by (ugh) burning coal, and around half from natural gas. Wind is growing, fast, but around yet a 20% figure, like coal. And lacking interconnections to the Eastern and Western grids, it is somewhat islanded.

By contrast California is more regulated, its power much more costly. In San Diego for example time of use, nighttime is great for electric car charging – similar to Texas; but San Diego fast jumps up to more costly 29 cents much of the day – and may leap to 50 cents late afternoon. Costs near 35 cents/kWh partly due to little competition, much regulation. And California imports much CO_2-laden yet needed brown power especially in heat waves roiling a West. Lacking energy storage, facing wildfires, 2020 saw rolling blackouts in the Golden State. Texas also lacking storage, was hit by blackouts due to freeze 2021. Ahead, drought - and fire.

Texas isn't thought of as a Clean Energy incubator, nor innovator. Oil & gas yes. But Texas is open to (clean) energy innovation – less regulations/more flexibility. It's also very vulnerable to climate change. CO_2 *may* cause sudden heating in stratosphere, weakening polar vortex boundary over Arctic; ironically global warming *might* mean bitterly cold Arctic air reaching briefly say, Texas. Record cold snaps once regarded every 100 years, may need to be regarded as every 20, even 10 years. Weather extremes, trying fossil fuel infrastructure. Texas lacks US interconnections; sparse demand response an issue, as well as antiquated grid. Elsewhere wind as a % of power is rising fast: in 2020 conservative Iowa (once an EV capitol) made 57% of its power from wind; it's not hard to envision Iowa, going over 100% before 2030! Conservative red Oklahoma, Kansas, Dakotas made over 30% of power by wind 2020 – like Liberal blue Colorado, New Mexico, Nevada, Vermont. Offshore wind may come to Great Lakes, US Gulf coast, West Coast: maybe US offshore wind powerhouses ahead. With equity, inclusion, environmental justice – and all while building back better+ with Europe 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 CO_2, nor Climate Change *per se* – but helping to move forward solar, wind, electric cars, etc; the ecologically & economically better paths. Threat of global heating has been one driver - but CO_2 hasn't been a focus of Reports. Lately, however, climate crises are near worst ends of what models have foreseen. In short: CO_2 matters increasingly, so let's address it here.

For just one acute example of recent science, an 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 in population, a narrow temperature niche that our species has long required, is projected to change more in just next 50 years, than past long 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 that 1) clean energy's costs can beat *unsubsidized,* fossil fuels; 2) there's growing recognition of science, first in Europe, and 3) since Covid-19 crash of oil demand, the idea of decarbonizing away from dirty fossils – into cleaner paths while creating jobs – is more approachable worldwide.

Looking near-term decades ahead to early 2100, there's some good news. Intercomparisons of some 56 climate models, indicates most awful possibilities *may* be perhaps a bit less likely. Barring say methane feedbacks, underseas clathrates, water vapor, or permafrost, and hoping for no other major contributions, then of models, the scariest rises near 9 degrees F by 2100 *may be* less likely on current understanding. (Less than 9 F from now, since there's already been some warming to date). Those models assume high fertility, widespread coal still worldwide, and failure to strongly embrace renewables. Such models may be realistic, but highest/worst-case predictions of (unbearable) 9 degrees F warming soon, less likely.

If we do regard highest end Representative Concentration Pathway (RCP) unlikely, heaviest CO_2 emissions in that RCP 8.5 – 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 one (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 catastrophic rise of near 7 degrees F, as possible, soon as 2100s. Even say 'low-end' RCP 8.5 possibilities ought concern nations & leaders greatly. RCP 8.5 was one basis for predictions (above) of a mass loss of inhabitable sliver/niche of climate by 2100.

The next 'lower' RCP 6.0 may be rather closer to where we're trending – on 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, stays high, drops only slowly since it accumulates). Coal plants would thus 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 how altered is incoming solar energy vs. outgoing balance in our Earth-atmosphere system. Consequences of that may be dire for our species over centuries ahead, yet seems about what one might 'hope for'.

Next, better, very ambitious is a most hoped for RCP 4.5: emissions peak in about 20 years near 2040, then fall fast. CO_2 not long ago stable near 280, now >400 & rising fast, in this vision only goes to 'just' some 650 – unlikely stopping. Strong decarbonization is assumed here undertaken, from now with CO_2 slowly dropping. That *might* be possible, although it's a huge stretch to be sure. And very unlikely given present CO_2 is already some 50% greater than roughly 280 ppm pre-industrial era; and rising fast. Especially improbable, since hundreds of new coal plants are *being built, right now* early 2020s. Each with a life of 20 years or more, hence operating perhaps in 2040s and after, unless they are prematurely shuttered.

