WilderShares, LLC

Q4 2020 Quarterly Report: WilderHill Clean Energy Index®, December 31, 2020

The Clean Energy Index® (ECO) began 4th Quarter 2020 around 125, and ended Q4 around 215, strongly up Q4. ECO Index® started Q1 2020 near 70, initially rising to 90. Then like much in Q1 it crashed on pandemic, saw a close in March under 50 – bouncing back Q2. Afterwards it gained a large +50% for 3rd Quarter. Momentum in this singular theme continued, for a Q4 gain around +70%, and remarkably some +207% year gain in the ECO Index®. Thus, even after falling hard due to Covid, this decarbonization & ESG story since March roared back 4-fold(!). A past say, 4 years since start of 2017, when the ECO Index® was 38, it's notably up +460%.

ECO passively covers an emerging risky theme so it at times 'drops like a rock', as in 2020. Big gains occur here, and bigger drops too. Yet, greater interest *might be* paid here ahead: solar is about to become the lowest-priced electricity, *ever*. Potentially that *may* create vast new demand from U.S., Europe, Asia. As infrastructure & good-jobs, equity & social justice – overlap with climate solutions, there *may* be striking moves ahead. Not just volatility in solar, *perhaps* too in wind power, batteries and innovative energy storage, electric vehicles, green hydrogen, fuel cells, and decarbonization of everything– unlike anything before.

Last 5 years, this Benchmark ECO Index® live since 2004 and the 1st for climate solutions is up +300%. This over a time when perhaps *any gains in energy* stand out. For over these same 5 years, once-dominant CO_2-laden oil & gas have dropped far down -70%. Likewise last 10 years, fossil fuels are again down -80%. That in contrast to decarbonization as one organizing theme in ECO, which has gone volatile to upside, clearly strongest returns for energy.

Worldwide too, the WilderHill® New Energy Global Index (NEX) +200% last 5 years, also beats fossil fuels. ECO and global NEX outperformed vs. a different, good, independent global clean energy Index every sizable period, 10 years, 12+ years, since inception; far fewer components in that other Index may help explain that divergence. And a sustainable clean ocean theme also reflecting new decarbonization (OCEAN) is up too. In sum sustainability & ESG thinking in ECO, NEX, OCEAN significantly outperformed fossil fuels – broad Indexes too. In past our energy came down from in the ground – increasingly it comes from up in the Heavens.

Clean Energy Index® (ECO) as benchmark shows that older coal, oil & gas are not the only energy stories. Better still, the ECO Index® outperformed all fossil fuels over this past decade. Live since 2004, ECO like related NEX & OCEAN Indexes capture sustainability and a range of climate solutions: solar & wind power, new batteries, electric vehicles, green hydrogen, fuel cells, decarbonization and more. They're innovative respected leaders, with robust performances and useful non-correlation vs. fossil fuels. Plus, they provide diversification, transparency and ESG thinking that can help diversify a model portfolio.

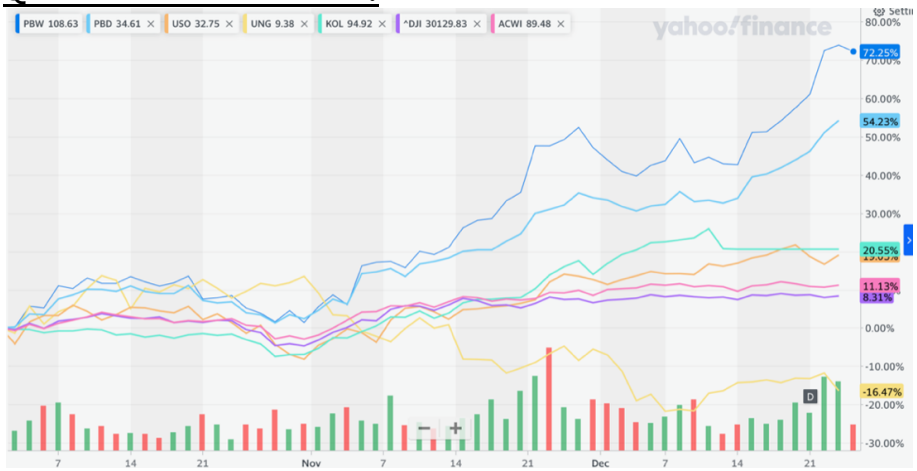
Source: NYSE.com

Let's turn to clean energy & markets this latest Q4, so to ECO, NEX & OCEAN Indexes. First, is this granular Q4 chart for past 3 months to late-December. All 3 WilderHill themes showed strength 1st half of October up +10%, dipping a bit end of 1st month. By contrast, Dow, NASDAQ/S&P500 were down in October. Next, with election results known, ECO jumped +20% in 2 weeks, up +50 for November; NEX was up some +30%, OCEAN up +25% (OCEAN isn't shown here simply as no tracker just yet). All 3 were up far more than Dow, All Country world Index etc – for them 'strong' Novembers. December was even more up for 3 WilderHill Indexes this 3rd month (ECO up >70%), a far better Q4 than the broad Indexes – far better too, than once-dominant dirty energy themes of coal, oil, natural gas. Late December ECO equities dipped, perhaps partly given big unrealized clean gains+maybe higher capital gains taxes 2021.

Fossil fuels were bedeviled 2020, as discussed ahead, helping explain their lagging so badly. Each has faced unique obstacles: Oil for example fell greatly due to Demand Collapse in pandemic. The global oil industry needs oil prices well over >$50, >$60. Near ~$50/barrel punishes indebted shale producers. Oil near just $50, in Q4 2020, foretells misery ahead for producers, even countries relying on reserves. Equities are inherently forward-looking, so oil's vexed theme over 2020 hadn't much seemed a very attractive destination for capital.

A key point, to be repeated, is *the costs of solar/wind electricity, by contrast, can go very low at times, naturally*. This variability is a characteristic, indeed core trait of renewables. Oil instead faces 'make or break' price floors beneath which industries suffer. Past oil busts meant near-term lost capacity – less jobs, wells non-producing, shut in, hikes later. In 2020 oil didn't enjoy a firm floor; toughest reserves may be stranded assets. Over 2020, this **Demand destruction** was key, along with competition from renewables, maybe electric cars too ahead. This Chart shows ECO/NEX outperforming at least in Q4 to late-December. Though it must be added having had a 'stellar' 2020 – ECO/NEX can always soon 'drop like a rock'!

Q4 2020 to late-December:



Source: finance.yahoo.com

Coal for instance, is 'best' fossil here yet it lags badly: no new U.S. coal plants are being built regardless of 'who sits in the Oval'. Coal's economics swamp even firm political will for it. So coal producers often look overseas to export their product. It's not to say thermal coal isn't burned, worldwide. Asia still has an enormous appetite and thermal plants are going up there. Yet, the fact America's thermal coal once was last century's cheapest, dirtiest, most fixed stable cost source of electricity, is suddenly no longer much in its favor.

More interesting, are possible Positive factors behind ECO, NEX, OCEAN rising recently. Given the themes stood out as 2020 Year top performers worldwide, a topic is How/Why did these 3 themes do so 'well'? Some factors enumerated below may help add a bit of colour.

One factor could be market inefficiencies. WilderHill Indexes have all long held smaller-cap equities, not so followed by mainstream analysts. Fewer analysts in new cutting-edge clean energy innovation, in lilliputian electric cars, Li-ion, storage, hydrogen, fuel cells, solar IP – may mean sizable pricing inefficiencies. Less experts here (and those that are, do excellent work!) may mean if/when a flood of new attention is drawn in, especially 'animal spirits' in tow, there's scope for gains. Another factor is very human: Disbelief! Difference of opinion is what makes for a market. Skepticism, even shorting say what may become +12,000% gains in a clean energy stock can be impactful, stemming from unfamiliarity with technologies.

We'd seen a bit similar in 2003 – 2007. Then clean energy (unknown to mainstream) came acutely in spotlight, sharp rises in sparse tiny solar, startup electric cars, emerging li-ion batteries, storage, H_2 & fuel cells. Some stubbornly-held (dis)beliefs broke down just a bit, or not. Views often heard 2003-2007 included: that electric vehicles could *never* be as fast as even slow 'real cars', EVs couldn't reach a 100 miles range, nor be pretty or as fun to drive. A similar view was fixed that solar/wind power weren't yet real vs. 'always-cheap' oil, coal. Future earnings estimates on near-term valuations, resisted penciling anew. Valuations importantly were based mainly on 'promise' in 2007. Clean energy was too costly a decade ago. All crashed here on global overcapacity, and on 'promise only', 2008-2016.

Re-think 2021 what's maybe possible next in 2020s; this *may be* more promising with change. Possibly coming: 5 million-mile batteries; whole regions making and competing on renewables & electric cars; solar-electricity costs <penny a kilowatt/hour; cheap green hydrogen perhaps – all may cause a newer look at valuations. Closing equity inefficiencies, more accurately valuing truer prospects ahead, is never a bad thing: narrowing gaps is an engine of growth. Clean & new, displaces dirty & old. Over & over, so many ways, differences closing going from 'state A' – to 'state B' – can propel. From smallest, physical quantum-level worlds, scaling up to macro that's visible, and further up to our small solar system and bit bigger galaxy.

Or, think financial sphere. Melt-ups, redux. In ECO Index® top 6 Gaining components all up over +1,000% from past 52-weeks lows mid-Q4, Nov. 20, 2020 (left) – then Dec. 24 (right):

NIO:	**+2,412%**	**+2,072% (on Dec. 24)**
WKHS:	**+1,860%**	**+1,646% (on Dec. 24)**
BLNK:	**+1,713%**	**+3,860%(!!) (on Dec. 24)**
FUV:	**+1,660%**	**+1,439% (on Dec. 24)**
SOLO:	**+1,114%**	**+ 680% (Dec. 24; but PLUG is +1,306 on Dec. 24)**
FCEL:	**+1,054%**	**+1,364% (on Dec. 24)**

6 components in any Index theme with Gains all +1,000% from 52-week lows (even +3,800%!) - is perhaps, a bit remarkable. It perhaps helps to explain ECO's rising 4-fold+ from March.

Driving factors too may be *Speed* by which clean becomes lowest-cost energy in the world; and *Speed by which governments are embracing zero-carbon mandates* – given facts of climate change. It's this last issue: how much CO_2 can we afford, that is new to us, maybe most vital speed limit of all. Vague, distant 2050 goals are meaningless. Instead: what *actually must* be done to decarbonize, Now? Latter drivers may help explain a bit jumps past 52 weeks in all three WilderHill Indexes, and so may merit the few more words, next.

The Good

To be concise let's tag factors in equity changes/delta: the Good, the Bad, and the Ugly. Good reason for 'delta' is ***Huge Cost Reduction in** clean energy. Solar/wind is now *the *Least-Cost* Electricity* in much of the globe. Not only that; solar was just singled out as soon to become *Least-Cost Electricity in World History ever!* Unimaginable to so many models a decade back, most projections then saw old fossils instead as still lowest cost in 2021.

A next good factor is ***unprecedented commitments*** by the 3 biggest economic world blocs: China, U.S., and Europe. Not yet well appreciated in the West, was that China lately made some important statements on decarbonizing. President Xi Jinping announced in 2020 China's new aim to become "carbon neutral" by 2060. Devil is in the details, to be fleshed out in and after Spring 2021 when a seminal next 14th new 5 Year Plan is publicly released.

To be seen: Is it all greenhouse gases? Methane/CH_4, HFCs, for climate neutral vs. just CO_2? How much (disagreeably) might there be carbon capture & storage (CCS) at source; direct air CO_2 capture; low-biodiversity monoculture replanting; mitigating economic fictions like CO_2 as per unit of GDP growth. All the latter may fudge true numbers around 'net-zero'.

Near term, bureaucracy may seek to retain coal. Or given power shortages late 2020, CO_2 may peak only later this decade, post-2025, presumably steep CO_2 cuts later. *Maybe* rapid draw down late decade. In a fudge, oceans & land may be 'nature-based solutions': 'CO_2 sinks'. Yet pushing off to later, or hoping for a 'Hail Mary' ought to be resisted. Sinks can fast become sources. *Renewables were always the answer:* Glinda the Good Witch knew Dorothy's ruby-red slippers could always take her home. But Dorothy first had to follow a golden yellow-brick road to learn that. China's own ruby red/golden solution, renewables & EVs are here now.

A few years may hopefully bring energy changes faster still - most comprehensive in China's history. Tsinghua University modelled how China may be net-zero CO_2 2050, all greenhouse gases by 2060. That clearly requires giant declines in coal electricity generation – plummeting from 70% – to <5%. Cutting coal from high-heat processes like steel & cement. Instead, to more slowly cut coal – means sharper declines in 2030. Far better, is to aggressively start to decarbonize: Now. Thus a more linear decarbonizing from 2021 – shifting from coal into better jobs with greener goals. Going forward, this stronger path is preferable to so many.

Either way China's costs may top $15 trillion! A far greater spend than contemplated by U.S., or Europe, with re-allocations to its economy. Most ambitious Plan the world has ever seen. Say, 12-fold fast increases in its solar, 7x in wind, (maybe 10x to 100x solar manufacturing capacity soon?) with tremendous ramps in storage – and new technology like green hydrogen for heat in steel and cement. Championing electric vehicles. Disruptions managed by fast re-positioning into a healthier, better, green economy; the changes would be colossal.

Consider, just the batteries for both electric vehicles, and energy storage. In 2020, apart from Tesla in the U.S., China is most seizing opportunities along with Japan, S. Korea, Taiwan. About 1 million EVs were sold in China 2019, 54% of world total, 3 times the 2nd place U.S. New EV growth in China may surpass 25%/year to 4+ million EVs 2025. Hence maybe a reason for recent delta in ECO/NEX/OCEAN! Demand helped push battery costs down 80% in 8 years, maybe well <$100/kWh in 2023. Battery demand may grow 5-fold. America's sole leader in 2020, Tesla, had capacity for ~35 (gigawatt/hours) GWh of lithium-ion batteries; it aims for 100 GWh by 2022, then a great 3,000 GWh (or 3 TWh) by 2030. That 3 TWh give or take, would be about all world battery manufacturing capacity back in 2020. Change is happening!

So fast rising demand may be a reason for valuation delta. Converting all the world's vehicles from fossil fuels to electric, may need >10,000 GWh new battery manufacturing(!) each year, next 15 years. Twice that+ maybe needed in energy storage: on batteries, renewables replace fossils. Beyond lithium-ion, new is coming: maybe solid-state lithium-metal batteries with faster charging. Maybe zinc deeper discharging grid batteries and little thermal management, great cycling, recyclability, longevity while starting out rather cheap to boot, etc etc.

China's focus on batteries was fruitful. 2020 it had 80% of world refining material capacity, could manufacture 77% of battery cells, 60% of components, had 72 GWh of battery demand; no one else was close! Europe's long attachment to dirty diesel had held it back, but EV incentives now in Germany, Norway etc are fast moving forward. New battery plants are going up in the EU, yet some owned by Asian firms. A century ago, Des Moines, Iowa in the USA was world capitol for electric cars: 30,000 were made there in 1912. Afterwards they let that good world-lead slip away, something that China seems very intent not to let happen to it.

All opportunity for green jobs: China recognizing this, has its foot harder on accelerator. In 2019 China added 30 gigawatts (GW) new solar, 26 GW new wind. That raised its generating capacity solar/wind to 204 GW/ 210 GW respectively. New plans may call for 50 GW solar, 50 GW wind every year. 100 GW/ year is noteworthy. Yet some *Climate* models based on CO_2 call for 10x-100x that due to carbon – 7 TW of solar PV by 2050 to achieve climate goals.

Or look West at Europe's aims; a new European Climate Law is enormous. It lays out carbon neutral by 2050, getting 55%+ there *this decade* by 2030. It's little-discussed in the U.S. (again like China's 5 Year Plan), yet seminal. First fleshed out December 2020, it's a first legally-binding net zero target of the 3. Perhaps 2030 target of 60 GW offshore wind, a 5-fold increase from 2020. 300 GW by 2050. Sizable goals beyond unhelpful CCS. Plus unlike in China/U.S., Europe is beginning vitally *now* - very quickly, not over a decade.

It's voluminous. Decarbonizing not only in energy, but whole industries, infrastructure, water, agriculture, buildings etc etc; all subject to consideration and change. Broadly an EU Green Deal may soon produce carbon tariffs, and/or taxes, trillions of euros spending, carbon border adjustment mechanisms, impacting its trading nations etc etc. Likewise details are being fleshed out early 2021; this might soon be start of a whole new Decarbonizing world.

In the U.S. there's ample coverage of what the President may do. With Senate – or not. Sans a Senate allows obvious actions such as rejoining Paris Treaty, more with a strong unitary executive theory, replacing last Administration executive orders, preference for good-paying jobs, and equity in coal/oil areas hardest hit. New infrastructure where bipartisan; one can imagine cooperation given jobs. Far tougher, would be carbon taxes, or ending some fossil subsidies (hard even on both Houses), or renewables standards. A Senate filibuster blunted by emergency reconciliation may shift dirty to clean. Upstream, low-margin solar may be Asia's domain. But cheap PV helps electrify all, with EV charging part of Building Back Better – on new good paying jobs too eg in transmission, distribution, wider EVs charging etc.

The Bad

There's just perhaps 'bad' factors relating to 2020's delta, if 'bad' in sense that some equities may not yet (to some observers) have warranted such exuberance. Today, brown hydrogen (H_2) & fuel cells, comes to mind. It's not that they won't *one day* - possibly sooner than expected - be key too. It's more that they, perhaps, haven't quite yet justified such hype – unless some major breakthroughs first come to pass. But, this is just a passive Index.

Still do consider how brown H_2 is now burdened by high costs, little CO_2 avoided, low efficiencies. Most all H_2 now is from natural gas. Brown H_2 inextricably is tied to fossil fossils - so not worthy of solution. ('Blue H_2'too is also intimately tied to fossils, so only considered on very low bar). Fossil fuel interests dipping a toe into H_2 see a chimera of 'blue H_2'; it might be promoted by them - but frankly, it's not nearly clean and is not renewable.

The much better *green hydrogen* is made 100% by renewables like solar & wind: only clean green H_2 will do. Or is H_2 made biologically, or by nanotechnology, by say by hydro and/or geothermal places like Iceland. Spain hopes to see 9 billion euros go into green H_2 in 2020s albeit via private spending. France aims for 2 billion euros spending on H_2 next few years; Germany looks at spending 9 billion euros by 2030. A fresh Catapult plan sees new 25 GW by 2026, all from renewables with green H_2 under $2 per kilogram. Saudi Arabia has a $5 billion plant in consideration that might utilize 4 GW of solar and wind, making 650 tons/day.

Green H_2 is still 'hope (hype?). But more plausible than before. Demand for green H_2 *could* perhaps grow enormously: $70 billion+ by 2030 worldwide. Europe could reach 200–500 billion euros by 2050 – more in theory. Oil firms inching into renewables are already experienced in engineering, procurement, construction. With marketing budgets, they may tout hydrogen or easier to move 'green ammonia' (H_2 + Nitrogen) that's made e.g. from offshore wind. Visuals of wind turbines, solar & green H_2 - in place of oil rigs, seems a prettier future than past.

A rub, first is cost. H_2 has strong affinity for other elements so demands much (solar, wind) power via electrolysis to split water, H_2O. So far green H_2 is too expensive – vs the brown H_2 from natural gas itself costly in its own right. So consider the two new key inflection points: 1) Costs of solar & wind came down enormously last few years for making new green H_2; and 2) green H_2 can fall well <$2/kg or less by 2030, <$1/kg by 2050 or sooner to become profoundly no longer 20+ years in future. On a carbon tax of $50-60/tCO2, clean H_2 *could* make heat for steel, cement. Power ships, ports, planes, more. In the sustainable clean ocean theme (OCEAN) maybe vastly cleaner ships, ports, robust marine biodiversity sustainability. In Asia, manufacturers have reduced H_2 costs 80% in 3 years, <$2/kg is being targeted.