Renewables now make only some 20% of electricity in many nations (although growing), coal is still burned widely, cars mainly oil-powered: ambitious RCP 4.5 is a very unlikely bet. That said 'unexpected' events like ice sheets seen destabilizing, heatwaves, drought, might catalyze action. Sudden scary events, could hasten stronger and real action on climate.

Climate models, inevitably, are getting more complicated. Until recently they'd ignored eg ice sheet destabilization, seas melting glaciers from below. If a big pulse of change is visibly underway, then skeptics may melt away too. Especially in clean energy as *most economical choice*, creating jobs; it alone can go unsubsidized, and may save us.

Inertia, Even on Decarbonized Power Grid 2040, Climate Neutral World by 2070

Lastly let's imagine decades hence. Europe & US were aided by low-cost solar from China, cheap renewables, energy storage, and on great efforts, they 1st reached 100% carbon free power in 15 years by 2035. Much of world got there 2050. Electric cars scaled immensely, faster than expected! Green H_2 came to fore in industry. Rich nations climate neutral by 2050. China, on nuclear, got there by 2060, meeting its targets. Rest of world by 2070 although with much fudging like with CCS, and on hopes that the Earth's 'natural sinks' remain so.

That timeline, fairly ambitious, is absolutely do-able. Unfortunately, mainstream science also implies that inertia in such CO_2 scenario may destroy much of the world's low-lying lands & megacities due to sea-level rise from climate change. 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.

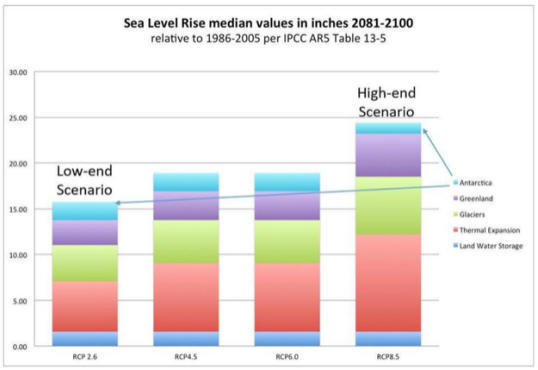
That the actual sea levels seen in 2100, could be greater than IPCC projections is well laid out in the 2020 piece, 'Twenty-first century sea-level rise could exceed IPCC projections for strong-warming futures' by M. Siegert et al., One Earth, 3 (Dec. 18, 2020).
https://doi.org/10.1016/j.oneear.2020.11.002

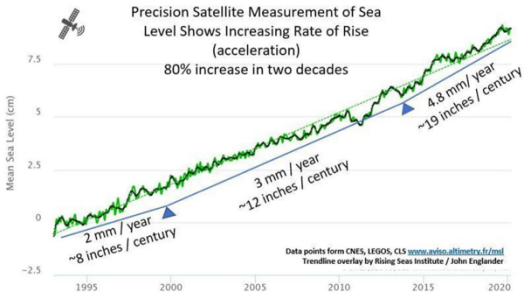
Their first paragraph nicely lays out in cogent clear words what scientists may find mainstream – yet these same thoughts ought to be viewed by a wider public with alarm:

> 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:

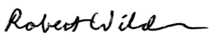
The Clean Energy Index® (ECO) started 2nd Quarter around 200, and ended Q2 around 195, falling about -3%. After a strong +203% gain in 2020, when this decarbonization story rose by 6-fold in about best performance of most any Index or Fund anywhere, a sell-off was maybe overdue. Thus it wasn't so surprising after ECO had dropped by one-half Q1 2020, to see that after rising, it once again fell by one-half to a first half 2021 nadir. Volatility here is partly due to the 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 about +390%.

The first *global* clean energy Indexing theme is New Energy Global Innovation Index (NEX). Live since 2006 it is up +200% last 5 years to late Q2, starkly beating fossil fuels: there's now a tracker in Europe (GCLE; London). Both ECO & NEX have outperformed too vs. a younger, independent global clean energy Index most every sizable period: Year to Date, past 1, 5, 10 years, since inception etc; differences in weights and purity help explain a long divergence. In sum these volatile WilderHill themes have performed notably. And energy, long dirty taken from underground and burned – is increasingly captured in disruptive & sustainable new ways – coming to us cleanly, freely and renewably from up towards the Heavens.

In a cadence akin to a past 15+ years, 3 Additions to ECO Index for the start of Q3 2021 were: FTC Solar, Lion Electric, and Stem; and 2 Deletions to start Q3 were: Aemetis, Air Products. And at Global NEX Index for start of Q3 2021, the 5 Additions for start of Q3 there were: FTC Solar (US), Lion Electric (Canada/US), SK IE Technology (South Korea), Soltech Energy Sweden (Sweden), and Stem (US); and the 5 NEX Deletions there for start of Q3 were: Aemetis, Montauk, Powerhouse Energy, Renewable Infrastructure Group, and Tilt.

As always, we welcome your thoughts and suggestions.