And yet. Contrast such dreams, vs reality past 2020. Green H_2 costs x times more, everywhere, and is seldom available, anywhere. There were some 42 hydrogen filling stations in ambitious California 2020 – vs. 22,000 electrical outlets for possible charging spots. Worse, are inefficiencies. Compared to batteries, H_2 doesn't stack up, losing near half going from water – to hydrogen/oxygen. There are further losses in going from H_2 as energy carrier – back to electricity at a fuel cell. Yet it may soon beat archaic heat engines now in rail, planes, ships – so we may start there on a carbon tax - but inefficiencies remain a hallmark of H_2:

A good case for hydrogen might arise *if* very cheap surplus solar/wind electricity arrives. 'Time shifting' intermittent power is a holy grail for firm power & heat as abundant as needed. Green H_2 may start by mixing with and replacing natural gas, in just small amounts. Fuel cells are key too, and they must also quickly see radical cost reductions, durability gains so as to not be poisoned by imperfect fuels: much attention is being placed there too.

H_2 fuel cell hope (hype?) may be partly too why green energy jumped 2020. Equities, forward-looking, may speculate though the story is less clear than solar, wind, electric cars. Latter 3 for certain increasingly displace the old. H_2 by contrast is riskier; it embrittles steel, fuel cell stacks harmed by imperfect fuels, short life. Still, once only conceivable, they're *maybe* plausible - if renewables deliver cheap power. No doubt much is risky & uncertain …

The Ugly

Ugly factors, mainly tangential, perhaps highlight how better are green solutions. Unpretty but much-raised (especially by fossil fuel industries) is the notion of Carbon Capture & Sequestration (CCS) that might extend use of fossil assets decades. It may push captured CO_2 back down underground, say, to help produce more oil. But the question then, is, why??! When burning *much less* oil is where we ought be headed - in the first place?

There's matters they don't discuss: like what to do when that CO_2 leaks, just a few centuries hence or less?? Recall how that happened in Lake Nyos, killing over a thousand people.

Plus, because solar & wind now undercut costs of coal without sequestration, costly CCS is in fact No Answer for coal at all. Add in a costly non-starter of separating/capturing unwanted CO_2, then pumping that underground – and coal rockets to 4x the costs of clean! It's why we've all seen 'clean coal' in ads for years – but never in actual commercial use.

Unpretty too, direct CO_2 air capture is very energy intensive. Requiring so much energy, it needs more power plants, for more CO_2, so forth and so on. Thinking about how it too, likely only worsens oil, coal, and gas use – and that underscores why we must instead focus on green in the first place. The case for Sustainability, may again mainly boost green equities.

Quite ugly too are notions of Geoengineering (Seriously, dimming the planet's air - or dumping CO_2 in deep oceans without knowing effects??!): such notions are rejected by this theme. Yet even that hydra-headed monster - is overshadowed by today's real climate change threat. Climate change is fundamentally altering our once-cool planet. This last specter, one that's real, is concentrating the mind on how better and sensible to avoid CO_2 in the first place.

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

Recall how closing gaps, like progressing from past commonly-held (wrong) views – to today – maybe helped propel clean equities in 2020. In 2000 conventional wisdom saw seen solar & wind as costly toys at margins. Seated at a kids' table they weren't truly regarded. Instead of 'listening to the sea' and thinking holistically, looking forward - electric cars were viewed as 'golf carts' confounded by smallest inclines, their range forever 'known' as a sad joke.

How wrong. From 'known' 20 years ago – sleek electric cars have grown vastly better: they were fated to do so! Foreseeing that fate made fortunes. Solar & wind today, similarly. Closing gaps between state "A" (assumptions) – and "B" (actual laws of physics) - meant everything. It has produced useful work and is arguably creating an ongoing delta in valuations – and delivering 'alpha' in financial terms. That goes on delivering great shifts ever-ahead.

It's very non-linear. In tremendous falls 2008, green themes plummeted; profit margins went non-existent and spent many years then down. There's non-Euclidian curved geometry to the real world. Like disjointedly compressing margins, there's few straight lines here. Margins becalmed a bit, firms grew, and we learned how to make solar become *least-cost electricity in history*. Learned cost-reduction curves led to virtuous circles. Electric cars got better every way. Think of heat engines all around us: their spark plugs ignite fuel, explosions move pistons for power. Coal too makes electricity via heat difference, like nuclear (world's costliest boiling water): delta is in heat. They all need a difference of state, a temperature gap between "A" vs "B". As we better understand clean, equity values may change. Innovation is fated to always create differences, and a welcome delta, a bit like nature itself.

True too, nothing's certain. Razor-thin margins in risky PV commodity businesses may again be upended. Valuations could plummet again in 2021, long bear periods like a decade ago. Still, consider too, growth *may* be possible 2021 on potential demand - and CO_2 limits. These *may be* possible drivers for clean energy. Or certainly: it all may again fall well apart …

Return now to another factor, likely greatest – standing alone: Physical Climate Change. Potentially it may devastate all humanity in time, whole societies and cultures. It's truly an existential threat – still not enough appreciated. Tipping points, feedbacks, methane bursts, clathrates, GHGs that can't be unwound. No matter how hard we humans may beg, bargain with, or badger nature. On most topics scientists counsel calm. Soothingly, they remind us things aren't as bad nor as extreme as non-scientific laypersons may paint them.

Not so on climate. Singularly researchers are shouting. So perhaps it's Conservative to heed the science – Radical to ignore it. This may grow acute ahead. It might hit us not in spirit of happily looking to smarter solutions. Nor boldly advancing best of our natures. Instead, it may mean hastily saving what little may still be well saved (remember sand beaches? Healthy Corals & Seas? Stable glaciers?). How better to prevent this last prospect being a future we needlessly bequeath. Especially, when sustainable and clean, No Regrets paths make lives healthier, happier, richer, safer, more secure. When it could save spending spiraling blood and treasure, addressing diseases and despair only wrought by knowingly doing harm.

Entirely different, are markets, green themes this decade. 6 components in ECO's story saw as noted unusually big gains, +1,000% from their own lows in last 52 weeks to mid Q4 2020. Look similarly at NEX for clean new energy worldwide. As of mid-Q4 (Nov. 28, 2020) there were 8 components each with gains over +750% from their 52-week lows. Some even going higher still one month later seen on December 24 – for a second column at right:

Nio:	**+2,459%**	**+2,069% (on Dec. 24)**
FuelCell:	**+1,935%**	**+1,364% (on Dec. 24)**
McPhy:	**+1,176%**	**+ 752% (on Dec. 24)**
Plug:	**+ 933%**	**+1,306% (on Dec. 24)**
CS Wind:	**+ 807%**	**+1,074% (on Dec. 24)**
Sunpower:	**+ 777%**	**+1,031% (on Dec. 24)**
Bloom	**+ 754%**	**+ 917% (on Dec. 24)**
Sunrun	**+ 751%**	**+ 775% (on Dec. 24)**

Seeing 8 components in any Index theme with Gains of +750% from their past 52-week lows, may again be a bit remarkable. It maybe helps explain an NEX rise 3-fold from March. Similar results in OCEAN, same 8 components again over +750%. So OCEAN Index too is up strongly since March 2020, again all 3 green WilderHill themes are far above broader Indexes.

Once upon a time, fossil fuels were all humanity had. Their magical power magnified what we humans could do, many-fold. Yet we can't let the centuries of dominance, now waning fast - convince us what's bad for now-fading coal, oil, gas - is bad for humanity. Arguably we might embark for green, sustainable's sunlit uplands, a choice that may be seminal.

20 years ago, the value in a passive Basket here mitigating individual risk, was manifest. It still it. One can't know today, what single component/s in solar, wind, H_2 fuel cells, electric vehicles, decarbonizing, or all above(!) may do well ahead. Which equities all-very risky, may fail - which may thrive. Since these passive baskets capture & track a decarbonization theme - they might be of interest. We'll step farther back for a wider view.

Let's see ECO 2020 next for all year (Year to Date). Chart next page shows clean energy is the most up, over +200%(!) Note too, that a useful non-correlation that ECO so often shows vs dirty energy - is again vividly seen. What fine example of diversification among themes! While oil's much-followed story was in historic free fall last year, instead clean energy's story and thus ECO Index® & the NEX – marched across 2020 to a distinctly-different drummer.

Decarbonization's clean & ESG stories far outperformed dominant dirty themes all year (YTD). Clean also beat handily major Indexes. What was captured by ECO, NEX, OCEAN spiked up, more than broad Indices. A COVID-related crash had hit everything very hard mid-February, dropping markets 'round the world' along with ECO/NEX/OCEAN to a nadir late-March.

Clean afterwards resumed a climb to end 2020 – exceptionally higher vs. dirty. Contrast that from late 2020 vantagepoint, with *dirty energy which was worst performing sector in the S&P 500 4 of past 6 years; down -30% in 2020 (while clean energy roared up. In the S&P 500 'energy' still is mainly the fossil fuel-related equities). That little slice of S&P 500 in fossil fuels was off -51% in Q1 2020, a period when overall the S&P 500 was down 'only' -19%. Partly, it may be due to that Index's weighting methodology: just 1 big component in S&P 500 using market capitalization weighting, may potentially be heftier than all dirty) energy components combined. It is evolving and improving slowly with smart addition of Tesla to S&P 500 in 2020 – even if late as a 4th biggest company there – and with Enphase, added early in 2021.

In 1H 2020 (dirty) energy was just 2.5% of S&P 500. By contrast, energy before was bigger; 7% in 2015, 11% in 2010, 16% back in 2008; in 1980 dirty energy was 7 of top 10 in S&P 500 by market cap, over 25%! Conversely the 18% in technology stocks in 2010, grew to 28% by 2020. Technology rose – though green themes not being much captured there, yet. (Some had anticipated Tesla's addition might come Q3 2020 at just over 1.4% of that Index, significant with ~$4 trillion in trackers. But it was passed over, added Q4 and jumped +50% on that news). For further insight, let's consider the case say of oil and gas behemoth Exxon.

Latter 2020 the Dow Jones Industrials Index announced it would drop Exxon from its leading 30-stock Dow basket. Why? Apple was splitting 4-1; that meant a price-weighted Dow needed to find component/s to add to keep up with other baskets (Dow significantly had lagged in performance of late). New representation was chosen - but Not coming from anything in old-style dirty energy like oil – instead it was adding in 3 technology-heavy names.

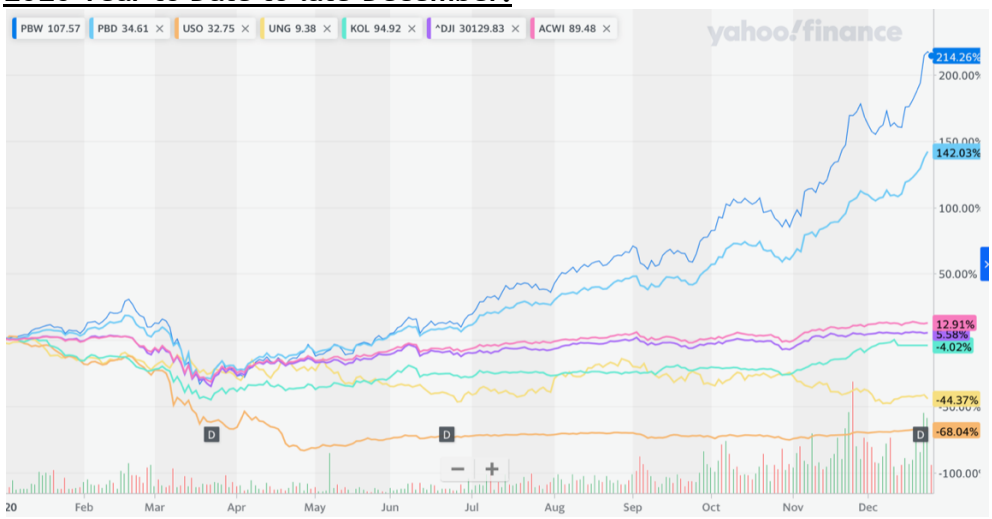
So Dow deleted Exxon that had in various incarnations been in since 1928. Once longest-serving component of Dow, no more. Only Chevron, among oil, stayed. That's a reflection of both what's happened last decade – traditional dirty energy fell fast – also indication of maybe what's perhaps ahead. Technology including clean sustainable energy may possibly ascend robustly into Dow ahead, like into the S&P500 – others might reach market caps heights.

Battles are going on quietly influencing hundreds of billions of dollars. Back in 2018-2020, the last Administration's Department of Labor using 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 – into sustainable energy themes. It's been reported that fossil-fuel industry & climate skeptics were an impetus, trying to slow inflows to ESG (Environmental, Social, Governance) investing. They'd perhaps hoped to see 'non-pecuniary' goals like on climate, get subverted (change of Administration has much bearing).

Yet real-world returns for clean energy are hardly 'non-pecuniary'. Look at 2020 to late-Dec. chart: 2 best performers are again ECO & NEX via trackers, nicely non-correlating to all else. ECO & NEX grew strongly positive over +200% & +140%(!), far better than all of old energy. (OCEAN up +75% has no tracker quite yet). All much better than S&P500, Dow, all country world theme – latter 3 major comparison bogeys. Contrasts too with oil, coal, gas trailing far behind; coal nil, natural gas -45%, oil down -70%. So was maybe no surprise to see tens of billions of $$ dollars flowing into ESG early 2020 breaking all 2019 records. As ESG thinking has wildly outperformed, even its own winning attention to climate change (IB 2015-1) came under quiet attacks in 2018-2020, reportedly by fossil fuels interests under ERISA.

In a nutshell, sustainable energy did wildly better than other themes. Far better than most all active mutual funds, or other ETFs. So if proposed rules sought to prevent look at climate change risk, because of it being 'non-pecuniary', then that's a bit curious given the facts:

2020 Year to Date to late-December:



Source: finance.yahoo.com

For 2020 year (YTD), ECO/NEX are high-end of vertical barbell-returns, at top well up apart from all are the green stories. Opposite at far bottom – are old-style energy oil, gas, coal, clumped, negative, big declines. In middle are 3 broad major market 'bogeys' for comparison: the S&P 500, Dow, and an all country world theme basket. Latter 3 finish around +5% to +15% so just up, close to many active-managed funds this period. Over a 2020 smitten by diseases, by wildfires, by temperature extremes and by storms, increasingly we see mounting evidence that the economy is a wholly-owned subsidiary of the environment.

And in a 2020 chart above one key theme – Oil – also distorts all by falling -70%, *Downwards*. Oil futures fell tremendously, negative, rebounding back only a bit. A few words about that unique oil index basket & tracker. Very unlike ECO/NEX/OCEAN, that other oil theme is instead based on a commodity - rather than equities. 'Worse' it was based on far front-end oil future contracts, pricing in turn influenced by tracker that can't take physical possession of oil. It's been constrained by known rules & subject to pricing attack. So when very nearest front-end month oil contracts 'broke' into contango in Spring, that oil index went extremely down. Nearest monthly prices may move quite unlike more stable futures pricing 12 months out, that better represent actual physical oil. We'll discuss oil some pages farther ahead, but a point is that oil over 2020 vastly fell. Clean, happily, was very, very different.

Solar did see useful consolidations due to growth 2020. A leading U.S. solar panel maker sold its operations and management arm to another O&M. A second dedicated solar name split in two. Once-vertically-integrated it had made solar panels – and installed/serviced them. Splitting with a spin allowed parent to re-focus downstream on residential & commercial solar in North America. That's a big market (albeit thin margins) plus storage too permits branding, distributed generation, and can fast get bigger. It is also in-country work that can't be outsourced, nor done overseas by cheaper, commoditized competitors elsewhere.

The event shines a light on solar tight margins downstream – that led to consolidations. Post-spin that parent *may* see better valuations in a heating-up space. U.S. solar installs already are rising fast: in fact a separate merger latter 2020 brought 2 leading U.S. solar installers together as one behemoth. Post Q4 a PV installer may see useful valuations comparable to the new solar downstream parent: all are seeking low cost access to capital.

Meanwhile, upstream, that new spinoff is aiming to manufacture premium panels affordably. But margin pressures are unrelenting here, too. Some manufacturing is moving from China, like to Malaysia, Philippines, Mexico etc. There's huge commoditization in making solar upstream ('just get good panels, at least cost'): modules prices down 80% since 2012. Meanwhile downstream, parent installer may use panels from its spinoff, a brand leader in Singapore facing razor-tight margins placing commercial & residential PV globally. Will be interesting to see how both do as the coming performances unfold. Once upon a time it was fat 30% margins; now, it's tougher 10% margins in some power purchase agreements.

Thus did a roller-coaster 2020 feel like such an exhausting, thrilling year. That full 2020 chart was remarkable; the world hadn't seen anything like it – nor quite this delta in clean (far up!) - vs dirty (far down!). Hence ~60 dense pages in this Report. Overshadowing all 2020 of course, was the Covid pandemic. Job losses had skyrocketed on the Great Lockdown/s. Markets cratered in most themes hard Q1 – and may do so again ahead. Oil imploded to places not seen in 100 years. Past rising attention late 2019 for climate change and clean energy solutions – was initially overtaken by pandemic – then again resurged in 2020.

Moving on let's consider a longer Past 5 years next. Fossil fuels again stand out next page for declines. An interesting shift though is seen in 5-year chart. Until about a year ago, last 5 years for ECO had been generally down, a long spell. Breaking that end of 2019, ECO left a long spell down past 5 years; suddenly, sharply, clean energy shifted past 5 years end of 2019 to be up, positive, returning +50%. 1st half 2020 the divide grew starker. ECO was up well over +50%, as dirty fell yet more. End 2020, it's even more a striking divergence. Clean up +300%, all strong in green energy themes - vs. the dirty themes down -30 to -70% or worse.

Because 2016 had declined in ECO/NEX – once 2021 scrolls ahead, past 5 year charts ahead could by a mathematical coincidence improve further – even if ECO/NEX are both flat in 2021. Or should ECO/NEX happen to even gain in 2021, then the past 5 years chart could really rise. That's simply a mathematical fluke without much significance; just do be aware of it.

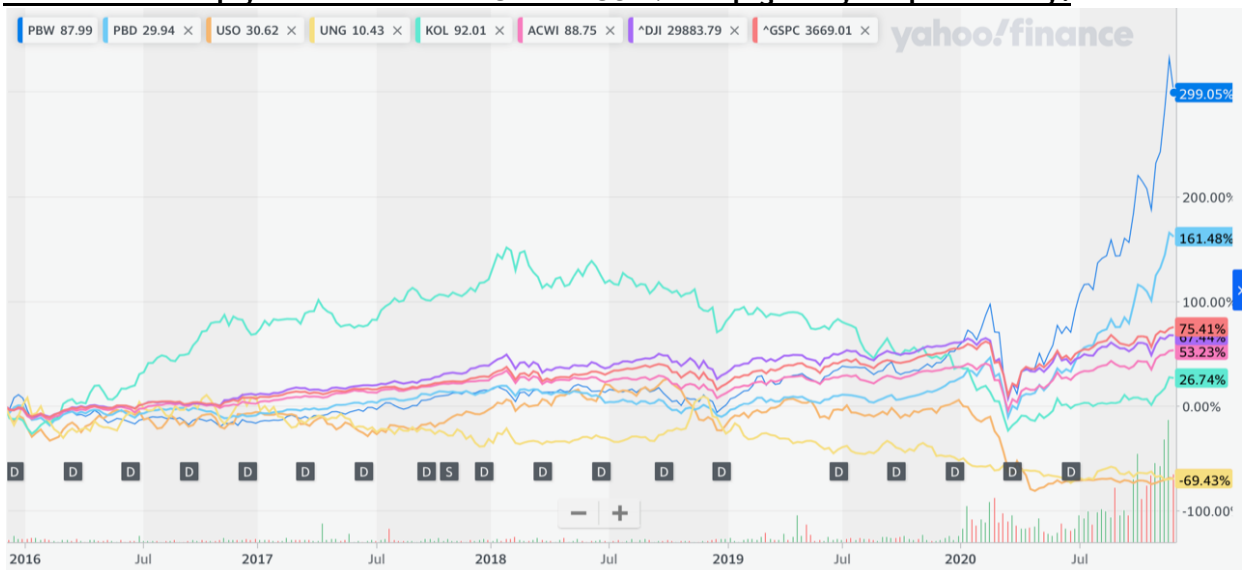
5 years captures but a sliver of time. Corrections happen, trees don't grow to the sky. And temporal slices just snapshots; e.g. at end of 2019 the past 1-year ECO already was up sizably by +59% - so perhaps a big drop wasn't very 'surprising' early 2020. And clean energy's theme, once long stuck as being *down* past 5 years in prior Reports across 2010s, has now shifted. A once-monolithic *A**ll (clean too) energy far down*,** has lately been changing, a lot.

Two striking factors in this 5-year Chart are: a) Clean energy's story and so ECO/NEX is leaving the 3 Down years 2014-2016; and b) this has 4 Up years 2017-2020, gains in ECO, NEX, OCEAN. With clean here being up +300% here, it has left all dirty fuels 'in the dust'.

Past 5 years then ECO tracker is strongest of all stories here, up +300%. 2nd best is the global new energy NEX up +200%. A separate good global clean energy Index, not ours, seen ahead trails both (as noted that separate global clean energy theme underperformed vs ECO & NEX in every sizable period here of last 10 years, 12 years, & since inception). That along with an excellent solar-only story, and an active alternative energy fund are all 3 seen in charts for relevant energy stories the past 10 years, 12+ years, more. (Too many lines clutter charts; those 3 replace the Dow, S&P500, and All Country world theme for visual clarity).

Big drops in clean energy *happen*; ECO fell at times, more than broad Indexes. *After starting 2019 around 45, 2020 around 70, 2021 around 215 (up 3-fold) - a plummet in 2021 would be Not surprising just on regression to mean.* On the other hand, last 5-year Chart shows clean energy's *gains* may also outpace major Indexes too. Consider August 2020: Dow gained +7% for its 7th biggest August gain since 1984; S&P500 +7% its 8th biggest August gain since 1986. Meanwhile same month, ECO Index was up August +20%, NEX was up +15%, & OCEAN was up +12% (nor was that their greatest monthly gains: November, then December saw more).

ECO / NEX trackers vs. varied other clean & fossil fuels themes in Rolling Past 5 years: December 2015 to end of November 2020. Once seen as 'tough times' for all of energy, this is now sharply Differentiated - Clean ECO/NEX top greatly outpaces dirty:



Source: finance.yahoo.com

Next a past 10 year rolling chart is now positive for clean. Until recently, clean energy's story for past 10 years was a relatively a 'dog'. What's changed so? From a strict charting sense, it's due to leaving steep declines longer ago in late 2000s/very start of 2010s.

2008 to 2012 were final legs in a steep plunge in renewables. So all or most those years had bent performance downwards. Clean was still relatively 'outperforming' dirty then, at times. Yet clean had also plunged very hard too. that warrants attention. Seen next is a rolling chart for the rough past 10 years, from December 2010 - to end of November 2020.

Past 10 years, the NEX is here up most +130%, ECO up some +80%. This period starts leaving behind a Great Recession that thunderously dropped all 2008-2012. That put in bottoms for *non-energy* stories, many of them moving up afterwards. But not so in energy stories, broadly: those got hit harder, longer. As seen here especially among dirtier themes, much in energy would go on falling afterwards in early 2010s with no immediate rebounding up.

Clean vs. dirty energy have diverged greatly since – lately (happily) by a lot! Thus in apt 2020 words of the Wall Street Journal, 'Green Energy is Finally Going Mainstream" (June 24, 2020), "After many false dawns, the sun is finally starting to shine on green-energy bets. …. The poor long-term track record of clean energy stock indexes and funds has much to do with the period roughly a decade ago when Chinese solar-panel manufacturers scaled up and drove down costs. That accelerated panel installations but crushed margins, leaving many much-hyped U.S. and European manufacturers, and their shareholders, in the red."

Solar upstream stabilized latter part last decade better coping with past overcapacity and commoditization's (thin) profit margins. *Global* NEX is most positive as noted, +130%. ECO positive too about +80% for 10 years to late November. A good independent, separate global Index (not ours) tells a differing narrower story and is up some +60%. An excellent, narrower solar-only story is here up +20%. An active, alternative energy fund up +12%. Meanwhile all 3 fossil fuels plumb depths far down here some -80% to -90%. It's a tale of two cities: Declines big in Dirty – as opposed to Clean well-up. This has been trending for some time.

This new decade, solar power + electric cars will increasingly converge – both captured core themes in the ECO basket. We wrote about this 10 years ago, for example in Solarsense: The Economic Case for Dumping Gasoline Car and powering Your Car by the Sun' (2011) and 'Driving on Sunshine', https://wildershares.com/pdf/solarsense_v1.2.pdf Looking at chart below, passive Solar-only is down last 10 years; yet is far better recently – brought low only over past decade. An active-managed fund below, shows it's tough to beat the passive Indexes.

So highest is green global NEX, then ECO. They far outperform vs. other energy themes here – yet trail far behind the broad Indexes like say an S&P 500. On the other hand, clean ECO & NEX clearly did the 'best' last 10 years – vs. other energy stories. And as 10 years rolls on well those past earlier, tough years, it *could* begin perhaps telling a quite different story:

Rolling Past 10 Years from December 2010 to late November 2020:

Source: yahoofinance.com

Just before moving on to longer 12+ years period – an interesting development stands out. It's that the **Global NEX** (light blue, next page) well outperformed an independent, separate **global clean energy theme (dark blue, next page)** every lengthy period: past 10 years, past 12+ years, since inception – increasingly since start of respective trackers. Why is that?

3 factors may help explain why that other global clean energy Index trails behind global NEX for worldwide clean energy. Perhaps in part it's because that other non-NEX basket:

* Is far more concentrated, with far fewer stocks, & heavily weighted in its top ten;
* Represents countries and weights outside of a top few there are often more limited;
* Diversity in its clean stories is much narrower, given there's fewer stocks in that basket.

Consider differences of **global NEX Index** – vs. that other good, global clean energy basket. NEX Index went live first, just before that other Index, 12+ years ago. Generally NEX has had around ~100 (very roughly 80 to 120) components in past. By contrast that other global Index has had ~30 components. Arguably 30 may make it a bit more difficult to capture so many fast-growing global stories in EV cars, buses, trucks, in green hydrogen, fuel cells etc.

Weighting methods matter too; that other basket sorts components by market capitalization. As a result just top 10 components alone in other tracker may reach some half (or more) total Index weight(!). New energy stories worldwide, are broader than 10 stocks – yet such a concentration can also mean sharp upturns when its top 10 narrowly do very well.

Instead, the NEX uses equal weighting given such a diverse arena worldwide. That can allow the NEX (& tracker) to capture emerging stories in more diverse areas globally, solar, wind, electric vehicles, energy efficiency, geothermal, green hydrogen, fuel cells, etc, etc.

Neither approach is 'right'. They simply provide differing ways for the story to be captured: in this case, it is clean new energy innovation worldwide across developed countries.

Comparing their baskets, mid-2020, showed marked differences. There's about 3 times more components (some 90) in NEX tracker. Its top 10 in NEX tracker made up 17% of total weight, so it lets many other stories (83%) be captured in its basket overall. As important as top 10, is Top 50% - again, here NEX has far more components. This means more stories can be covered in global new energy, in more countries, a far greater diversity across the theme.

Now that these 2 Indexes are calculating live 12+ years, we do see widened performance differences. It may be a bit interesting as to Why. Clearly better performing NEX tracker (next page, in light blue) is doing much better (+20%) vs. that other tracker that's down some -40%. One difference may be variety / number of representative countries in each Index. That other tracker in Summer 2020 had just 2 countries making up some 50% there: merely the U.S. (38%) and China (12%) had made up fully about half the countries by weight.

4 other countries helpfully added roughly 7% more each: Canada, New Zealand, Brazil, Spain. Then there's seven more countries generally making up the rest, at under 5% each. So a big difference mid-2020 there is that just 2 countries made up about half that other Index, with 11 more in its other half – as 1 or 2 companies each in a few nations. Total there was some 30 components meaning 13 represented countries in that other, global green energy theme. To repeat, that's one fine approach to such basket; these are differences of flavor.

NEX by contrast has much different construction. Seen in its tracker 2020, top 2 countries were U.S. (25%), China (9%) for about 34% - which allows more components and more weights from other nations. Arguably useful, given diversity here. A case could be made that this may allow better reflection of the global diversity of new energy innovation worldwide.

More nations may be represented among a larger say ~100 components: U.S. (22 names), China (8), also many too as from Canada (7), Germany (5), Japan (5), Spain (5), Taiwan (4), New Zealand (4), S. Korea (3), Britain (3), Denmark (3), Norway (2), France (2), Sweden (2), Switzerland (2), Italy (2), and from Ireland, The Netherlands, and Finland (each 1).

Hence more weights from more varied nations 2020. Relatively more in NEX outside 2 nations, U.S. and China. Had those 2 global new energy Indexes simply always gone on trading places in their respective leadership, their performances going back and forth, such differences may not have much mattered. But the performances of the two Indexes has plainly favored one, the **NEX tracker (light blue)** - consistently ahead of that other global clean energy theme (dark blue). Hence these thoughts about possible reasons for widening trends. Given a lead seen now every period of a lengthier past 10 years, past 12+ years, since inception etc.

Lastly one metric on which they starkly differ is weighting style – yet that one does not identifiably lean towards better performance one way or the other. It is a fundamental difference, so worth a moment's discussion. Whether an equal weighting (modified, straight) in NEX – is 'better' for new energy, than market capitalization cannot be said. Much ink has been spilled over this in major Indexes. Probably it's simplest to say there's periods equal-weighting does 'better' – and periods market capitalization does 'better'. Neither predictable – each identified only in hindsight. When leadership is a few very biggest names, market cap may do better. Other times, speedy growth at a once-small cap stock would favor equal-weight representation. So there one approach does better – at other times, the other.

Here is the global new energy theme as captured by two Indexes live since their trackers' inception 12+ years ago to late December 2020. Interesting to see performance of each of the two Index tracker funds. In sum **global NEX (in light blue) tracker fund** has had so far a much better performance in capturing this clean sustainable energy story worldwide:

Source: finance.yahoo.com

One last point about Charts, before moving on. A small problem with *rolling* Charts like past 1 year, 5 years, 10 years etc is in a few years they *may* show very strong returns for ECO. Once charts leave a huge fall in ECO from 2008-2012, later tough times all energy 2014-2016, then relative drops removed ECO *may* show far greater relative gains. For that reason, a view is needed with ECO's huge declines 2008/2009 preserved: hence this Chart below. From a fixed 2008 it looks onwards. Long-running ECO+tracker could have started in 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 a tale of big energy declines. Unsurprisingly, fossil fuels do lag green sizably. But relative to a rolling 10 years, above, one difference increasingly stands-out; a global crash 2009 brightly highlighted, is strongly forever preserved. What energy may perhaps show ahead will doubtless be of interest as 2020s scroll on ahead. Yet what was before-viewed as tough time across all of energy – the last 12+ years - *may* show instead ahead as very tough for the fossil fuels, only… Or perhaps, Not!

Calculating live since 2003. ECO Index® is far and away the first & original for clean energy. We'd also note that an ECO predecessor, the WilderHill Hydrogen Fuel Cell Index, calculated from 1999-2007. Given this chart below then picks all up from 2008, we've been uniquely capturing a Hydrogen & Fuel Cells theme more than 20 years: since 1999! For latter theme, see our 20+ years 'cousin site' at The Hydrogen Fuel Institute, http://h2fuelcells.org

Now this chart below preserves as in amber Big drops in energy, after steeply up mid-2000s. From about 2008, as many trackers are commencing near peaks, all would next plunge. That crisis and crash brought crises across countless themes, globally. A bog & deep mire since, stretching across both clean energy and dirty energy, is brightly preserved here 'forever'.

Starting from bottom, is fossil fuels, plus a solar theme; those 3 + 1 fell here -80% to -90%. Next, 'above' is solar off -70%; then an independent other global clean energy basket that's off -70% as that theme fell hard this period: just 30 components there differs greatly vs. NEX. 'Above' those all and still down as dramatic falls of 2009 are included is ECO here at -20% so far outperforming a separate global clean energy theme. Clearly 'highest' of energy baskets is the global NEX, though only near nil +3%. Broader, major Indexes outside energy (not seen here) did *far* 'better' here and yet differ sizably: energy is a sliver there. Plus since 2017, all of clean energy has shown up volatility too, which *may* yet change everything ahead.

Roughly Last 12 ½ Years starting from a Fixed June 1, 2008 to November 2020:

Source: yahoofinance.com

In a side note clean energy's plummeting February/March 2020 left only 1 ECO component positive at bottom March 18, 2020. That March 18th inflection was a bit memorable: ECO opened at 51.88, then fell to an intra-day low 45.85 losing -12.57%; it closed at 47.37. So this basket had dropped by over ½ early in 2020, from a 93.65 high intraday Feb. 20 (closed 92.53). In just weeks ECO had plummeted by over -50%!! World markets were crashing too amidst fears of a 2nd Depression like unemployment. All seemed on the brink that moment.

Lest this Report over-emphasize such negatives, e.g. spotlighting falls long ago last decade - there's also been sharp rises here too like recent 2017 to 2019 and more lately 2020. For example ECO components jumped over just a 3 day stint in 2020 from March 24th on a sharp +25% rebound. Volatility after those lows, pushed ECO upwards some +15% in hours.

After closing under 50, on March 23rd at 48.75 on fears of 25% unemployment & Depression II, ECO Index reached 55.87 on March 24th, closing at 55.74 on hopes of $2 Trillion stimulus. Focused green support wasn't expected in a stimulus Phase 3: as expected such help didn't arrive as it was opposed politically. Yet clean energy as detailed ahead, is fast-growing cost-competitive even *without* subsidies (unlike fossils/nuclear always needing support).

So gains too *may* happen in clean energy. At times they may show alongside broader markets, though with perhaps more volatility. Consider say, April 6th to 10th of 2020: in 1 week the S&P 500 & Dow rose some +12%, biggest 1-week S&P gain since 1974, the 7th largest for Dow. Both ECO & the NEX can at times plummet downwards to be sure; here, they were just as or more volatile upside: ECO rose by +19%; meanwhile the volatile NEX gained over +12%.

What led? Looking at ECO/NEX early 2020, some bunching is seen best performers such as in electric vehicles, hydrogen (H_2) and fuel cells, solar, charging, and energy infrastructure.

Hydrogen fuel cells is a sector noted ahead, considerably more speculative than fast-growing and increasingly profitable solar & wind power, and electric vehicles. Making green H_2 is uncertain: it would first require key breakthroughs in both production & in storage – meanwhile companion fuel cells making electricity from green H_2 would need breakthroughs to be cost-competitive, and durable too. They're not yet close to that today.

Solar, wind, EVs are different, fast growing more profitable and can go unsubsidized, vs. more uncertainty of H_2. That said, there's growing interest in H_2 perhaps on ideas like its transport as ammonia (simply H_2+nitrogen) as means to transport hydrogen like an energy currency. For applications where super high furnace temperatures are needed, like making steel, cement, aluminum etc, clean electricity from solar and wind can't accomplish that. But, adding an extra step, potentially could. On electrolysis from super-cheap clean power, green H_2 made from water (H_2O) – could in turn be combusted for super high temperatures.

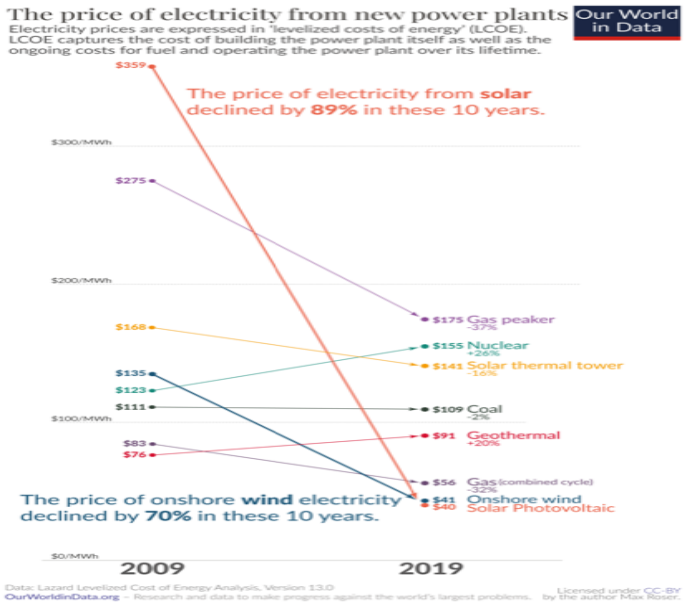
Making sponge-iron for steel now produces 7% of carbon dioxide emissions globally; 10% of all CO_2 emitted by Sweden. So note a test project there for green H_2 made by electrolysis aims to release only 25 kilograms of CO_2 per metric ton steel – versus 1.6 tons today.

ECO, NEX, OCEAN & a prior early pioneering H_2 Fuel Cell Index all had exposure to H_2 & fuel cells earliest inception 20+ years ago in late 1990s. Very soon next, in first week of Q1 2021, some volatility may instead reflect outcomes of an uncertain Senate race.

Capping a decade end of December 2020, a flip side of enormous growth is where we stand, today, on renewables, is awful. Today, U.S. offshore wind power (which could be already hundreds of GW) is instead today almost entirely non-existent. Solar makes up only 3% of U.S. electricity. Yet solar with wind could clearly be meeting 100% of our electricity demands. Today's built electric cars, trucks, airplanes etc are but a tiny rounding error. So it may feel like we've come a way now in 2021 – but it's only because of how pathetically we began. The World Economic Forum observed using 'Our World in Data' (OWiD) figures, that the polluting fossil fuels 2019 made up 79% of energy production worldwide. Note: that's due to their having long been far cheaper in a long past, relatively speaking, than clean alternatives.

Solar now, is forecast to soar, because its price has plummeted 89% last 10 years. That's no one-off. Solar's costs ahead, like in wind, energy storage have continued dropping hard 2021. Coal, oil & gas are suddenly relatively costly - given they must always pay for their fuels. Plus they are costly to operate, they must pollute, and seem powerless to reduce their own costs follies much further. Unsustainably, they created 87% global emissions of CO_2. Estimates are their air pollution alone is causing 3.6 million deaths every year, which is 6-fold more than all the annual war deaths, terrorist attacks, and murders combined!!