Sincerely,



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Appendix I:

ECO Index (via independent tracker PBW) Descending Weights in latter-Q2 on 6/7/2021, or about ~3 weeks before the rebalance to start Q3 2021, 66 Stocks:

Name	Symbol	Weight
Daqo New Energy Corp ADR	DQ	2.21
Albemarle Corp	ALB	2.18
Livent Corp	LTHM	2.17
MYR Group Inc	MYRG	2.17
Ameresco Inc	AMRC	2.13
ChargePoint Holdings Inc	CHPT	1.99
Eos Energy Enterprises Inc	EOSE	1.96
Lithium Americas Corp	LAC	1.93
First Solar Inc	FSLR	1.92
JinkoSolar Holding Co Ltd ADR	JKS	1.91
XPeng Inc ADR	XPEV	1.88
Air Products and Chemicals Inc	APD	1.88
NIO Inc ADR	NIO	1.88
TPI Composites Inc	TPIC	1.84
Quanta Services Inc	PWR	1.84
Lordstown Motors Corp	RIDE	1.83
Ormat Technologies Inc	ORA	1.80
Renewable Energy Group Inc	REGI	1.79
Woodward Inc	WWD	1.76
Gentherm Inc	THRM	1.75
Itron Inc	ITRI	1.75
Advanced Energy Industries Inc	AEIS	1.69
Willdan Group Inc	WLDN	1.69
Tesla Inc	TSLA	1.67
Canadian Solar Inc	CSIQ	1.67
Workhorse Group Inc	WKHS	1.65
Blink Charging Co	BLNK	1.65
Kandi Technologies Group Inc	KNDI	1.64
Sociedad Quimica y Minera de Chile	SQM	1.63
Piedmont Lithium Inc	PLL	1.62
Cree Inc	CREE	1.60
Universal Display Corp	OLED	1.54
Bloom Energy Corp	BE	1.53
ReneSola Ltd ADR	SOL UN	1.46
ESCO Technologies Inc	ESE	1.44
Sunnova Energy International Inc	NOVA	1.44

Infrastructure and Energy Alternatives	IEA	1.43
SolarEdge Technologies Inc	SEDG	1.43
Enphase Energy Inc	ENPH	1.43
Gevo Inc	GEVO	1.42
Beam Global	BEEM	1.42
Azure Power Global Ltd	AZRE	1.41
MP Materials Corp	MP	1.41
Romeo Power Inc	RMO	1.38
ElectraMeccanica Vehicles Corp	SOLO	1.37
Plug Power Inc	PLUG	1.37
Sunrun Inc	RUN	1.36
Shoals Technologies Group Inc	SHLS	1.36
Fisker Inc	FSR	1.34
GreenPower Motor Co Inc	GP	1.33
SunPower Corp	SPWR	1.28
American Superconductor Corp	AMSC	1.28
Sunworks Inc	SUNW	1.25
Ballard Power Systems Inc	BLDP	1.19
FuelCell Energy Inc	FCEL	1.18
Advent Technologies Holdings Inc	ADN	1.17
Arcimoto Inc	FUV	1.17
Maxeon Solar Technologies Ltd	MAXN	1.09
AYRO Inc	AYRO	1.07
Array Technologies Inc	ARRY	1.05
Canoo Inc	GOEV	0.95
QuantumScape Corp	QS	0.92
Aemetis Inc	AMTX	0.90
Broadwind Inc	BWEN	0.50
Flux Power Holdings Inc	FLUX	0.50
SPI Energy Co Ltd	SPI	0.46

There's strong representation at top from *Solar, *Electric Vehicles, *Lithium/Batteries and Materials, Energy Efficiency, Electric Vehicles/Charging, and Hydrogen & Fuel Cells.

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

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

INDEX (ECO) SECTOR & STOCK WEIGHTS FOR START OF Q3 2021. 67 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 - 20% weight (11 stocks @1.72% each +2 *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.
**Broadwind,* BWEN. Wind, steel towers, gearing fabrication, and solar arrays.
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 (16 stocks @1.59% each +1 *banded)
Albermarle, ALB. Lithium, specialty materials in batteries for energy storage.
Chemical & Mining of Chile, SQM. Lithium, large producer for energy storage.
Eos, EOSE. Zinc grid batteries, 100% depth discharge, longer-life, is not li-ion.
**Flux Power,* FLUX. Batteries, lithium-ion packs for fork lifts, stackers.
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.
Tesla, TSLA. Electric vehicles, pure-play across EVs, advanced energy storage.
Workhorse, WKHS. Electric Vehicles, large electric delivery trucks, early-stage.
Xpeng, XPEV. Electric vehicles, advanced mobility, swappable batteries, China.

Power Delivery & Conservation - 23% sector (15 stocks @1.50% 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.
Fisker, FSR. EV crossover SUV, is assembled by contract manufacturer.