Our species depends on many forms of energy, so decarbonization must be broad - but we'll focus right here on Electricity, made which varied sources. Here coal, the most harmful source is generating 37% of our electricity and most CO2. Natural gas, 2nd makes 24% of our power; these 2 emit 30% of that CO_2. Coal's costs were mainly flat last decade, as gas power's costs dropped sizably. Yet that's been dwarfed by wondrous-huge, lovely price declines in solar power (down that -89%!) and onshore wind (down -70%) - both going lower 2021/2022 etc:



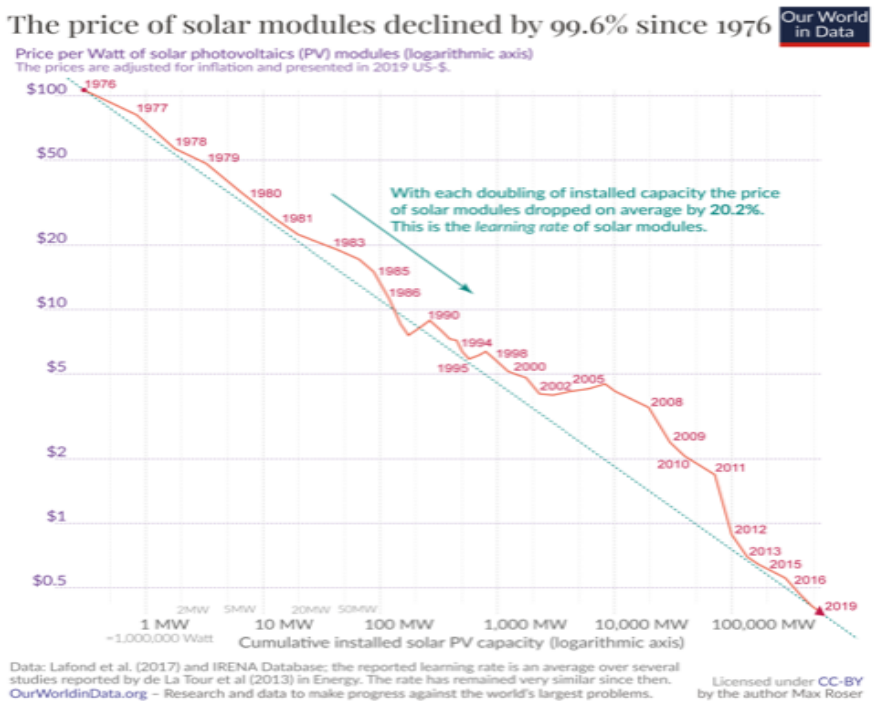
Source: Roser, Why Did Renewables Become So Cheap So Fast? Our World in Data (Dec. 2020).

So fossil fuels & nuclear grew terribly situated, 2021 as ways to make electric power. Think about it: they are vexed by *high costs to Buy Fuel & store wastes (at nukes for centuries and millennia after shut-down!), plus their own very high *Operating Costs with many hundreds+ of employees. Those costs can't/and won't decline. Non-standardized U.S. nuclear, with each new plant costing *more* to build(!) - is the exact opposite of solar/wind.

At a coal plant, fuel costs by contrast may be 40% total operating costs. Natural gas plant fuel costs declined last 10 years, but it's Not a long-term trend, nor going very far lower.

By contrast, clean renewable solar & wind enjoys *zero costs for fuel. Relatively-speaking *close to zero Operating Costs. How horrible it must be, for fossil fuels and nuclear to compete with that! Only by amortizing sunk costs at built coal, gas, and nuclear, can they reduce costs significantly until the extant plants age-out. Then, in comparing like for like, new renewable solar/wind are simply much more affordable on levelized costs – better than all the rest.

That OWID Report identified one early solar cost in 1956, as $1,865/per watt(!). 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. Valued nonetheless for deep space applications, solar went on getting better, prices coming down very fast. *So with solar, it's all about Technology*. Similar to integrated circuit chips in computers, we grew much better quickly at cramming in lots of performance ever more cheaply. It's been a virtuous circle, similar to computer chips which enjoy ever greater: new deployments = so prices falling more = so more competitive new markets = so demand increases: repeat that over and over!



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

Solar module pricing fell enormously -99.6% since 1976(!) because it's all about Technology. The Administration in 2021 may reduce, or repeal existing PV tariffs, becoming even cheaper. Fossil fuels – by contrast, are not about technology alone; they may be doomed. Declines seen above, as in wind power, are impossible long term for dirty to catch. How can coal, oil, even gas hope to keep up for decades with this learning curve in solar? They can't, if economics is a sole metric. But fossils have great inertia, influence, capital, lobbying, and will deploy it (more on that later). No doubt they won't go gently into the night. Still, no wonder solar & wind now are most power generating construction. Energy storage is becoming what's needed 2021 along with policy change. Look at recent past and what's yet to be seen …

Recent Past under Covid-19 – and Near-term future Ahead:

A new President, plus perhaps a new Senate majority (or not) – is historic for clean energy policy. Possibly impacting the decade. Consider our future: young voters today demand a far more sustainable, renewable, zero-carbon future than what 'oldies' ever contemplated.

For some glimpse of what might be sought 2021 and after, see a 500 page Select House Committee on the Climate Crisis Report that was compiled in the Summer of 2020: https://climatecrisis.house.gov/sites/climatecrisis.house.gov/files/Climate%20Crisis%20Action%20Plan.pdf This is worth a look for voluminous changes contemplated. Clearly not close to it will be accomplished. Speculative equity gains late 2020 may be dashed on rocks of reality. But real steps in a 2020s decade towards true decarbonization would be a big change.

The Plan is no small beer. It's also far more ambitious & aggressive than was contemplated early 2020. With new White House (+ maybe Senate), this decade **may** be unlike anything seen in clean energy. "Transformative" is a big word yet could be, especially with ambitious Europe and China. Still bear in mind when expectations get too ahead of reality – as on unmoored *hype* like past hydrogen fuel cells (called 'fool cells' by many) – then big drops grow more likely. Plus expectations will often shatter, as big changes require legislation and so the Senate, home to compromise, inertia and realpolitik. Too, emphatically this is a very volatile sector, one where equities *can and does* at times certainly drop like a rock!

Consider too how little actually was done for U.S. clean energy during Covid-19 back in 2020. Summer 2020, federal pandemic aid for fossil fuel-heavy sectors reached some $68 billion; yet much was 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 2021).

More directly, fossil fuel interests got $3 billion in forgivable small businesses loans in Summer 2020. That contrasted with little support specific to clean energy. Impossible to know if we're in calm before another pandemic wave 2021 & after. But solar installs gained well especially at a Utility scale; they were up some 43% in 2020 to 19 GW. Costs dropped 5%-8%, many big installers re-reached pre-Covid expected levels. Yet for smaller solar installers, like many small businesses everywhere, 2020 had been tough times given pandemic consequences.

Still early 2020, the big offshore wind globally did do especially well - despite Covid. In fact first 6 months of that year were the best ever 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 in first half of 2019. Major offshore wind array decisions in 1H 2020 included a new 1.5 GW Vattenfall project off The Netherlands and the 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.

A core driver was huge declines in offshore wind costs. Since 2012, levelized offshore wind costs dropped startling 67%. Onshore, wind faces tough land availability. Oceans instead, are immense and often quite windy spaces for massive turbines farther from view. Another driver had been wind subsidies expiring (some extended in 2021). Wind Farms can be a stable, fairly reliable return on capital. Thus renewables investments rose 1st half of 2020 to $132 billion, vs first half 2019 at $125 billion partly on offshore wind (and some geothermal).

Even under Covid, 3 nations saw especially strong new renewables investments in part thanks to their offshore wind early 2020. China was up then more than +40% over 2019; France had tripled, and The Netherlands gained by 2.5 fold over 1H in the prior year.

Solar too has been advancing. China confounded early 2020 expectations for slowing solar manufacturing due to Covid: instead, its solar manufacturing there actually gained. First half 2020 it had produced 59 GW of solar panels, or about 15% greater than in 1H 2019.

Some European nations point to gains in decarbonizing. First half 2020 the EU made more renewable power – than from fossil fuels. Notably, nations there with more renewables, have enjoyed **cheaper** electricity prices – obliterating a 'higher costs' argument oft leveled against green. Despite oppositional dings that renewables 'suffer' from intermittency, there was strong electricity supply 2020 in Europe (unlike power interruptions in California).

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

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

Wind & solar are growing. From 13% EU's electricity in 2016, to 22% 1H 2020; yet there's a long, long way to go given constraints of CO_2. Greater renewables, flexibility, ability to export excess power, better transmission, batteries are All Needed! US has made less progress. Renewables just 18% of electricity generated 2019, fossils 62%. Recall again how European nations with *more* renewables, oft see *lower* *Wholesale* electricity costs, rewarding green areas. EU chooses to add more Taxes, rendering its Retail power costs higher than the US – but that's a differing matter. In a surprise late 2020 the House/Senate extended the 26% ITC tax credit 2 years in solar & fuel cells; PTC $0.15/kWh wind 1 year. Hoped for cash in lieu from Treasury didn't materialize. Batteries standing alone still wouldn't get a credit unless bundled with solar. Nor was a $7,500 credit re-extended for GM or Tesla cars.

2020 consolidations continued, solar fast maturing this decade. E.g. one large residential solar installer bought another for hopeful economies. A China-based solar maker sought dual equity listings on U.S. & 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 a few small solar listings possible for ECO, or global new energy NEX, we well recall back in 2003, 2007, or 2010.

Data and facts reveal an energy landscape where costs are now changing so fast, it challenges 'all we know' about energy. Clean energy looks to overtake fossil fuels on price. Even more compellingly clean energy – *Without Subsidies – will soon be more affordable than once-dominant fossil fuels & nuclear*. That, more than all else, changes everything. Economics here are vital – and trending smartly. Especially given coal, oil & nuclear would all mainly shrivel away and die without their necessary subsidies. Energy is no longer staid.

As coal pricing stayed level - while renewables (and gas) got very affordable - green energy plus natural gas thus became leaders. Especially on a demand loss, when Utilities turned 1st to its low-cost sources. Those were renewables on free sun, wind + natural gas. Coal was left out in the cold. Gas is big, capable, flexible and fracking brought fuel price collapse (though some price spikes as drilling got shut in). Relatively small equity gains seen since in oil, gas & coal 2020 from off lows were 'cute' but dirty lacked robust prospects for sustainable decades of strong returns ahead – especially versus clean/decarbonization today.

Some green themes flowered in recent months, key cases like never before. Consider for instance Electric Vehicles. Here again, Carnot's Limit helps explain why new electric cars are destined to outdo old-school 'gassers'. Today's best gasser cars are inefficient, archaic at best. Their diesel or gasoline heat engines in cars/trucks only let them reach theoretical bests near 40% efficiencies. More typically today's car heat engines may be sadly 20% efficient(!). Gigantic heavy SUVs, anchored further down by their lacking-in-torque heat engines, are relegated at times to silly model differentiation like by the number of cupholders.

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

Or consider, sadly, big thermal power plants today – vs. what Mr. Carnot observed in 1800s. Today's natural gas turbine steam plants might reach efficiencies around 40s%. Cutting-edge combined cycle power plants bump up against theoretical efficiencies in 60s%. How silly, how ineffective, what a plainly dottery way to achieve needed electrical generating power.

As we learned 100 years ago from Mr. Einstein, and subsequently in quantum work, flat to increasing entropy (disorder) gives us Time – a second law of thermodynamics – and Time moves one direction (centered on basic C, velocity of light). What's notable is that time's arrow, given entropy, means 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; photons have been harnessed by solar panels 50+ years. Recently, benefitting from latest research on differing wavelengths, solar panels may yet enjoy maximum efficiency ceilings far higher still vs. silly heat engines. And since fuel (sunlight) is free, it doesn't much matter! On time's arrow gifted by entropy, we've learned swiftly how to harness Mr. Sun's free photon 'packets' at ever-lower/better costs per watt. Unlike fossil fuels, there's a learning curve here profoundly pushing only-down on costs of solar, often rapidly.

Beyond such academic musings; let's recall practically how decarbonizing themes in 3 Indexes performed lately. Solar/ wind/ EVs/ hydrogen saw sharpest gains 2020. Less 'strong', were competing dirty ideas in oil & coal along with 3 well-known Benchmarks: S&P500, Dow & global all country world. Latter 3 among best-known 'bogeys' in world. Not directly relevant to clean, they're widely used benchmarks, performance comparisons – so shown. Those were shown for past 2020 and past 5 years. After that a lengthier past 10 and 12+ years included too an excellent solar-only basket, a separate and independent (not ours) good global clean energy basket, and actively managed alternative energy. Cleaner 'beat' brown.

We avoid politics. So just a side-note is no hope had existed in 1H 2020 of stimulus squarely for green energy. 180 lawmakers did sign a June 15th Letter to House Leadership, calling for direct relief, given loss of 600,000 clean energy jobs since the pandemic. But that calculus for directed big green-only funding – let alone akin to a Green Deal like vetted in the European Union – wasn't aligned in 1H, nor Q3 2020. Senate Majority leadership squarely opposed it and was also a non-starter in the White House. But much *may* change.

Musing over what conceivably may be 2021, 2 Senate seats may potentially go any of many ways in January. Policy action regardless, might easily include Oval Office push for bigger future Tax Credits for Solar, Wind, Storage after surprisingly bipartisan support in December. But there's a potential just ahead for far greater, decadal-sized U.S. policy change.

Policy action could go much deeper; as well-known $2 trillion+ *might* be spent next few years. Utility solar early on >100 GW/year, battery storage early >40 GW/year, in time approaching today's installed electric generating capacity. Maybe flowering green growth. Cheaper batteries are a hardy perennial globally – lodestones for intermittent renewables & EVs. Their capacity capabilities may soon go from <300 Wh/kg to >400 Wh/kg. "Made in U.S.A." should = good-paying jobs. Solar manufacturing capacity fast to 100s of GW/yr. Yet scary climate scenarios still show need for enormous 7 TW of solar PV to be installed globally, fast.

There's precedent for green stimulus. U.S. 2009 ARRA package boosted climate-friendly sectors by $90 billion of then $800 billion. That helped triple U.S. solar/wind installs, grew U.S. clean energy jobs from a few hundred thousand, to 3+ million. Today in Europe a Green Deal, and maybe carbon tax are being shaped. Although a 2020 U.S. CARES Act boosted jobs in carbon-heavy, older industries – a package in 2021 would potentially be far greener. Costs reductions here are unlike oil or coal. For once renewables *achieve great cost declines, they hold onto & grow farther still;* they are stickier, sustainable and welcome.

Pandemic/s mustn't take our eyes off a 'climate solutions' prize. A Juggernaut that was clean energy Q4 2019, throttled back Q1 by Covid, returned 2020. Economies prostate on backs, may be revived. A focus on climate & CO_2 was diverted by Covid, demand for clean energy lightened, solar & wind auctions waylaid, credits incentivizing solar/wind only just renewed; no one knows if/when global economies may regain prior confidence. Economies may yet crash again – and volatile ECO can always once again drop like a rock! Yet, it's becoming known too solar & wind like new batteries may thrive on no subsidies. Same can't be said of dirty energy requiring vexed fuels – on brittle supply choke points like Straights of Hormuz. Nor of costly nuclear power, seen nowhere without immense government support. Climate risk and pollution & their high costs now bedevil all the fossil fuels like never before.

As repeated, a key turning point start of 2020s, is renewables are often now increasingly *the most affordable* choice worldwide. With that change, conversations can & should now shift. Fossil fuels no longer cheapest option. Climate change, increasingly, accepted fact. This decade U.S. energy *may* pivot towards carbon free grid by 2035, saving money to boot. It's now feasible! We'll look at freshening possibilities next. This *may* be a transformative decade in the U.S., Europe, and Asia. Let's start with the U.S., to envision possibilities:

These go beyond what was even lately thought possible.

Assume that climate science is correct. If so, we all must act far faster – cutting CO_2 emissions by ½ by 2030, to then see 'only' 1.5 degrees C of ravaging warming. Yet we're nowhere close to near-term 50% cuts! Actual trends in 2021 go weakly, languidly to 2050 before seriously decarbonizing. That's much too hot a world while progress arrives much too late.

Instead given action is needed in 2021, key is plunging solar, wind, & energy storage costs *immediately change everything*. A U.S. grid with 90% (in our case, 100%) less CO_2 is not only feasible, it can be reached in 15 years – with *cheaper* electricity. Competing analyses differed on last pieces of 100% zero-carbon puzzle. Beyond 90% is small and as models *agree* on 90% – (using 100% here), this 2020 Report blueprinting how to get there from U.C. Berkeley is very important. (So too, Dec. 2020 Report, Larson et al, 'Net-Zero America: Potential Pathways, Infrastructure and Impacts', Andlinger Center and High Meadows Environmental Institute. More Reports coming! We'll cite here from this 2020 Report from U.C. Berkeley.

It shows how near carbon-free can be achieved swiftly: within 15 years by 2035. Retail electricity costs in 2035 may be 10% less for consumers than today. Past assumptions got it wrong on how hard (not very) - and how costly (it saves money) for this cleaner U.S. path.

Remarkably, eliminating CO_2 is a 'no-regrets' path sensible in its own right, better than status-quo No New Policy, with cost savings. This "2035 Report: Plummeting Solar, Wind, and Battery Costs Can Accelerate Our Clean Electricity Future" (2020), https://www.2035report.com – has a companion Report, "Rewiring the U.S. for Economic Recovery" from Energy Innovation. Their conclusions interestingly differ sharply from reports seen just 8-10 years ago, that once had foreseen carbon-free electricity as adding much new cost. Instead, now:

> "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."

This study allows use of all known 'zero-carbon' generation options. As expected, a focus is on the cleanest: solar, wind, energy storage; yet baseload big hydro, geothermal, biomass, and even nuclear could be permitted. (As in theory are fossil fuels with carbon capture/ sequestration – but least-cost models do not include new nuclear or sequestration). In contrast to this Zero Carbon path, is a No New Policy of mere state & federal trends status-quo. That latter model reaches only 55% clean by 2035. So it falls way far short of what's required. Crucially this clean plan means reliable, firm power fully dispatchable, as needed. It will thus meet all demands, every hour of each day; there's no compromise on performance.

To reach this (near) zero-carbon target by 2035, annual U.S. deployment of U.S. solar & wind must notably double/each year in 2020s, triple historical bests 2030s. This rises up hard up from 15 GW of solar installed in 2016, and from a 13 GW of wind installed in 2012.

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

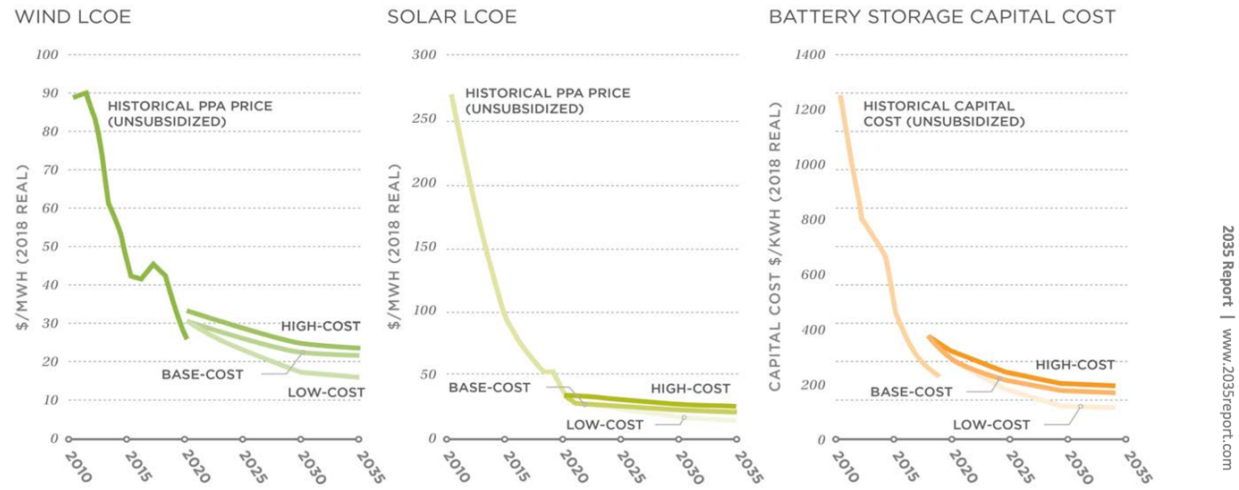
Only modest new transmission or spur lines will be needed to interconnect this expanding clean power, so a less pressing need for costly, long-to-build intergenerational lines. No imposing demand to overturn grid infrastructure, requiring long lead times. But what does change, is the composition of both generation and storage over a fast-arriving 15 years.

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

Second, *no new* U.S. natural gas fired plants would be 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 to zero.

Since gas-plants pay for fuel, reducing their use helps achieve 2035 wholesale electricity costs *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.

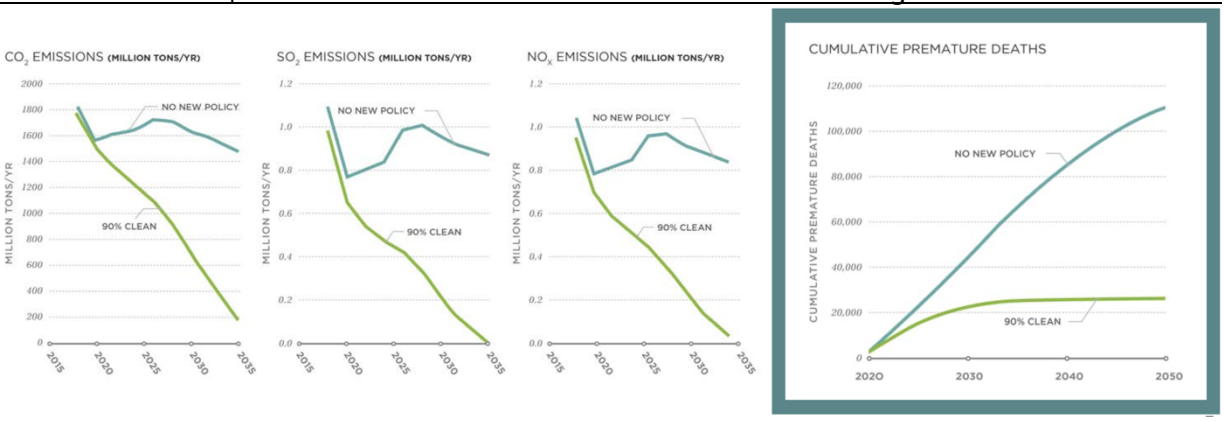
<u>Dramatic Declines in Costs Have Arrived 2020 Far Sooner than Expected:</u>



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).

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 might assume solar for instance needs warmest climates, but in fact solar power does quite well in freezing settings - even say, at Poles and literally space.

Electricity in this model is made by solar for less than 3.5 cents per kilowatt/hour (kWh) in these places shown here in yellow/green: thus most of the U.S. Wind power similarly is made at less than 3.5 cents kWh 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 begins to wonder 2021, if even this projection is off; 2035 renewables getting cheaper!)

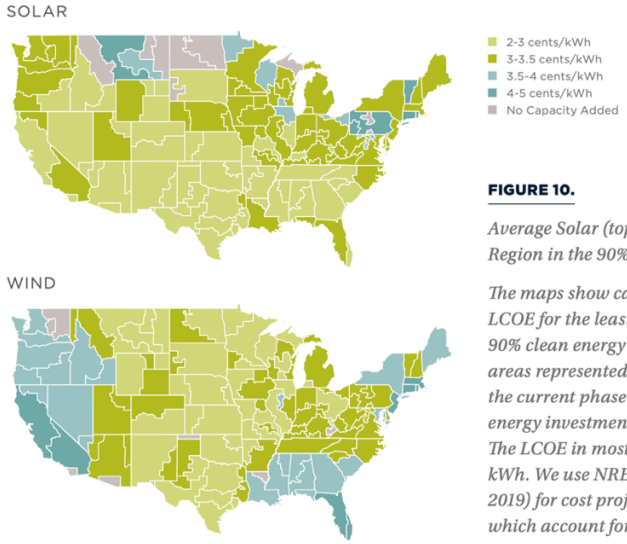


FIGURE 10.

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.

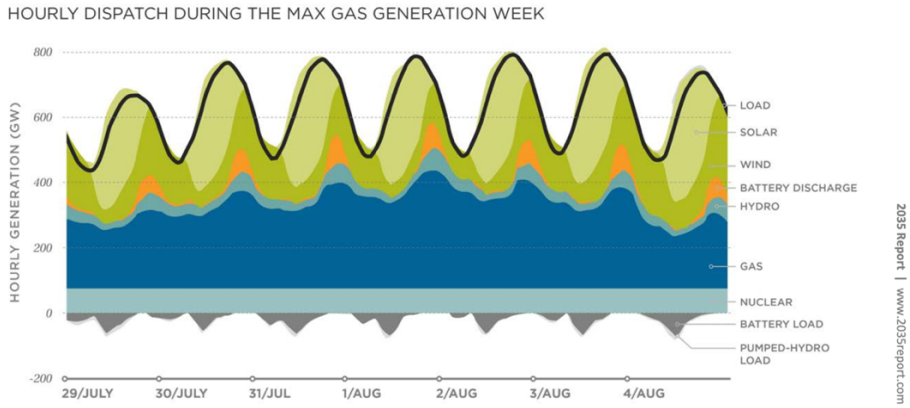
This Plan is so different from what's seen today, one may naturally ask: How is this done? We know solar is binary: every day it makes zero power all night long. So what happens as high demand in evening hours – overlaps with little wind – drastically curtailing output?

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.

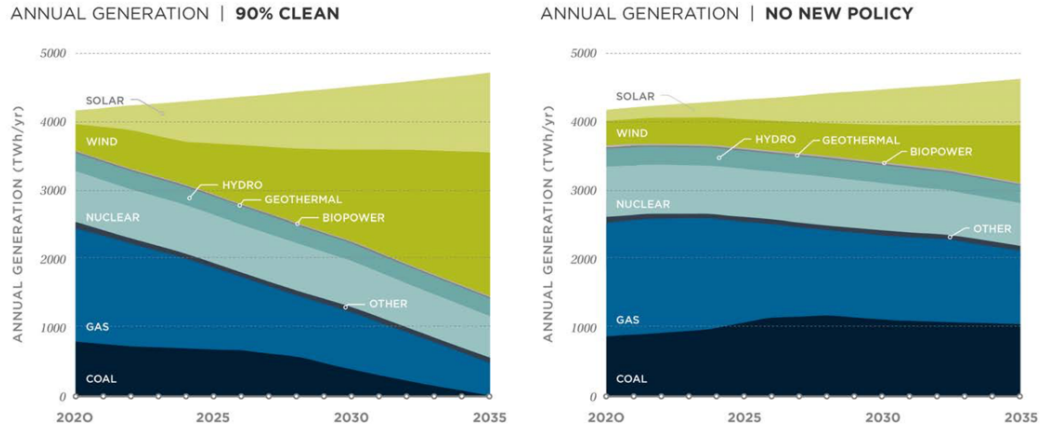
A Worst-Case Generation Period for Renewables: Still Moving Off of Fossil Fuels/Nuclear:



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 of new clean energy investment. An enormous sum, although less than one early COVID stimulus, and here with enormous positive benefits.

No-Regrets path not only lowers consumer electricity costs it improves human health and reduces damages - *without* considering climate change. Especially if one considers the impacts from say, sea-level rise over centuries, maybe millennia ahead – advantages can be compelling. (We briefly discuss some potential impacts of e.g. just sea level rise ahead).

Economics of retiring all existing U.S. fossil fuel power plants 2035, is far less onerous than one might have guessed. A December 2020 piece in Science, calculates that more than 70% of 2019 extant fossil fuel plants reach end of lifetimes before 2035, see Grubert, "Fossil Electricity Retirement Deadlines for a Just Transition" Science 1171 (Dec. 4, 2020).

So an old argument that beyond clean is too costly in terms of stranded assets of coal, and natural gas plants that have not yet recouped all their costs – is now much less relevant. From 2021 these simply need to be no longer built in light of storage + renewables.

Given renewables' intermittency and their range of outputs, there's another side to this coin: they do at times generate Far MORE power than immediately usable. At times electric power prices even go Negative. It's not a disaster for clean energy - like it was for fossil fuels when oil prices went negative – everything possible then done to get oil prices back up in 2020. Instead, it is here a *feature* of the clean renewables system – and one that really ought to be taken advantage of. Happily there's many ways to do so ahead. Batteries are sensible & on track: maybe new single-crystal cathodes, perhaps silicon nanowire anodes, etc, etc.

This 2035 Plan has so much solar & wind built that 14% 'surplus' renewable power is curtailed/ shut at times. Consider then: it could also be stored in many new ways. Ponder hydrogen (H_2). That *still requires breakthroughs* to be cost-effective. Physics presupposes if one has made electricity, to be used immediately, it makes little sense to lose efficiency by electrolysis in converting water into hydrogen for long-term storage. One incurs then further loses again converting hydrogen back into electricity later, via fuel cells, or by combusting it.

But: if a unique situation presents itself: free green electricity, that alters this equation. If sun shining & wind turbines spinning make excess power, it must be used or sadly curtailed as prices go negative. It is a case for green H_2 be made renewably, no CO_2. Clean zero-carbon hydrogen - unlike H_2 from reforming natural gas/CH_4 is costly, yet it has been mused about for decades. For an example, http://h2fuelcells.org; or in a piece from 20 years ago, see e.g. R. Wilder, 'We Need Clean Hydrogen Soon'. Engineering News Record. 244/59 (May 8, 2000); also: Wilder, 'Develop Eco-Industrial Parks'. ENR (June 7, 1999). In Europe, standard dirty 'grey' H_2 from gas may cost around $1.5/kilo, while far better clean green H_2 might cost more than 3, 4, or 5 times that. Plus a vast hype about hydrogen has clearly spiked up of late.

Hydrogen is fiendishly difficult to handle, it is unwieldy, an uneconomic energy carrier, a tiny molecule vexing to store, transport, embrittles steel, and it is tied to dirty fuels. Pile uneconomic H_2 atop uneconomic fuel cells, especially if solar & wind are now least-cost power - and no wonder many aptly call these 'fool cells" – and makes a case too for a passive basket, like an Index. So there's some hype about green H_2, energy carrier that;s a ways off. But… if green electricity is ahead 'near free' – or better yet if one is paid to split water to make green H_2 – it's a new ballgame. Sunny, windier hours of excess power making green H_2 can time shift surplus to windless nights. It could then be used to create high temperatures too like in making steel and cement. In sum, on the will plus - abundant renewables and negative prices - *and with needed breakthroughs in both H_2 & fuel cells,* then much may be possible.

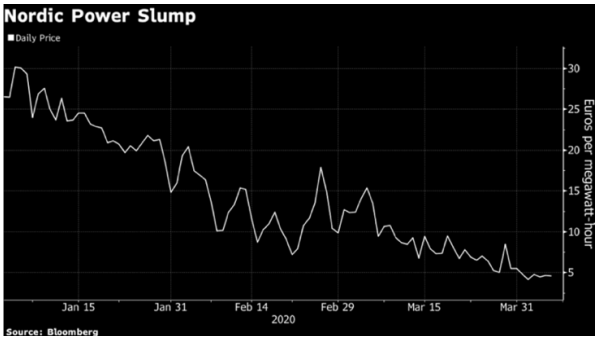
Moving on, let's recall *applied* clean energy in 2020. Cases where new renewables prices can and did drop swiftly – happening good snowballing ways (unlike in oil). So we'll note here 1st that Solar Power cost hit a Record 2020 Low cost of *only 1.35 cents per kilowatt/hour* at a big 1.5 gigawatt solar farm going up in Abu Dhabi! True, it's in excellent solar circumstances, desert for instance. But there's great deserts in Western U.S. too, and 1.35 cents is cheaper than any new U.S. coal power, today, tomorrow, or in short ever. New solar power for about a penny, is less pricey than new natural gas too. Frankly, no new fossil comes close.

As a practical matter, consider 2 renewables when joining together in a world-leader, say Sweden. There clean energy tells a 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 (just like hydro, solar, geothermal) can in good circumstances, heartily underprice costly non-renewable, firm, nuclear. That wind farm owned by a Dutch Pension Fund consists of 80 large turbines each rated 3.6 MW, for together near 300 MW of installed capacity expected to annually make 900 GWh. That's big – but certainly not huge. 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. (Most places on Earth could use myriad untapped renewables even if they're inexplicably being ignored; blowing winds onshore and/or offshore, often good sunlight for solar power, or geothermal potential, maybe run of river for smaller hydro too that could be much better than limited 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 wind farms are capitalizing on windy days – plus good hydropower conditions – then together they make good use of all 'free'. Such increasingly crowds out fixed fossil fuels, & the nuclear plants that must pay much for fuel and operations. Costly, rigid, risky nuclear moreover must pay too to store its toxic wastes long after closed. An upshot was that electricity prices there start of April 2020 were hitting welcome new Lows. Were there say a fleet of electric vehicles as required ahead in California – with Vehicle to Grid (V2G), then future fleets with EV batteries could also store/sell that cheap surplus electricity too, to be released as needed into the grid. It might earn a nice sum for many car owners.



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

Yes, of course, renewables are intermittent. There's not always a blowing wind, nor seasonal rains for hydro. Such times other renewables may be tapped in theory. For instance geothermal might possibly grow more common as firm power. Especially if oil rig counts drop on cheap crude, geothermal may become more attractive. Idled oil drilling capability may be harnessed, helping accelerate geothermal as baseload. Capital is what's needed; geothermal can need deeper wells, wider bore holes; it is costly upfront vs solar or wind.

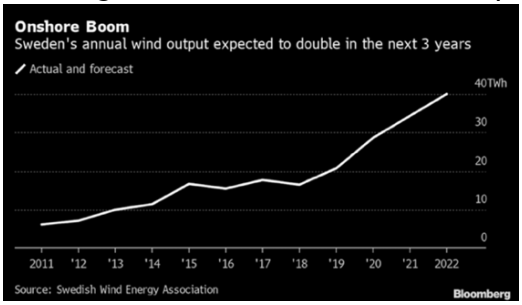
U.S. big Oil hasn't before looked very much at such big renewables projects. But if oil stays long near $50/barrel, renewable projects could rival $$ returns in a new oil field. Geothermal is costly now – maybe 3x or 4x more-than wind/solar. But geothermal is firm power and build-out utilizes skills well-understood in oil/gas: how to drill holes deep into the ground. In time geothermal might grow more affordable. This is especially relevant say in California, where major ~10% firm power supplied by 1 nuclear plant – is soon to be removed.

So a natural situation in Sweden is exacerbated in a good way, when windy days coincide with high-hydropower output. These charts from Bloomberg New Energy Finance (BNEF, prior longtime partner on global new energy innovation, NEX Index) illustrate nicely how daily wholesale power costs in Sweden were driven down "naturally" 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.

To local industries seeking low-price power, big hydro is welcome. Sweden's mills, smelters, miners, aluminum manufacturers are energy-sensitive. Big hydro is a static source, potential capped, limited to big dam-able areas with huge ecological burdens. So recently wind power has entered in a 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 midst of a wind boom.

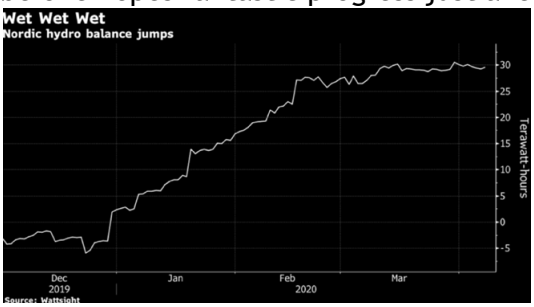
Indeed Texas may have added 2020 as much new wind faceplate capacity, as past 5 years. Solar there is jumping from 3,800 MW to 21,000 MW in 2023. This U.S. renewables leader has 29,000 MW solar & wind; large-solar may soon beat a 13,000 MW in California. Texas' ERCOT queue 2020 had 77,000 MW contemplated; that's 13,000 MW each of solar/wind in its queue, a portion of which may be possibly built. Little wonder when the wind power there in Texas can be generated as low as 2.6 cents per kWh in 2020. Here's booming Wind in Sweden:



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

Because wind, solar, hydro enjoy free fuel, they can get *very* inexpensive (painful to a Utility, bonanza to off-takers) in abundant times. Combine hydro with abundant wind, & solar, and the benefits snowball. Clean power potentially gets very inexpensive (below zero!). Given fast-declining costs, it's credible that China too reaches its peak CO_2 very soon.

More dauting than Sweden, is China's newest aim of "carbon neutrality" (if not tougher "climate neutrality") by 2060. Costly nuclear may ramp a lot (maybe too not-desirable 'ugly' CCS, though it makes coal 4x to costly!) – while better green energy storage must rocket up greatly. Intermittency is an issue. Solar yields zero at night predictably; less forecastable it drops hard on clouds. Wind is best windy days obviously. Hydropower too requires dimpled landscape, snow/rain; some seasons there's less precipitation (run of river micro-hydro ecologically far less burdensome than big hydro). We are in very early innings, and there's to be one hopes fantastic progress just ahead in 2021 with renewables like in Sweden:



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

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

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

At that time, 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. The 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 were unusable to many in that tough time, so happily became liquid cash payouts. Developers were allowed as much as 30% of project costs, instead of as tax credits. 2009 stimulus helped prime a pump that next decade for growth since. Also of help, at start of that decade was a U.S. SunShot Initiative, which reached its end goal early helping make solar much more competitive vs. dominant dirty energy. Consider that in a decade since Recovery Act, the U.S. solar power generation capacity has 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 arenas. 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, U.S. and elsewhere. Profit margins dried up. Many legacy firms couldn't keep up. Chinese firms enjoyed low costs of capital, cheap labor, often free land, less environmental regulations. Local governments were glad to see big employment gains these factories brought. Solar costs, pricing & margins plummeted.

Germany did ramp installations in 2010s. 2012 alone it placed 7.6 GW of solar panels. It with other European nations like Denmark also embraced wind power. Thus by 2013, subsidized wind power reached cost-competitiveness in many places, with coal & gas. Where winds are plentiful, the equation grows *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 & U.S. 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 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 clear 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 U.S. 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 slashed jobs in U.S. clean energy - as in other industries and nations. March 2020, 100,000 new unemployment claims were filed in the U.S. 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 the grid, storage, and cleaner fuels. It looked very bad Spring 2020.

First part 2020 there may have been 600,000 clean energy jobs lost in the U.S. Yet as will be discussed, far greater losses have been seen in coal, and in oil. There, things are far worse. Coal now is a shadow of its former heft – due to mechanization brought in by that industry itself – and not by any clean industries. Here, in clean energy, there was waning consumer confidence Q1 2020 meaning residential solar cancellations, caution at Utilities, auctions halted on fresh wind/solar projects. That said, Q3 2020 and then Q4 were better - and perhaps far side after this pandemic – if reached, that could possibly bring much 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 such total re/views, encumbered inertia and old-ways of thinking can allow the 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 gave come down to less than half the cost of nuclear power (and nukes still have centuries of costly toxic waste to dispose of). Thusly are renewables preferable to even once-cheap King coal. At times lower than 'cheap' new natural gas. Issues are shifting to energy *storage* - for 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 this fact of 'free' solar/wind. Especially as solar & wind only get cheaper. Take solar cells, built soon using more wavelengths. On group III-V semiconducting materials, more solar output is captured than cells today. 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 since 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 entirely new possibilities over years ahead. Solar getting (much) cheaper still…

In reality the Paris Accord's so-called targets are not close to being met, whether or not we've signed. Rising CO_2 hit new records in 2018, 2019, 2020 etc. The peak in global CO_2/ greenhouse gases aren't expected in a soon-year. Not by 2023, 2024, nor 2025 - despite flowery aspirational words to contrary aiming for 'just' 1.5 or even 2 degrees C of warming. Blowing past the hopes of Paris is a certainty.

1H 2020 did bring some inspiring wins at margins. First half 2020 Ireland's slice of electricity made from wind surpassed all other sources, including natural gas. Wind turbines met 43% of Ireland's demand – vs. 41% met by natural gas. Spain, looking too to its natural blessings turned on Europe's largest solar farm, 500 megawatts (MW) of power for 250,000 people. In May, a bigger 690 megawatt U.S. solar farm was approved in Nevada powering as many people (since Americans consume more); notably it includes 380 MW of battery storage.