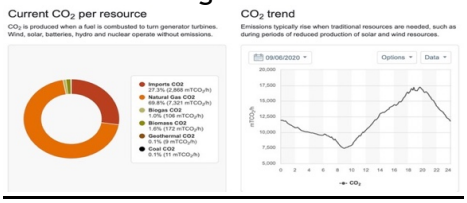
Infrastructure and Energy, IEA. Renewables, power generation to delivery.
Itron, ITRI. Meters, utility energy monitoring, measurement & management.
MYR Group, MYRG. Grid transmission and distribution, for solar & wind farms.
Quanta Services, PWR. Infrastructure, modernizing grid & power transmission.
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 - 19% sector weight (13 stocks @1.46% 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.
MP Materials, MP. Rare Earths, domestic U.S. sourced 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 – 9% sector weight (6 stocks @1.50% each)
Beam, BEEM. EV Charging, rapidly deployable portable PV powered utility.
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.

Practical Issues in Renewables: In a California Flex Alert, CO_2 Emissions allowed to spike to get Supply High as Possible >50,000 MW to meet demand. Natural gas+peaker plants maxed at 100% with no maintenance, power imported from out of State. Demand in Heat Wave on that Sept. 5, 2020 outstripped normal capacity. Here demand is not yet peaked at mid-day, wind nominal, solar power troublingly about to fall hard. California's Demand History shows Renewables+Batteries must grow very, very fast, given huge energy efficiency strides were already made – California is adding more electric vehicles swiftly creating yet more demand – and shuttering its lone nuke. Here, Demand is already seen at times over >50,000 MW:



Source: CAISO.com - Sept. 6/7, 2020 at 2:30 p.m.

Appendix III: **WilderHill New Energy Global Innovation (NEX)** descending weights late-Q2 via independent tracker (PBD) 6/7/21, ~3 weeks before Rebalance to start Q3 2021. 125 stocks:

Name	Symbol	Weight
VERBIO Vereinigte BioEnergie AG	VBK	1.26
Signify NV	LIGHT	1.19
Nibe Industrier AB	NIBEB SS	1.15
Caverion Oyj	CAV1V FH	1.08
AFC Energy PLC	AFC LN	1.06
Prysmian SpA	PRY	1.02
Kingspan Group PLC	KSP	1.02
Xebec Adsorption Inc	XBC	1.02
CS Wind Corp	112610 KS	1.00
Ganfeng Lithium Co Ltd	1772 HK	1.00
Novozymes A/S	NZYMB DC	0.99
ChargePoint Holdings Inc	CHPT	0.98
Livent Corp	LTHM	0.98
Ameresco Inc	AMRC	0.98
SFC Energy AG	F3C	0.97
Verbund AG	VER AV	0.97
Ecopro BM Co Ltd	247540 KS	0.95
Koninklijke DSM NV	DSM	0.95
West Holdings Corp	1407 JP	0.95
RENOVA Inc	9519 JP	0.94
Everfuel A/S	EFUEL	0.94
Mercury NZ Ltd	MCY	0.93
Greencoat UK Wind PLC/Funds	UKW LN	0.93
EDP Renovaveis SA	EDPR	0.91
Landis+Gyr Group AG	LAND SW	0.91
Renewables Infrastructure Group	TRIG LN	0.91
Tilt Renewables Ltd	TLT	0.91
Sino-American Silicon Products	5483 TT	0.90
Terna SPA	TRN	0.90
Invinity Energy Systems PLC	IES LN	0.89
Alfen Beheer BV	ALFEN	0.89
XPeng Inc ADR	XPEV	0.89
Cell Impact AB	CIB SS	0.89
Voltalia SA	VLTSA FP	0.89
Gurit Holding AG	GUR SW	0.88
2G Energy AG	2GB	0.88
Aker Offshore Wind AS	AOW	0.88