But things are bleak on CO_2. Coal remains a worst carbon source, with hundreds of new coal plants being built, in 2020 across Asia. In China and in India, coal is still a cheap and leading main fuel given lax rules. Given that laxness, coal power can cost 30% less than renewables. Solar & wind are growing cheaper in China, and maybe will beat coal 2026 in wealthy regions. That said China remained in 2018 heavily dependent on coal (and on big hydro) for some 83% of its electricity mix - vs. growing wind and solar but that were still only 7%.

In 2019, coal capacity in China grew a staggering 37 GW, "more than the whole world" - for while coal was being shut other places like in Europe, U.K., and the U.S. - enough permits had been granted in China to potentially expand coal by about another 25% more.

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.

Besides coal going up in China, & in India, wealthy-Japan is set to burn coal for decades. Look at Japan 2020: in 5 years it might build to 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 U.S., annually. Even Germany still gets ~33% of its electricity from coal. While renewables are at least 40% there, it ok'd one (final) coal plant June 2020. Many plans in Europe to shut coal are being brought forward, shuttering sooner now in pandemic – but that's not happening everywhere. It's all a tremendous current to swim against - if one aims not just to *slow rates of growth* of emissions – but absolutely to *Cut* the total CO_2 concentrations in the atmosphere.

There's a Paris Agreement. Yet wealthy Japan set itself a very low bar, aiming for a meager 26% less greenhouse gases by 2030, than 2013. Even that's merely a goal. Coal makes up one third of Japan's power, and by 2030 it expects coal to still be ¼. Renewables, 10% of its power in 2010, in 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 is uninspiring. While clean renewables could become the cheapest 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 today. And its renewables are dominated by non-optimal, big hydropower. Plus it is exporting bad practices; only China gives more finance for coal plants overseas. There's airy talk of course, of so-called 'clean coal', always in future, and a concept that's never been real.

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

In Europe, carbon credit costs jumped 70% from March 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 can even *lose* money selling coal-fired electricity. Natural gas on the other hand, is relatively a bit less filthy, it 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.

It makes sense: global average solar PV costs 2019 were 6.8 cents per kWh; onshore wind just 5 cents per kWh. Average solar PV costs continue to fall; soon maybe under 3 cents. So beyond China & India (less burdened by environmental health and safety rules letting coal become cheap, renewables are making great progress. Ironically China's advances make renewables far cheaper today. Beyond a Petrostate, it may become in future be an 'Electrostate'.

Confronting us all, is the fact Earth doesn't care about renewables' growth initially small, and in rich nations. And we oughtn't pretend coal's impacts on us alone, are all that matters. As air-breathing mammals we see only the terrestrial impacts. That's a mistake. Earth's surface is mainly oceans: their health is declining fast. Skeptics who may question links of CO_2 to warming, have no ground here on which to stand. For oceans' CO_2 uptake is undeniable; rising CO_2 concentrations in air equals acidifying seas. Devastating harms ahead for reefs, for kelp forests, fish populations, shellfish, marine mammals, more. Marine life, once weakened by acidification, then stands lesser chance of surviving marine heat waves.

Ways shellfish for example calcify to grow shells from surrounding seawater are understood. Hence it's perplexing to consider we know how acidification lowers pH, doubtless enfeebling species essential to ecosystems, *yet we care not a bit*. Shells getting too thin, accreting calcium from seawater too difficult – likely means tipping points, catastrophic collapses. Naturally perturbated places with more 'acidic' waters like nearby volcanic seeps, both fish and habitats are negatively impacted by CO_2 levels only a little above that today.

And then there's warming. Post-2050, deep seas may 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, yet 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 only 5 years, to 2025 at today's rates, before we're in big trouble.

It's why distant vague promises about 2050, are absurd. Levering down now is vital.

We know from the scientific perspective that major threats to oceans include: climate change from CO_2 & greenhouse gas emissions, overfishing, non-point source pollution, habitat destruction, acidification – all harm marine biological diversity. Each presents as a daunting problem to overcome. Each is so locked-in. Difficult to resolve, to protect the oceans.

Seemingly most intractable, most vexed, hardest one of all to remedy: is CO_2 & climate. So it's surprising: the solution here is economically/ecologically sensible – and saves money!

This key answer of course is clean renewable power. Solar power shining brightly (another option blowing in the wind just overhead, wind's story). The question is, how to get there? What will it take to power the entire world, off of mainly clean solar and wind power?

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

In short solar manufacturing capacity worldwide, 2020, was less than $1/10^{th}$, maybe $1/100^{th}$ where we need to be in building PV panels fast enough. In 2020 we made a little over 100 GW/year. (Better looking back, than a 0.250 GW in 2010!). We've seen PV manufacturing is a low-margins commodity business. After a decade of consolidations wringing out excess capacity, solar 2020 was profitable, and 2021 is getting cheaper all the while growing.

Early 2021 roughly ~9 of every 10 panels is being made in China/Asia. Now the planet's biggest solar production plant is going up in Anhui Province, China: it alone with capacity to make 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 get to on CO_2 2035, it's a (small) start. It's a beginning… yet wildly small if we aim to make ~60% total global electricity from solar.

Consider: without vast ramping, current trends global capacity makes just ~400 GW/year ahead of PV. Incrementally that increases global PV installed capacity slowly. It grows, but far, far too slowly. On those economics, taking too many decades to get to that 60%.

Given where we should be due to CO_2, past PV overcapacity, overexpansion are less an issue. Solar had *needed to become* world's cheapest energy! It has. Now arguably we'll need to see major Policy Changes that allow much fasted ramping. It's a hand that CO_2 forced on us all.

We stand 2021 with nowhere near enough installed solar, nor the manufacturing capacity / factories needed to vastly ramp new PV fast enough next 5 years. Policy changes are needed. In 2020 China had world's most existing installed solar capacity at just over 200 GW; European Union was 2^{nd} and growing at over 130 GW; US was third at just over 75 GW etc.

Starting from so little installed solar capacity – PV manufacturing capabilities may get far bigger, fast to hit 60% of world electricity generation. Because of climate, ramping may 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 the 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 a number of important observations and reach notable conclusions.

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 challenging conventional wisdom worth unpacking. Start with a latter one: that moving quickly towards decarbonizing costs *Less $,* than the status-quo of incremental additions of solar and wind. Partly on renewables being cheaper; their 'Leaders' scenario shows greenhouse emissions fall 60% (from 1990) come 2030 in 10 years – reaching zero in 2040 (a decade ahead of 2050). By contrast, a more incremental approach of past conventional wisdom has Europe reaching only 53% emissions reduction by 2030. And this Solar Power Report here assumes no nuclear power, not due to risks, but on its high costs.

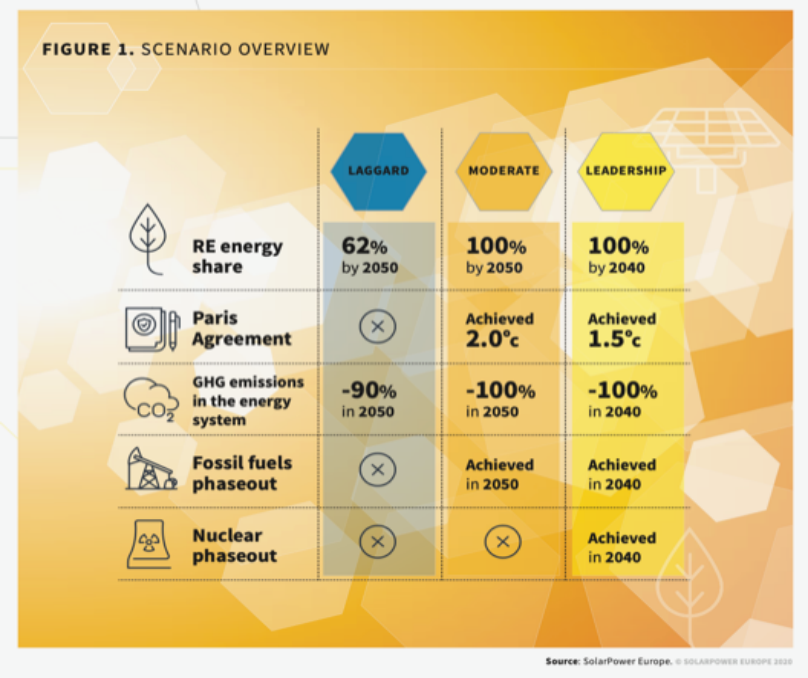
This Report recommends that policy makers immediately begin creating a new framework targeting installed 7 TW of solar power – and 1.7 TW of wind reached well before 2040.

That involves 2 factors: starting the upswing now soon as possible – and growing PV manufacturing abilities harder and faster. Given the CO_2 pressing issue, we may need to build 100 factories worldwide, each one capable of make ~60 GW of PV like that factory going up in 4 stages in China. Ramping up to around that 7 TW of solar 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 had ramped greatly its 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, by 2.5+ ppm/year. That number is only growing, accelerating.

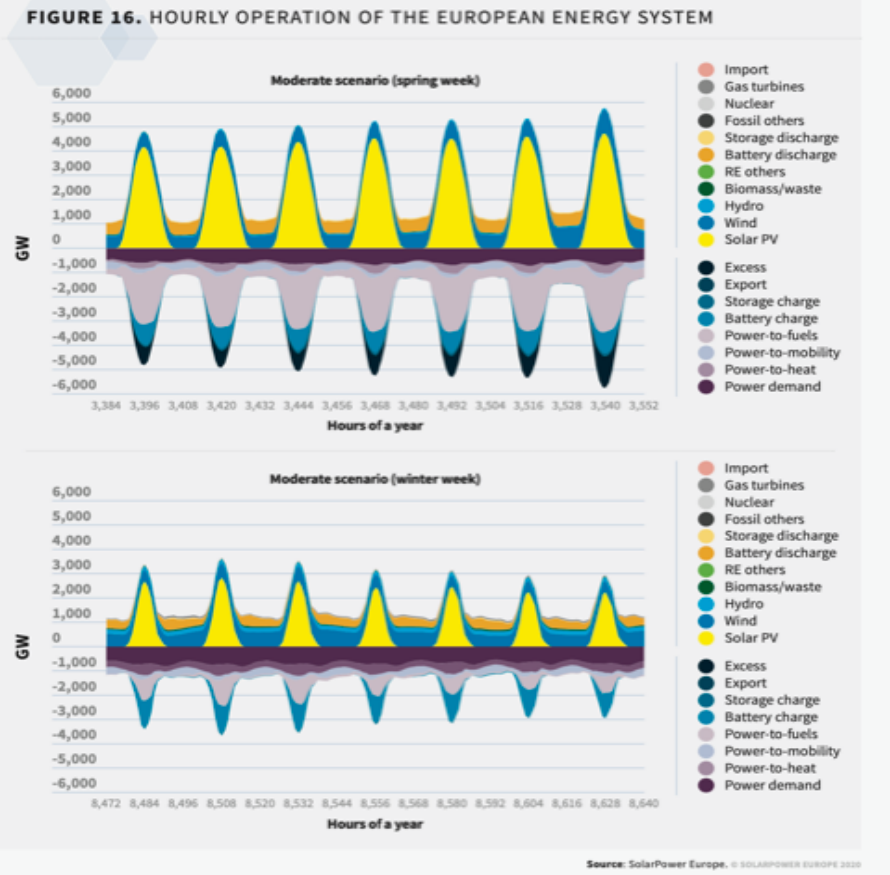
Their 2 good scenarios present a more Moderate level – and a Leadership level going quicker. Former achieves only the 2.0 degrees of warming goal under Paris, the latter achieves the more robust better 1.5 degrees goal. Again, it's a matter of when ramp begins, and angle of departure. But interestingly the stronger the action, the more $$ is saved over time!

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

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



Source: Solar Power Europe 2020.



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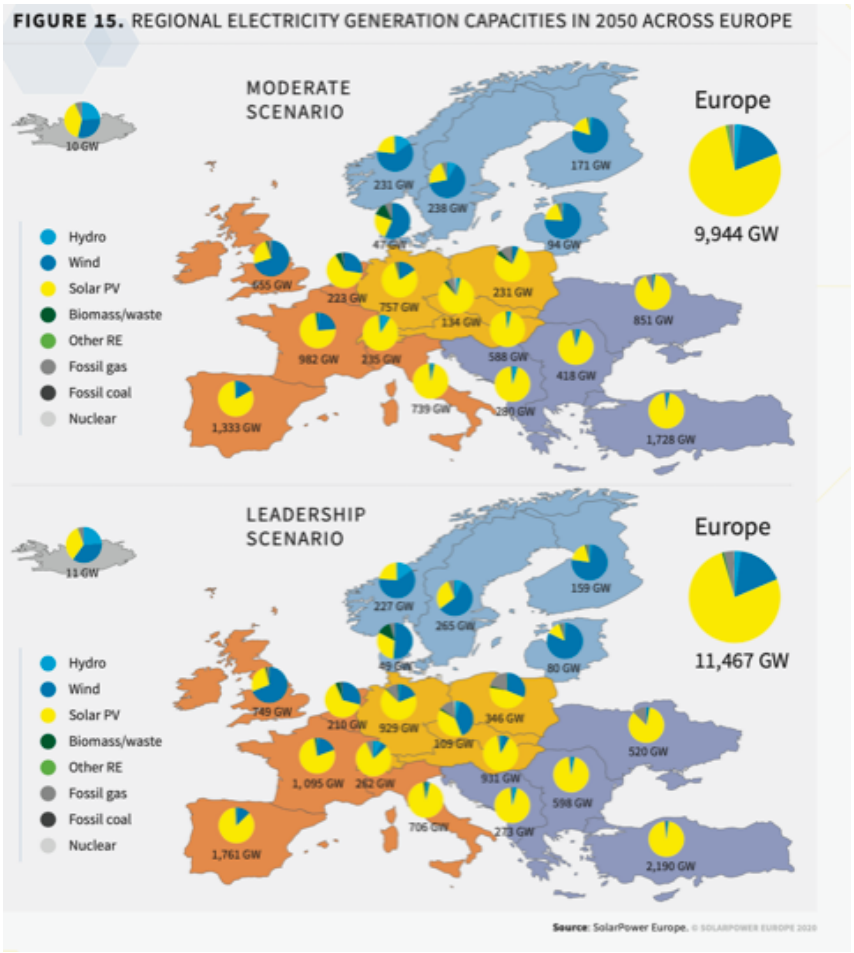

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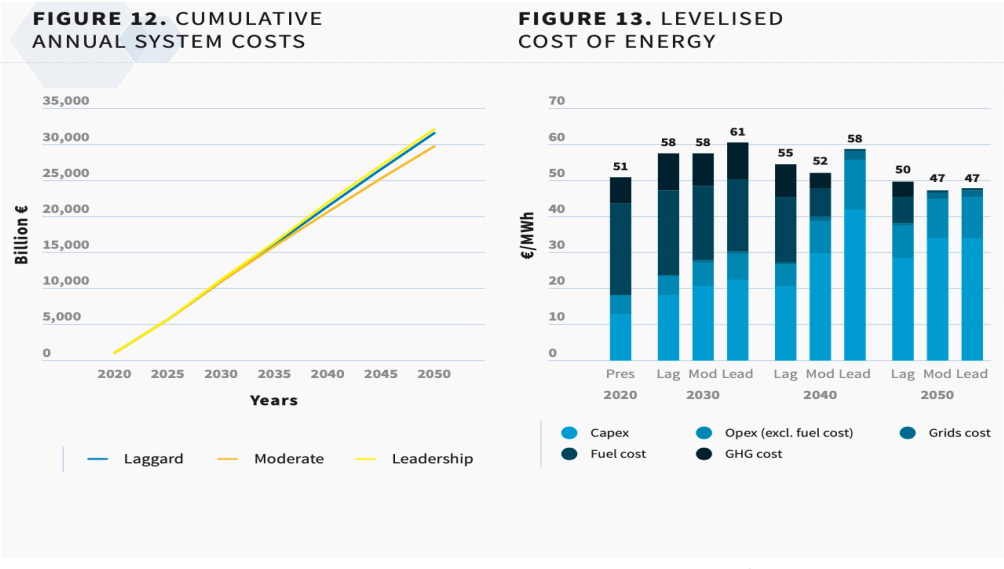


Source: Solar Power Europe 2020.

What may lay ahead for solar 2021? From an equities standpoint, as always Nothing's certain. Notably there's been far fewer Analysts last decade in clean/sustainable/decarbonization, than in areas like oil & gas. That may change, ahead! Over a decade plus, we've at times cited excellent Raymond James reports. Here similarly, is brief excerpt too from a very good report by Philip Shen et. al. Roth Capital Partners, from 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.

….

Given how renewables above, uniquely thrive on ever-lower prices – we'll contrast that next, by looking instead at **Oil** over a remarkable Spring of 2020. Oil moves *very differently*.

Major Crash of Oil in Spring 2020

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

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

Normally on slightly slackening demand for some reason, supply could be slightly curtailed, excess stored and so mopped up. But instead, Saudi Arabia & Russia had *ramped* production up wrestling for market control. One an important day, March 9th, crude prices plummeted by -30%, the greatest one-day 'fall off the cliff' in oil for roughly the past 30 years.

In March U.S. benchmark West Texas Intermediate (WTI) crude fell by -60% in an historic drop, from $60 to $20. A big factor was that Saudi/Russia ramp; but greater was that *demand* was dropping tremendously by -25% or more as world economies halted. A fear come Ides of March was that 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 under $30 is a threat to America's oil industry, including the shale and conventional producers. From the huge to tiny, it's a diverse lot and all felt pain. Texas some has 174,000 wells with most every imaginable kind of rig – some are curious sites hard to believe. So latter Q1 2020 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 for the indebted shale producers. But oil then near just $20 at that point was likely going lower due to demand destruction. It could go briefly below zero some places, or due to volatile futures contracts trading. Storage was filling, nearer tank tops, so fixes badly needed as a bridge until activity bounces back.

Now, May front-month WTI contracts would expire late-April. So on 25% less demand, if not met by great production cuts, fears grew of tank tops, like in landlocked Cushing, OK. May contracts would then 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 temporary artificial move, as a matter of finance wasn't really a great surprise at all! And not too much should be read into -$37 close. Contracts many months out were better, less distorted picture of physical crude, than May contracts expiring as storage evaporated. But WTI oil near $20 still showed oil markets were in distress. Even global benchmark costlier North Sea Brent crude briefly dropped down to near $20 by late April – but never to zero.

Oil near $20 furthermore meant production would change worldwide. Perhaps 1 million oil patch jobs and expertise might potentially disappear. Rig counts were fast dropping, capacity tightening, wells shut-in, bankruptcies – many wells perhaps never (expensively) re-started. Maybe forcing U.S. 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 disorderly consequences greater than maybe initially expected.

Perhaps all put-down to the timing. In 2014-2016, opening spigots failed because in a thriving well-lubed oil hungry world, impacts were muted. Oil had dropped near $50 briefly. Excesses soon readily absorbed, not enough to kill off America's shale boom. And shale which did bounce-back strongly, put something of a cap on prices that WTI oil might one day fetch.

Here a playbook might have been a world awash in oil could allow lowest-cost conventional producers, to later raise prices, post shale bankruptcies. It's long been said the cure for cheap oil, is cheap oil – as seen again & again in this industry. Commanding market-share could then be re-captured by those able to lift oil from the ground most cheaply by conventional means. Once competing shale capacity was well-gutted, low-prices should disappear. Unlike then clean energy, where lower prices go lower, oil prices going back higher is what's sought.

With pandemic + tank tops and oil unexpectedly under $20, quickly reviving economies & demand thus getting oil back up was essential. Oil-wealthy nations might ideally seek higher crude prices nearer $80. Such might in theory allow them to better balance their own books and their own national budgets. But now, regaining firm oil demand came first. Proposed conventional big new projects are often uneconomic, without oil at least above $40.

Plus for nations it's important to realize crude's intrinsic vitality while richly valued. Vast underground reserves, if 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 an ascent of electric vehicles, or simply changed economics.

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

So it was in April that OPEC+ with Russia agreed to a production cut of 10 million barrels/day. With 25, even 30 million barrels of demand gone – cuts really could have been more. Saudis in agreeing to the cuts understandably felt fellow producers should do so too, reducing their own production. And Russia understandably felt U.S. by 'organically' cutting – that is, just producing less on low prices – rather than cutting capacity, was as different as width from length. Given that 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, called proration, it's not an option. So with a wink and a nod, Saudis & Russia agreed to a 10 million cut. And even that unprecedented big move, was just a (necessary) patch-up fix. It made headlines. Concerns among technical oil-watchers were it was 2x or 3x smaller than it needed to be. Plus it didn't start until May, so it was pretty-much no surprise in April when in local cases 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 perhaps 25 million barrels/day suddenly no longer being needed. But it was expected demand would rebound. And the WTI Index and landlocked Cushing fears, proved not as useful as Indexes like for Brent Sea Crude (staying positive with $20 bottom) – and new Indexes like in the UAE.

It was about making it past the immediate crisis, and re-starting oil demand. Crude might then rise organically. Free markets are how U.S. oil prices work, rather than fiat, and paths were envisioned to stimulating rebounding. If say U.S. States begin re-opening and Covid-19 still-potent is increasingly endemic more like a seasonal virus; if immunity gets conferred even if only for a season; if effective treatments arrive, or better yet a robust vaccine for Covid-19+new variants, there were thus hopes for some return to demand normalcy.

A fascinating side effect from plunging oil, was that coal – long the dirtiest/cheapest – while still the dirtiest – had just become most costly. Fracking long ago pushed down natural gas prices wildly, seen in charts above. Natural gas -90% cheaper became very attractive for making power and unsurprisingly, one after another U.S. coal power plants had closed.

Thus when benchmark Brent crude fell in Q1 2020 to around $26/barrel, Australian coal sitting at $57 /metric ton, roughly equivalent by analysis to $27 oil, broadly-speaking crude went cheaper than coal. True coal vs. oil don't directly compete. Thermal coal is burned in power plants – unlike light sweet crude for gasoline, heavy sour in asphalt. Natural gas alone wasn't taking market from coal. As levelized solar & wind costs fell, they became attractive vs old coal. In sum, dirty was becoming much less desirable, and relatively costly too.

Surest path to oil rebounding is that economies revive, demand returns, and production cuts linger to eat up slack. Oil's fail had drawn uncomfortably near, which might have upended more in the oil patch. A key hub, Cushing's 4 huge tanks nervously filled. Pipelines that normally forward crude, had slowed more to like storage: that could have meant a kind of oil constipation backing-up to producer. Had 5,500 miles of pipes sending refined product Gulf Coast to mid-Atlantic stopped accepting gasoline, no contracted-buyers as product off-takers, a fascinating and scary April, might have yielded to a much different June 2020.

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

Throughout, clean energy was hardly (for energy) affected by oil's demand crisis. Instead, to growing its energy storage and renewables fast enough, was a much different issue. Storing electricity is simple if little is needed; push water or weights high, release as power is needed, inject air into caverns etc. Vast amounts needed, means ever more vital are 'million-mile' (or 5 million mile) batteries, infrastructure for innovative flow batteries, H2, etc etc.

For immense scale of what's needed, consider one U.S. leader: Texas. It recently had 5.5 GW of solar, still only 1.35% of the State's electricity supply; a healthier 17.5% came from wind power. That 5.5 GW of solar in 2019 is Only a start. Nonetheless were Texas a nation it would have ranked 5th after China (30 GW), the EU (16 GW), the 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 intermittent solar as needing to rise to say, 60% of all demand – given the sun only shines daytime and all those big Texas pickups will soon switch to more powerful pickups powered by batteries, and electric cars meeting new demand. That means very roughly a many dozen-fold increase in solar! A roughly 6-fold increase still in wind power. A new 1,300 MW (1.3 GW) Texas solar farm coming online 2023 is only a start. Energy storage needed, starting from scratch, is so enormous needs are not measurable by 'x-fold'.

Beyond oil's ride in 2020, another big trend stands out in an evolving energy landscape. One that needn't be 2nd guessed. Nor pondered, as mere possibility ahead, since it's so well along: *Coal lost a huge slice of the U.S. energy pie last 10 years.* As Yogi Berra said, "It's tough to make predictions, especially about the future" – and so let's glance instead backwards at a past seminal shift, a movement away from coal in the U.S. (like Europe) far underway.

In 2005, little thought was given the notion that U.S. coal could soon see dramatic losses. At that time 'King coal' had made up some 50% of U.S. electric power generation. Minor early gains (small in absolute terms, big percentages) had started in solar & wind – natural gas more so – but those then hit coal only incrementally taking coal 'down' only to 45% by 2010.

After 2010, though, U.S. coal dropped hard, down from about ½ to <¼ of American power generation. Renewables in 2020 (only) near 20% are rising, natural gas near 40%. Why, is easy. Fracking's revolution pushed down natural gas cost tremendously. For a power plant with 30+ year-life, natural gas doesn't suffer opprobrium so vexing coal. On ample domestic supply, it's embraced as safe & smart by industry. Gas became the easy choice. Dispatchable and firm power, less-dirty, with stable fuel-prices; it's widely popular and unquestioned.

What's perhaps more interesting now, is a bigger change just beginning to unfold. It is that lately, clean renewables are becoming this landscape's growing best bet. Now Energy Storage from 2021 is becoming fulcrum to really advance low-cost renewables. Especially with shut-in people & shuttered industry – zero-cost free sun & wind made renewables best poised to gain market share – even in a tough 2020 market period. In fact it was rather **due to, so because of** those tough conditions then with solar & wind (and gas) cheapest fuels, that coal got jettisoned, and prospects for inflexible big nuclear had dimmed considerably.

For retail power consumers, how electricity is delivered matters. Recall nimble Texas: some things there it does very well, on far lighter regulation. There's much more competition; 100% renewable power may be available at just $10/month – plus *wholesale* costs of power. Wind power plentiful at night can cost 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, around half from natural gas. Wind is growing, fast, but is around yet a 20% figure, like coal.

By contrast California is far more regulated, and its power is much more costly. In San Diego power may cost base ~$16/month (non-wholesale) plus big added costs time of use. Nighttime is great for electric car charging – similar to Texas a bit nearer 9 cents/kWh; but it fast jumps up to 29 cents for much of the day – and may leap to 50 cents late afternoon. So costs near 35 cents/kWh partly due to little competition and regulations. And as California imports much CO_2-laden but needed brown power especially in heat waves roiling the West, lacking enough energy storage, in 2020 there were rolling blackouts again in the Golden State.

In past Texas was maybe not thought of as clean energy incubator, innovator. Oil& gas, sure. But history shows Texas is actually open to a range of new energy innovations – and getting there on less regulations maybe puts it in more favorably vs. California. This decade will be fascinating with U.S. Midwestern States: Iowa (once world EV capitol), Oklahoma, Kansas, Illinois (including Great Lakes, East & West coasts etc) maybe wind powerhouses. Electric vehicles manufactured now around the country. And we're all building back better.

Consider CO_2: A Topic Gaining Importance

For 20+ years here at the 1st & benchmark Clean Energy Index®, our emphasis was *Solutions*. Not on CO_2, nor Climate Change *per se* – but helping to forward solar, wind, electric cars etc innovations where ecological & economically better. Warming's threat was a big driver - but CO_2 was hardly discussed. Lately however, science shows impacts are nearer worst ends of what models expected. In short, CO_2 matters, so let's address that science briefly.

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

Hence this brief excursion into climate as relevant to the wider clean energy story today. And consideration too of Environmental, Social & Governance/ ESG factors (especially the 'E'). First note CO_2 has been a hero to our species – in moderation. Earth without CO_2 might have had near 0 degrees frozen temperatures at surface. Instead, warming thanks to small CO_2 increases (much under 400 ppm) naturally gifted us with surface temperatures near an ideal for us, 59 degrees F. We evolved well to that in hundreds/tens of thousands of years.

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

In 1992 a global compact was reached. Signed in Rio this U.N. Framework Convention on Climate Change lacked specific cuts. Look back and that nebulous agreement to try to act was a real failure – nowhere close to task. CO_2 has continued on rising sharply. Rio only implied *cuts,* like calling for global emissions to be -20% lower in 2005 – yet instead CO_2 as it turned out only grew and by +34% *higher by 2005*. (Looking back it would go on rising another +22% higher in 2017). So mere aspirational words, absent real acceptance and robust action like was seen with COVID-19 in 2020, has woefully not achieved what's needed on climate.

So more specific cuts were laid out 5 years later in a 1997 Kyoto Agreement on climate. Yet CO_2 again went on rising, even more sharply. It was a mockery of 'action' on CO_2. An international agreement was again tried in 2009; that Copenhagen event also failed. CO_2 levels continued increasing, temperatures spiking up. In 2015 a Paris Agreement was roughly more of the same, CO_2 a uphill scary climb. Only 3 countries met an early target of the Paris terms: Marshall Islands, Suriname, & Norway, which made up only 0.1% of emissions globally. There's no cause today for optimism. A next gathering intended for Glasgow in 2020 was meant to take stock of progress (there's been none); it was postponed due to COVID-19.

In sum, commitment Isn't There. That's why it's crucial that 1) clean renewables are getting cost-competitive *unsubsidized* with fossil fuels; 2) there's growing public recognition of the Science, and 3) with COVID-19 we saw an historic oil crash making a decarbonizing shift from dirty fossils – to cleaner paths while creating jobs - more approachable worldwide.

Looking near-term decades ahead to early 2100, there's some good news. At intercomparisons of some 56 climate models, some most awful possibilities look perhaps a bit less likely. Barring say methane feedbacks, underseas clathrates, water vapor, or permafrost, and hoping for no other major contributions, then of these models, the scariest rises near 9 degrees F by 2100 *may be* less likely on current understanding. (Less than 9 F from here, since there's been some warming to now). Those models assume high fertility, widespread coal, and failure to strongly embrace renewables. Such models may be rather more unlikely at their highest/ worst-case ends predicting an (unbearable) 9 degrees F warming.

Yet if we regard that highest end Representative Concentration Pathway (RCP) unlikely, heavy CO_2 emissions in so-called RCP 8.5 - we should also regard lowest RCP 2.6 as even more unrealistic. It assumes widespread vigorous embrace of renewables that's already far greater than seen, and No coal; neither (especially the latter) is close to accurate in 2020.

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

Next 'lower' RCP 6.0 may be rather closer to where we're trending – on present 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, then drops only slowly since it accumulates). Coal plants would thus be built in Asia, as they are - but soon regarded as things of the 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 incoming solar energy vs. outgoing balance is in our Earth-atmosphere system. Consequences of that may be dire for our species over centuries ahead seems about what one may 'hope for'.

Next, better, and very ambitious is most hoped for RCP 4.5: emissions peak in about 20 years near 2040, then fall fast. Thus CO_2 levels not long ago stable <300, now past 400 & rising fast, in this scenario only go on rising to 'just' some 650. Strong decarbonization is assumed here to be undertaken, now, with CO_2 slowly dropping. That *might* be possible, although it's a huge stretch to be sure. And very unlikely. Especially since hundreds of new coal plants are *still being built, right now today* in 2020. Each may have working lives of 30 years or more, hence shall be operating in 2050 and after unless they are prematurely shuttered.

Since renewables make up only some 20% of electricity in many nations (although growing), coal still burned widely, cars mainly oil-powered, ambitious RCP 4.5 is a very unlikely bet. That said unexpected events like ice sheets destabilizing, might catalyze stronger action. COVID-19 and say, sudden events, could hasten strong and real action on climate.

Climate models, inevitably, are getting more complicated. Until recently they'd ignored e.g. ice sheet destabilization, seas melting glaciers from below. Yet if a big pulse of change gets visibly underway, then skeptics may melt away too. Especially when clean energy is the *most economical choice*, it creates jobs, it alone can go unsubsidized, and may save us.

Inertia: Even if Reaching Decarbonized Power Grid 2040, Climate Neutral World 2065

Lastly, let's imagine decades hence. U.S. & Europe helped by very low-cost solar from China, cheap renewables, energy storage, with great efforts had reached a 100% carbon free grid in 15 years, by 2035. Rest of world got there by 2050. Electric cars scaled up immensely, faster than a public expected! Green H_2 came to fore in industry. The richest nations were first to become fully climate neutral by 2045. China got there by 2060 meeting its targets, and then rest of world by 2065 although with excessive references to Earth's natural sinks.

That timeline, fairly ambitious, is absolutely do-able. Unfortunately, mainstream science indicates there's enough inertia in this CO_2 scenario, to possibly destroy much of the world's low-lying regions due to sea-level rise from climate change. It blows past 2 C Paris Climate goals (to say nothing of 1.5 C) and may soon place us some 4, 5, or 6+ degrees C hotter.

That's not alarmist: just consider where the science dispassionately points us. Heating that will grow over many decades, giving way to many centuries plus of sea level rise. It's possible such rise leads coming centuries to destruction of much of Florida and New York City. Inundation of large parts of the US Eastern seaboard, of the US Gulf Coast, parts of the West Coast. Indigenous peoples once lived in an area now City of St. Augustine, Florida founded in 1565, about 440 years ago. Yet we may be past its half-way point: that City, like say, lovely Jupiter, Florida, or Miami might not have near another 440 more years ahead.

Let's begin just 80 years hence. Some aspects of what's projected by U.N. Intergovernmental Panel on Climate Change (IPCC) about sea level rise, in 2100, may be just a bit misleading. End of this century, rise might be possibly unwinding at more rapidly accelerating rates, than are regarded as projected by IPCC. Getting this wrong, now, policy maybe allows more CO_2 and inertia to build unduly. It's something that can't then be halted nor unwound.

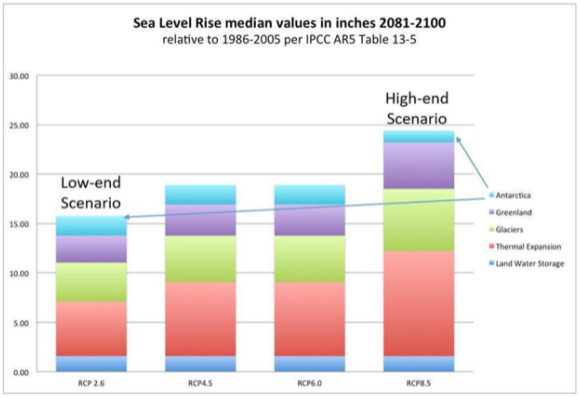
That the actual sea levels seen in 2100, could be greater than these projections, is well laid out in a Dec. 2020 piece, 'Twenty-first century sea-level rise could exceed IPCC projections for strong-warming futures' by Martin Siegert et al. One Earth 3 (December 18, 2020). https://doi.org/10.1016/j.oneear.2020.11.002

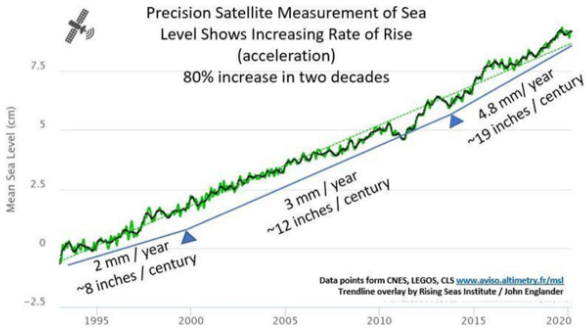
Their first paragraph nicely lays out in cogent, clear words what scientists might find to be mainstream – yet words that ought to be viewed by a wider public with some alarm:

> 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.

So near-term end of century, on strong warming, the sea in 2100 might be quite higher than a usually accepted IPCC range of 0.61m -1.10m, about what the public calls roughly 1-3 feet. In particular the upper end of projections unduly taken by laypersons as maxing out at about 1.1 meter (~3 feet) – is in fact not a final ceiling at all. It could be much higher.

Because of uncertainties cloaking immense Antarctic, with computer models excluding the unclear mechanisms - potential rise there is hazy. Shorn of important details, the absence of certainty here strongly suggests rise may not max out at 1.10 meters, roughly 3 ft. Difficulty in modeling aspects of ice sheet and glacier dynamics, in a nutshell, potentially has left possible Antarctica contributions out. That foreshortens complex & cascading rise, from what may soon potentially be a major factor. Especially in the high heat scenario, where we seem to be trending when comparing recent models to reality. Yet IPCC curiously indicates e.g. the least rise is coming from Antarctica, even in the RCP8.5 highest heat scenario 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 more ahead, is more concern. Scientists today understand how a crucial fraction of the airborne carbon already emitted from the industrial revolution, plus from this century (and maybe 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 ahead, may have committed the world to a great inertia seen in oceans. Impacts like rising seas, lasting for maybe centuries & even millennia.

Science suggests possibly many tens of feet rise, or much more on enough CO_2. An accelerating rise, maybe locked-in, perhaps going on for thousands of years. Times past, rise seemingly happened in non-linear ways and quickly. In a meltwater pulse on CO_2 from natural causes, at rates less than now, seas rose between 50 ft and 80 ft in just 400 - 500 years.

That is to say, massive ice sheets that once retreated very swiftly before, could do so again. Especially as we're engaging in pulling all kinds of climate levers, releasing CO_2 and potent greenhouse gases at rates not seen in hundred/s of thousand years. Global reshaping is what we're talking about. So put aside a moment political debate about climate. Ignore impacts like the bigger storms, more diseases, famine, droughts, collapsing ecosystems, and follow-on consequences spreading like ripples on a pond. Jus impacts of rise are enough.

In past we got our energy from the ground. That it was high-carbon was not perceived as a problem. Increasingly, our modern energy now comes from the Heavens. From clean solar that's shining brightly on our faces, wind blowing across our cheeks. They are sustainable, renewable, highly desirable, and potentially a future if we can make it …

Conclusion:

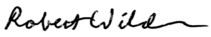
The Clean Energy Index® (ECO) began 4th Quarter 2020 around 125, and ended Q4 around 215, strongly up Q4. ECO Index® started Q1 2020 near 70, initially rising to 90. Then like much in Q1 it crashed on pandemic, saw a close in March under 50 – bouncing back Q2. Afterwards it gained a large +50% for 3rd Quarter. Momentum in this singular theme continued, for a Q4 gain around +70%, and remarkably some +207% year gain in the ECO Index®. Thus, even after falling hard due to Covid, this decarbonization & ESG story since March roared back 4-fold(!). A past say, 4 years since start of 2017, when the ECO Index® was 38, it's notably up +460%.

Last 5 years this Benchmark ECO Index® live since 2004 and 1st for climate solutions is up +300%, over a time when *any* energy gains are arguably notable. Over the same 5 years many CO_2-laden energy themes are far negative, with both oil & gas down some -70%. Likewise for last 10 years fossil fuels are far down some -80 and -90%, starkly contrasting with the green decarbonization story that's well positive, clearly strongest returns in energy. Both ECO and NEX have outperformed too versus a good, but separate other, global clean energy Index.

Deletions to start Q1 at ECO were: Atlantica, Hexcel, Veeco – many Adds as end of year were: Array, Ayro, Beam, Broadwind, Eos, Fisker, Flux, GreenPower, Lordstown, Quantumscape, Renesola, SPI, Xpeng. At Global NEX deletions for Q1: CS Green RE, Ecopro, eRex, Everlight – many Adds as end year were: 2G Energy (Germany) Alfen (Netherlands), Am. Super. (US), Array (US), Doosan Fuel Cell (S. Korea), Enlight (Israel), Eos (US), Fisker (US), Flat Glass (Hong Kong/China), Ganfeng Lith. (Hong Kong/China), GreenPower (Canada/US), Grenergy (Spain), Iljin (S. Kor), Livent (US), Lordstown (US), Motech (Taiwan), Quantumscape (US) Renesola (China/US), Royal DSM (Nether.), Solarpack (Spain), United Renewable Energy (Taiwan).