Arise AB	ARISE SS	0.88
Enlight Renewable Energy Ltd	ENLT	0.88
PNE AG	PNE3	0.88
Acciona SA	ANA	0.87
TransAlta Renewables Inc	RNW	0.87
GS Yuasa Corp	6674 JP	0.87
Iljin Materials Co Ltd	020150 KS	0.87
BYD Co Ltd	1211 HK	0.87
Eos Energy Enterprises Inc	EOSE	0.86
Itron Inc	ITRI	0.86
Lithium Americas Corp	LAC	0.85
Vestas Wind Systems A/S	VWS DC	0.85
Sociedad Quimica y Minera de Chile	SQM	0.85
CropEnergies AG	CE2	0.83
Boralex Inc	BLX	0.83
NIO Inc ADR	NIO	0.83
Powerhouse Energy Group PLC	PHE LN	0.83
Solarpack Corp Tecnologica SA	SPK	0.82
Daqo New Energy Corp ADR	DQ	0.82
Grenergy Renovables SA	GRE	0.82
Universal Display Corp	OLED	0.81
Doosan Fuel Cell Co Ltd	336260 KS	0.81
Innergex Renewable Energy Inc	INE	0.81
Piedmont Lithium Inc	PLL	0.81
Eolus Vind AB	EOLUB SS	0.80
McPhy Energy SA	MCPHY FP	0.80
Arcosa Inc	ACA	0.80
Samsung SDI Co Ltd	006400 KS	0.80
First Solar Inc	FSLR	0.80
Canadian Solar Inc	CSIQ	0.79
Xinyi Solar Holdings Ltd	968 HK	0.79
Greenlane Renewables Inc	GRN	0.78
Meridian Energy Ltd	MEL	0.78
Orsted AS	ORSTED DC	0.78
Falck Renewables SpA	FKR	0.78
JinkoSolar Holding Co Ltd ADR	JKS	0.78
Ceres Power Holdings PLC	CWR LN	0.78
Siemens Gamesa Renewable Energy SA	SGRE	0.77
Willdan Group Inc	WLDN	0.77
Renewable Energy Group Inc	REGI	0.77

Xinyi Energy Holdings Ltd	3868 HK	0.77
Neoen SA	NEOEN FP	0.77
Bloom Energy Corp	BE	0.76
United Renewable Energy Co	3576 TT	0.76
Flat Glass Group Co Ltd	6865 HK	0.76
Hannon Armstrong Sustainable Infra.	HASI	0.75
Cree Inc	CREE	0.75
SMA Solar Technology AG	S92	0.74
TPI Composites Inc	TPIC	0.74
Gencell Ltd	GNCL	0.73
SolarEdge Technologies Inc	SEDG	0.73
Motech Industries Inc	6244 TT	0.73
Xinjiang Goldwind Science & Tech.	2208 HK	0.73
Proton Motor Power Systems PLC	PPS LN	0.72
Ormat Technologies Inc	ORA	0.72
Scatec ASA	SCATC	0.72
ITM Power PLC	ITM LN	0.72
Gevo Inc	GEVO	0.72
Montauk Renewables Inc	MNTK	0.72
Hydrogen Refueling Solutions	ALHRS FP	0.72
Encavis AG	ECV	0.72
Lordstown Motors Corp	RIDE	0.71
Nordex SE	NDX1	0.70
Enphase Energy Inc	ENPH	0.70
Solaria Energia y Medio Ambiente SA	SLR	0.70
Hexagon Purus ASA	HPUR	0.68
Fisker Inc	FSR	0.65
NEL ASA	NEL	0.65
Sunrun Inc	RUN	0.64
Sunnova Energy International Inc	NOVA	0.64
MP Materials Corp	MP	0.63
Plug Power Inc	PLUG	0.62
American Superconductor Corp	AMSC	0.62
PowerCell Sweden AB	PCELL SS	0.61
Shoals Technologies Group Inc	SHLS	0.61
Aemetis Inc	AMTX	0.59
Sunworks Inc	SUNW	0.58
SunPower Corp	SPWR	0.58
Ballard Power Systems Inc	BLDP	0.57
FuelCell Energy Inc	FCEL	0.56

Azure Power Global Ltd	AZRE	0.55
GreenPower Motor Co Inc	GP	0.54
ReneSola Ltd ADR	SOL UN	0.53
Hydrogenpro AS	HYPRO	0.50
Canoo Inc	GOEV	0.49
QuantumScape Corp	QS	0.43
Maxeon Solar Technologies Ltd	MAXN	0.37
Array Technologies Inc	ARRY	0.36

Among the best performers seen in NEX in the period above, there's clear representation from *Biofuels, *Efficiency, *Lighting, Electric Vehicles, *Batteries and Energy Storage, and *Wind.

Appendix IV:

WilderHill New Energy Global Innovation (NEX) - for start of Q3 2021. 125 Stocks.

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

Name	Description	Sector	Currency	Activity
2G Energy AG	Hydrogen, biogas, and combined heat and power.	ECV	EUR	GERMANY
Acciona	Operates Wind, Solar/thermal, Hydro, Biomass plants.	RWD	EUR	SPAIN
AFC Energy	Fuel cells, alkaline has greater H2 fuels tolerance.	ECV	GBP	UK
Aker Offshore Wind	Offshore wind, new floating deepwater technolgies.	RWD	NOK	NORWAY
Alfen NV	Electric Vehicle charging, smart grid, energy storage.	EEF	EUR	NETHERLANDS
Ameresco	Energy savings, performance contracts, renewables.	EEF	USD	US
American Superconductor	Wind turbines, and grid power trnsmission.	RWD	USD	US
Arcosa	Wind tower structures, grid power and infrastructure.	RWD	USD	US
Arise AB	Wind Farms onshore, owns own, develops for others.	RWD	SEK	SWEDEN
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
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, clean energy storage infrastructure.	RSR	ILS	ISRAEL
Enphase	Inverters, micro-products for solar panels, storage.	RSR	USD	US
Eolus Vind	Wind power, also consulting services for wind.	RWD	SEK	SWEDEN
Eos Energy	Batteries, zinc chemistry for stationary grid storage.	ENS	USD	US
Everfuel A/S	Hydrogen electrolyzers, fueling vehicles, trains, ships.	ECV	NOK	DENMARK
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, with contract manufacturer.	ENS	USD	US
Flat Glass Group	PV panel glass, solar plants engineering & construction	RSR	HKD	CHINA
FTC Solar	Solar, ground mounted trackers; also PV software.	RSR	USD	US
FuelCell Energy	Fuel cells, high temperature and hydrogen.	ECV	USD	US
Ganfeng Lithium	Lithium, production of compounds, metals, for batteries.	ENS	HKD	CHINA
GenCell Ltd.	Fuel cells, hydrogen from ammonia, remote power.	ECV	ILS	ISRAEL
Gevo	Biofuels, lower carbon liquid fuels, renewable sources.	RBB	USD	US
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 projects, 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
HydrogenPro	Hydrogen, electrolysis from solar and wind power.	ECV	NOK	NORWAY
Hydrogen Refuel Solutions	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
Invinity Energy Systems	Flow battery, stationary, vanadium liquid electrolyte.	ENS	GBP	UK
ITM Power plc	Fuel cells, uses PEM technology; also hydrogen.	ECV	GBP	UK
Itron	Meters, Utility energy monitor, measuring & manage.	EEF	USD	US
JinkoSolar	Solar, wafers through solar modules, China OEM.	RSR	USD	CHINA
Kingspan Group plc	Efficient Buildings, insulation for conservation, Ireland.	EEF	EUR	IRELAND
Landis+Gyr Group AG	Advanced meters, modernizing grid, Switzerland.	EEF	CHF	SWITZERLAND
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 from Sunpower.	RSR	USD	US
McPhy Energy	Hydrogen, electrolyzers using water, H2 storage.	ECV	EUR	FRANCE
Mercury NZ	Clean power, 100% renewable hydro, geothermal.	ROH	NZD	NEW ZEALAND
Meridian Energy	Hydroelectric power stations, some wind, New Zealand.	ROH	NZD	NEW ZEALAND
Motech	Solar, cells and modules manufacturing.	RSR	TWD	TAIWAN
MP Materials	Rare Earths, US sourced strategic Neodymium, NdPr.	ECV	USD	US
Nel ASA	Hydrogen, in fuel cell vehicles, renewably, Norway.	ECV	NOK	NORWAY
Neoen SA	Renewable energy, mainly in solar, some wind.	RSR	EUR	FRANCE
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
PNE AG	Wind Farms, both onshore & offshore; also hydrogen.	RWD	EUR	GERMANY
Powercell Sweden	Fuel cells, transportation, marine, stationary uses.	ECV	SEK	SWEDEN
Proton Motor Power	Fuel cells, hydrogen systems and H2 storage.	ECV	GBP	UK
Prysmian SpA	Cables, renewable power transmission, global.	EEF	EUR	ITALY
Quantumscape	Lithium metal batteries, solid state, quicker charge.	ENS	USD	US
ReneSola	Solar, project developer and operator, worldwide.	RSR	USD	CHINA
Renewable Energy Group	Biodiesel, natural fats, oils, grease to biofuels.	RBB	USD	US
Renova	Wind, Solar, Biomass, power generation in Asia.	RWD	JPY	JAPAN
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
Solarpack Corporacion	Solar plants, engineering and operations, globally.	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 Energy	Solar, also energy storage, hydrogen and fuel cells.	RSR	TWD	TAIWAN
Universal Display	Organic light emitting diodes, efficient displays.	EEF	USD	US
Verbio Vereinigte BioEn.	Biofuels, manufacturer supplier to Germany, Europe.	RBB	EUR	GERMANY
Verbund AG	Electricity supplier, hydro, a large provider for Austria.	ROH	EUR	AUSTRIA
Vestas Wind Systems A/S	Wind, wind turbine manufacturing & services, Denmark.	RWD	DKK	DENMARK
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

Q3 2021 WEIGHT EACH COMPONENT = 0.8000%

125 stocks/100 = 0.80000

Changes to NEX Index for Q3 2021:

5 NEX ADDITIONS for Q3 2021: FTCI.OQ, LEV.N, 361610.KS, SOLT.ST, STEM.N

5 NEX DELETIONS for Q3 2021: AMTX.OQ, MNTK.OQ, PHEG.L, TRIG.L, TLT.NZ

125 Stocks for Start of Q3 2021.

NEX SECTOR WEIGHTS:	SECTOR	#	% Approx. Weight
Energy Conversion	**ECV**	**19**	**15%**
Energy Efficiency	**EEF**	**16**	**13%**
Energy Storage	**ENS**	**23**	**18%**
Renewables - Biofuels &	**RBB**	**9**	**7%**
Renewables - Other	**ROH**	**5**	**4%**
Renewable - Solar	**RSR**	**32**	**26%**
Renewable - Wind	**RWD**	**21**	**17%**
		125	**100%**

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

NEX Historical Sector Weight Information

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

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

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

Appendix VII, Sustainable Decarbonization Index (OCEAN) for latter Q2 2021, 116 components:

WilderHill Decarbonization (OCEAN) components	Theme	Activity	Sector
Acciona SA	Water Treatment; Renewable Energy.	Spain	WT
Advanced Drainage	Water management, drainage products.	USA	WT
Advent Technologies	Fuel Cells, make core membranes assembly.	USA	PP
Aemetis	Biofuels, replaces fossil fuels, also RNG.	USA	GS
AFC Energy	Fuel Cells, alkaline, may use ammonia.	UK	GS
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
Arise AB	Wind power, operating own turbines.	Sweden	CE
Azure Power	Solar power, India focus.	India	CE
Badger Meter	Water Metering.	USA	PP
Ballard Power	Fuel cells, future power in Ports and Shipping.	Canada	GS
Beyond Meat	Plant-based meats, less impactful proteins.	USA	PP
Bloom Energy	H2 fuel cells, power ahead ports, shipping.	USA	GS
Bollore SA	Better Sustainability in Ports & Terminals.	France	GS
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	GS
Cell Impact AB	Fuel cells, bipolar flow plate forming.	Sweden	PP

Ceres Power	H2 fuel cells, power ahead ports, shipping.	Britain	GS
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	GS
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	GS
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
Everfuel A/S	Hydrogen production and use, marine vessels.	Denmark	GS
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	GS
Geberit AG	Waste treatment, supply, piping.	Switzerland	WT
GenCell	Fuel Cells, hydrogen and ammonia.	Israel	GS
Greenlane Renewables	Upgrading waste biogas to renewables.	Canada	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	GS
HydrogenPro AS	Hydrogen electrolyzers, from solar or wind.	Norway	GS
Hydrogen Refueling	Hydrogen, turnkey refueling stations.	France	GS
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
Invinity Energy	Flow batteries, grid, non-degrading vs. li-ion.	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
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	GS
PNE AG	Wind, offshore and onshore, also hydrogen.	Germany	CE
PowerCell Sweden	H2 fuel cells, power ahead ports, shipping.	Sweden	GS
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	GS
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
Solarpack Tecnologica SA	Solar, utility-scale EPC and development.	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	GS
Watts Water Technologies	Water quality, rainwater harvests, 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 Q2 2021 of OCEAN Index

Deletes: Austevoll, Else, Tilt, Nomad, Norway Royal.

Adds: Advent, Aemetis, AFC, Arise, Cell Impact, Chargepoint, Eneti, Everfuel, Fisker, GenCell, Greenlane, Hexagon Purus, Hydrogen Refueling, Proton Motor, SFC, Shoals, Siemens Gamesa, Sunworks, Trimble, Voltalia.

Equal Weight = 116/100 = 0.862068% each. **0.862068**

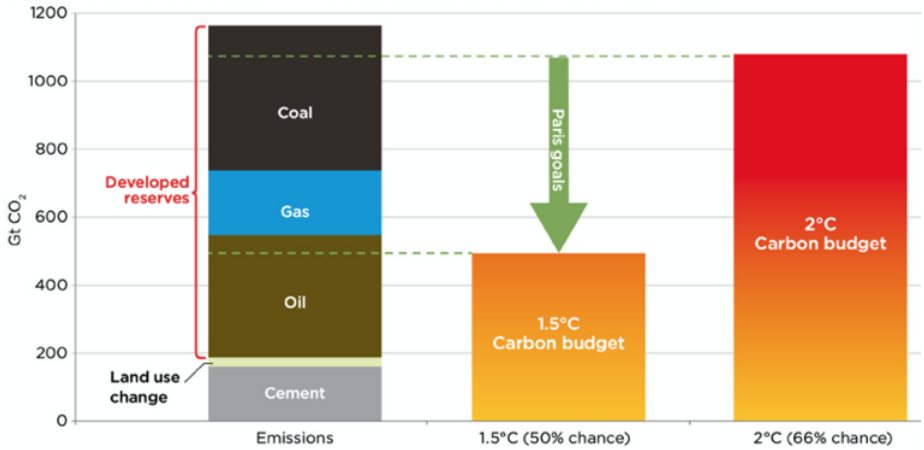
SECTOR	#	Approx. %
GREENER SHIPPING (GS) =	19	16%
CLEAN ENERGY LOW CO2 (CE) =	39	34%
WATER TREATMENT (WT) =	19	16%
SUSTAINABLE FISHERIES (SF) =	7	6%
POLLUTION PREVENTION (PP) =	32	28%
TOTAL CONSTITUENTS =	116	

For how Dire CO_2 Facts & Trends may already 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 just 1.5 C warming to be achieved – ALL the world fossil fuels proven reserves not now producing, would have to abandoned! No New mining or drilling there!

That seems almost 100% certain NOT to Happen. While some European oil firms are thinking seriously of becoming 'energy companies', the US majors and elsewhere seem more intent on marketing & 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 in Thanos-like snap of fingers – or we'll blow past 1.5 C. Only by halting all extant coal, plus most oil & natural gas in 2020s, may carbon budget see 'just' 1.5 C rise. It's simple physics & chemistry. Whatever oil firms might desire, nations may think, whatever leaders are prepared to 'promise' about a distant 2050, this budget if it's accurate, puts a hard ceiling on fossils now, period.

To state that our Planet & Oceans will likely, realistically blow past it this decade of the 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 the end of 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 conviction 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

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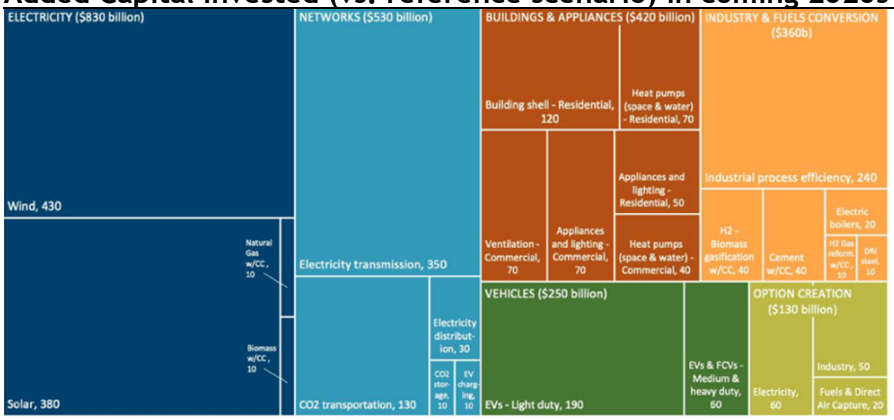
A Look at some important divergent Possibilities Over 2020s Decade:

From: Interim Report. Net-Zero America: Potential Pathways, Infrastructure, and Impacts. By E. Larson, C. Greig, J. Jenkins, E. Mayfield, A. Pascale, C. Zhang, J. Drossman, R. Williams, S. Pacala, R. Socolow, EJ Baik, R. Birdsey, R. Duke, R. Jones, B. Haley, E. Leslie, K. Paustian, and E. Swan. Princeton University, Princeton, NJ. December 15, 2020.

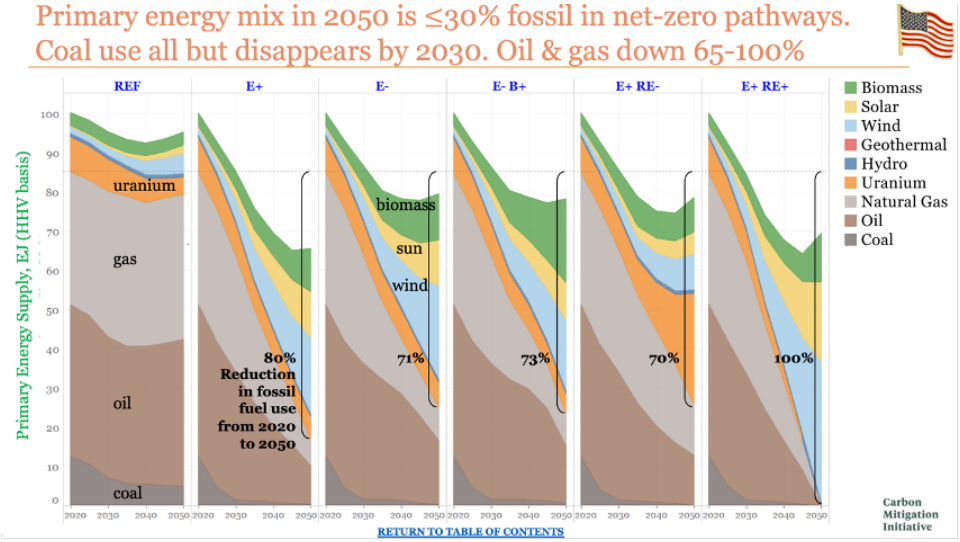
Added Capital Invested (vs. reference scenario) in coming 2020s might be >$2.5 Trillion:



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

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.