As always, we welcome your thoughts and suggestions.

Sincerely,



Rob Wilder
rwilder@wildershares.com

Appendix I:

ECO Index (via independent tracker PBW) Descending Weights latter-Q4 on 12/13/2020, or about ~2 weeks before rebalance to start Q1 2021, 46 Stocks:

Name	Symbol	Weight
FuelCell Energy Inc	FCEL	4.8
Blink Charging Co	BLNK	4.6
NIO Inc ADR	NIO	3.6
Plug Power Inc	PLUG	3.3
Livent Corp	LTHM	3.2
SunPower Corp	SPWR	2.9
Enphase Energy Inc	ENPH	2.8
Maxeon Solar Technologies Ltd	MAXN	2.6
Albemarle Corp	ALB	2.5
Daqo New Energy Corp ADR	DQ	2.5
Sociedad Quimica y Minera de Chile	SQM	2.4
Tesla Inc	TSLA	2.4
Bloom Energy Corp	BE	2.3
Kandi Technologies Group Inc	KNDI	2.3
Advanced Energy Industries Inc	AEIS	2.3
JinkoSolar Holding Co Ltd ADR	JKS	2.2
Hexcel Corp	HXL	2.2
Gentherm Inc	THRM	2.2
TPI Composites Inc	TPIC	2.2
Cree Inc	CREE	2.2
Sunnova Energy International Inc	NOVA	2.2
MYR Group Inc	MYRG	2.2
SolarEdge Technologies Inc	SEDG	2.1
American Superconductor Corp	AMSC	2.1
Woodward Inc	WWD	2.0
Lithium Americas Corp	LAC	2.0
Veeco Instruments Inc	VECO	2.0
First Solar Inc	FSLR	2.0
Itron Inc	ITRI	2.0
Ameresco Inc	AMRC	1.9
Ballard Power Systems Inc	BLDP	1.9
Willdan Group Inc	WLDN	1.9
Ormat Technologies Inc	ORA	1.8
Quanta Services Inc	PWR	1.8
ESCO Technologies Inc	ESE	1.8

Universal Display Corp	OLED	1.8
Canadian Solar Inc	CSIQ	1.8
Atlantica Sustainable Infrastructure	AY	1.7
Azure Power Global Ltd	AZRE	1.6
Renewable Energy Group Inc	REGI	1.6
Workhorse Group Inc	WKHS	1.5
Sunrun Inc	RUN	1.4
Air Products and Chemicals Inc	APD	1.1
Infrastructure and Energy Alternatives	IEA	0.9
ElectraMeccanica Vehicles Corp	SOLO	0.8
Arcimoto Inc	FUV	0.7

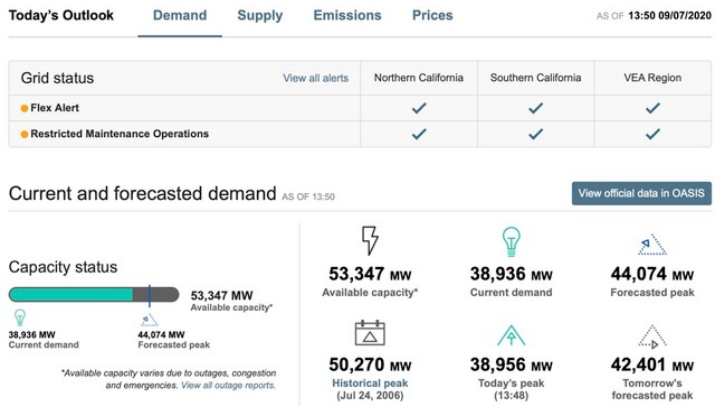
There's strong representation as seen above at top, in *Electric Vehicles, and *EV Charging, *Solar Power; *Hydrogen & *Fuel Cells; *Lithium & Batteries, and *PV Microinverters.

Starting March 2021, ECO rebalance announcements will be after close on the 6th business day preceding the last business day of the month. Next Effective: Open of Wed Mar 31, 2021:
Prior Announcement: Close of Thu Mar 25, 2021
New Announcement: Close of Tue Mar 23, 2021

Applied Renewables: In a 2020 State Flex alert California's Energy *Cushion fell near-zero!*

Demand in this Heat Wave on Sept. 7, 2020 nearly Exceeded All Available Capacity 53,347 MW – a Forecast Afternoon Peak Demand hit 44,074 MW (and was 48,522 MW day before)! That left almost no cushion against Blackouts; yet 53,000 MW+ Demand is foreseeable. Emergency steps, only, got supply just >50,000 MW. Far more Renewables + energy Storage needed asap. Rather than Natural Gas (that makes less in heatwaves) or electricity Imports for more CO2 – climate demands CO_2 goes towards zero. Too much (carbon) power still comes from Gas, and from neighboring States likewise in dire straits in big western dome heat waves.

So in this Sept. 2020 California Heatwave, far too much natural gas is being used. Solar can help right matters vs gas and (carbon) imports - but only daytime and it's still too small. Far more Renewables, Solar/Wind, Batteries, Energy Storage must play far larger roles ahead to grow clean supply. Texas, by contrast, less regulated, is more nimbly growing these!! –



Source: CAISO.com – Sept 7, 2020 at 1:50 pm. See caiso.com/TodaysOutlook/Pages/supply.html

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

INDEX (ECO) SECTOR & STOCK WEIGHTS FOR START OF Q1 2021. 56 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 - 22% weight (10 stocks @2.10% 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.
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 Conversion - 19% sector weight (11 stocks @1.72% each)
Advanced Energy, AEIS. Power conditioning: inverters, thin film deposition.
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 powertrains, 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.
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.

Power Delivery & Conservation - 23% sector (12 stocks @1.87% 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.
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.
Universal Display, OLED. Organic light emitting diodes, efficient displays.
Willdan, WLDN. Efficiency, in distributed energy, renewables, engineering.

Greener Utilities – 7% sector weight (4 stocks @1.75% each)
Beam, BEEM. EV Charging, rapidly deployable as a portable PV power 'utility'.

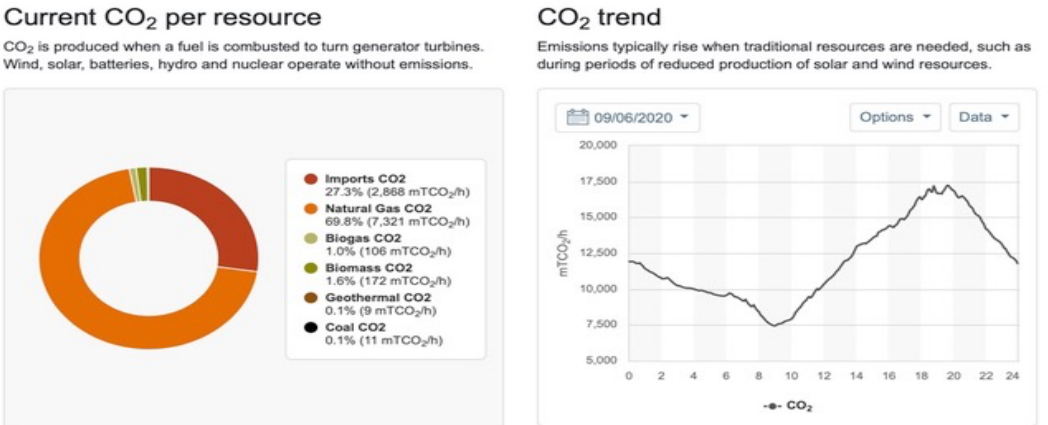
Sunnova, NOVA. Solar provider, operating fleet for residential, plus storage.
SunPower, SPWR. Solar system provider, storage and distributed generation.
Sunrun, RUN. Residential solar systems, lease, PPA or purchase rooftop PV.

Energy Storage - 26% sector weight (13 stocks @1.96% 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 swapping, China.
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 but loss-making so far.
Quantumscape, QS. Battery, solid state lithium-metal energy dense fast charge.
Tesla, TSLA. Electric vehicles, pure-play across advanced EVs, energy storage.
Workhorse, WKHS. Electric Vehicles, large electric delivery trucks, early-stage.
Xpeng, XPEV. Electric vehicles, advanced mobility and transport technologies.

Cleaner Fuels – 3% sector weight (2 stocks @1.50% each)
Air Products & Chemicals, APD. Hydrogen, projects for green hydrogen (H_2).
Renewable Energy Group, REGI. Biodiesel, natural fats, grease to biofuels.

Practical Issues in Renewables II: In a California Flex Alert, CO_2 Emissions are Allowed to Spike to get Supply High as Possible, >50,000 MW to meet demand. Natural gas + peaker plants maxed at 100%, no maintenance, more (dirty) imports from out of State. Demand in California e.g. in a Heat Wave, Sept. 5, 2020 outstripped normal capacity. Demand that afternoon is not yet peak late-day, wind nominal, solar power troublingly about to fall hard. California's Demand History shows Renewables/Batteries must grow very, very fast, as huge energy efficiency strides had been already made – California is now adding more electric vehicles swiftly creating more demand - yet Demand is already over 50,000 MW. One option is greater Vehicle to Grid (V2G) doubling up EVs as batteries during peak load moments:

September 2020:



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

Appendix III: **WilderHill New Energy Global Innovation (NEX)** descending weights late-Q4 via independent tracker (PBD) 12/13/20, ~2 weeks before Rebalance to start Q1 2021. 85 stocks:

Name	Symbol	Weight %
FuelCell Energy Inc	FCEL	2.8
RENOVA Inc	9519 JP	2.0
JinkoSolar Holding Co Ltd ADR	JKS	1.9
NIO Inc ADR	NIO	1.8
Plug Power Inc	PLUG	1.8
XPeng Inc ADR	XPEV	1.8
BYD Co Ltd	1211 HK	1.6
Ceres Power Holdings PLC	CWR LN	1.6
Enphase Energy Inc	ENPH	1.6
SunPower Corp	SPWR	1.6
Xebec Adsorption Inc	XBC	1.5
Daqo New Energy Corp ADR	DQ	1.5
eRex Co Ltd	9517 JP	1.5
VERBIO Vereinigte BioEnergie AG	VBK	1.5
Sino-American Silicon Products Inc	5483 TT	1.4
Xinjiang Goldwind Science & Technology	2208 HK	1.4
Nordex SE	NDX1	1.4
Scatec ASA	SSO	1.4
Bloom Energy Corp	BE	1.4
ITM Power PLC	ITM LN	1.3
Veeco Instruments Inc	VECO	1.3
Sunnova Energy International Inc	NOVA	1.3
West Holdings Corp	1407 JP	1.3
Ameresco Inc	AMRC	1.2
SolarEdge Technologies Inc	SEDG	1.2
TPI Composites Inc	TPIC	1.2
Cree Inc	CREE	1.2
PNE AG	PNE3	1.2
Itron Inc	ITRI	1.2
Tilt Renewables Ltd	TLT	1.2
GS Yuasa Corp	6674 JP	1.2
Renewable Energy Group Inc	REGI	1.2
Meridian Energy Ltd	MEL	1.1
Maxeon Solar Technologies Ltd	MAXN	1.1
Xinyi Solar Holdings Ltd	968 HK	1.1
Samsung SDI Co Ltd	006400 KS	1.1
CS Wind Corp	112610 KS	1.1

Sociedad Quimica y Minera de Chile SA ADR	SQM	1.1
Universal Display Corp	OLED	1.1
SMA Solar Technology AG	S92	1.1
Hannon Armstrong Sustainable Infra.	HASI	1.1
Xinyi Energy Holdings Ltd	3868 HK	1.1
Verbund AG	VER AV	1.1
Vestas Wind Systems A/S	VWS DC	1.1
Eolus Vind AB	EOLUB SS	1.1
EDP Renovaveis SA	EDPR	1.1
Solaria Energia y Medio Ambiente SA	SLR	1.1
Willdan Group Inc	WLDN	1.1
NEL ASA	NEL	1.1
Mercury NZ Ltd	MCY	1.1
Siemens Gamesa Renewable Energy SA	SGRE	1.1
Ballard Power Systems Inc	BLDP	1.1
Gurit Holding AG	GUR SW	1.1
Ormat Technologies Inc	ORA	1.1
Orsted AS	ORSTED DC	1.0
PowerCell Sweden AB	PCELL SS	1.0
Canadian Solar Inc	CSIQ	1.0
Azure Power Global Ltd	AZRE	1.0
Landis+Gyr Group AG	LAND SW	1.0
Encavis AG	CAP	1.0
Arcosa Inc	ACA	1.0
McPhy Energy SA	MCPHY FP	1.0
First Solar Inc	FSLR	1.0
Nibe Industrier AB	NIBEB SS	1.0
TransAlta Renewables Inc	RNW	1.0
Boralex Inc	BLX	1.0
Innergex Renewable Energy Inc	INE	1.0
Lithium Americas Corp	LAC	0.9
Signify NV	LIGHT	0.9
CS RE Fund Green Property	GREEN SW	0.9
Neoen SA	NEOEN FP	0.9
Prysmian SpA	PRY	0.9
Acciona SA	ANA	0.9
CropEnergies AG	CE2	0.9
Kingspan Group PLC	KSP	0.9
Everlight Electronics Co Ltd	2393 TT	0.8
Terna Rete Elettrica Nazionale SpA	TRN	0.8

Greencoat UK Wind PLC/Funds	UKW LN	0.8
Ecopro Co Ltd	086520 KS	0.8
Sunrun Inc	RUN	0.8
Caverion Oyj	CAV1V FH	0.8
Renewables Infrastructure Group	TRIG LN	0.8
Albioma SA	ABIO FP	0.8
Falck Renewables SpA	FKR	0.8
Novozymes A/S	NZYMB DC	0.7

Among best performers in NEX in this period above, there's again clear representation from *Electric Vehicles and *Batteries/Energy Storage, *Solar Power, *Hydrogen and *Fuel Cells.

Appendix IV:

WilderHill New Energy Global Innovation (NEX) - for start of Q1 2021. 102 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
Albioma SA	Biomass, sugarcane, hybrid combustion, cogeneration.	RBB	EUR	FRANCE
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
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
Caverion OYJ	Energy efficiency, buildings, infrastructure, Europe.	EEF	EUR	FINLAND
Ceres Power	Fuel cells, high temperature steel units.	ECV	GBP	BRITAIN
Cree Inc.	Power electronics, electrifying powertrains, SiC, LEDs.	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
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
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
Flat Glass Group	PV panel glass, solar plants engineering & construction	RSR	HKD	CHINA
FuelCell Energy	Fuel cells, high temperature and hydrogen.	ECV	USD	US
Fisker	Electric cars, electric SUVs, with contract manufacturer.	ENS	USD	US
Ganfeng Lithium	Lithium, production of compounds, metals, for batteries.	ENS	HKD	CHINA
Greencoat UK Wind plc	Infrastructure fund, invested in U.K. wind power assets.	RWD	GBP	BRITAIN
GreenPower Motor	Electric vehicles, transit, school and charter buses.	ENS	USD	CANADA
Grenergy Renovables SA	Solar projects, and wind, batteries, Spain, Latin America.	RSR	EUR	SPAIN
GS Yuasa	Battery technologies, also lithium for EVs, Japan.	ENS	JPY	JAPAN
Gurit Holding AG	Composite Materials in wind, lightens cars, planes.	RWD	CHF	SWITZERLAND
Hannon Armstrong	Energy efficiency, capital & finance for infrastructure.	EEF	USD	US
Iljin Materials	Rechargeable battery materials, elecfoils for batteries..	ENS	KRW	S. KOREA
Innergex Renewable	Renewable power, run-of-river hydro, wind, solar.	ROH	CAD	CANADA
ITM Power plc	Fuel cells, uses PEM technology; also hydrogen.	ECV	GBP	BRITAIN
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
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
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
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
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
Renewables Infrastructure	Wind Farm & Solar Park revenues assets, U.K.	RWD	GBP	BRITAIN
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 parks, develops, owns and operates worldwide.	RSR	NOK	NORWAY
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
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	US
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
Sunnova	Residential solar and energy storage installation.	RSR	USD	US
SunPower	Solar, efficient PV panels with rear-contact cells.	RSR	USD	US
Sunrun	Residential solar, leasing, PPA or purchase rooftop PV.	RSR	USD	US
Terna SpA	Transmission of electricity, increasingly is renewables.	EEF	EUR	ITALY
Tilt Renewables	Wind Farms, Australia and New Zealand, some solar.	RWD	NZD	NEW ZEALAND
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
Veeco instruments	Thin film equipment LEDs, energy efficient electronics.	EEF	USD	US
Verbio Vereinigte BioEn.	Biofuels, manufacturer supplier to Germany, Europe.	RBB	EUR	GERMANY
Verbund AG	Electricity supplier, hydro, a large provider for Austria.	ROH	EUR	AUSTRIA
Vestas Wind Systems A/S	Wind, wind turbine manufacturing & services, Denmark.	RWD	DKK	DENMARK
West Holdings	Solar, Japan-focused residential and commercial PV.	RSR	JPY	JAPAN
Willdan Group	Energy efficiency in infrastructure, engineering.	EEF	USD	US
Xebec Adsorption	Gases for new renewable energies, hydrogen.	EEF	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	RSR	CHINA
Xinyi Solar Holdings	Solar, ultra-clear glass products, China.	RSR	HKD	CHINA
Xpeng Motors	Electric Vehicles, internet and autonomous features.	ENS	USD	CHINA

Weight Each Component for Q1

102 stocks/100 = Individual Weights for Q1 2021 = 0.98039216

NEX SECTOR WEIGHTS for Q1 2021:	SECTOR	QUANTITY	% Approx.
Energy Conversion	ECV	11	11%
Energy Efficiency	EEF	16	16%
Energy Storage	ENS	15	15%
Renewables - Biofuels & Biomass	RBB	6	6%
Renewables - Other	ROH	5	5%
Renewable - Solar	RSR	28	27%
Renewable - Wind	RWD	21	21%
		102	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%

*Prior to Q3 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. Subsequently after Q3 2019, NEX components are all equal weighted, respective sector weights assigned according to number of components assigned to each NEX sector.

[1] PWS (Power Storage) name change to ENS (Energy Storage) at end of the 4th Quarter 2009.

[2] HFC (Hydrogen & Fuel Cells) name change to ECV (Energy Conversion) end of 4th Quarter 2008.

[3] HF (Hydrogen And Fuel Cells) became HFC (Hydrogen & Fuel Cells) after 2007 and then changed it's name to ECV (Energy Conversion) at the end of the 4th Quarter of 2008.

[4] DS (Demand Side Energy Savings) and GE (Generation Efficiency And Smart Distribution) were combined into EEF (Energy Efficiency) after 2007.

This Announcement made Oct. 28, 2020, simply noted number of Decimal places going from 6 to 3 for NEX:

Announcement | Wilderhill New Energy Global Innovation Indices | Change to the number of decimals for index calculation

Please be informed that as of 28th October 2020 the index levels for the following Wilderhill indices will be distributed with a precision of three decimal places, reduced from six.

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

If you have any further questions regarding this email, please reply to: equity.ops@solactive.com

Thank you and kind regards,

Equity Indexing, Solactive AG

Tel.: +49 (69) 719 160-410

Address: Platz der Einheit 1, 60327 Frankfurt, Germany | Fax: +49 69 719160-25 | www.solactive.com

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Appendix VII, Clean Sustainable Ocean Index (OCEAN) Composition latter Q4 2020, 88 components:

Clean Ocean components (OCEAN)	Theme	Activity	Sector
Acciona SA	Water Treatment; Renewable Energy.	Spain	WT
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
Austevoll Seafood ASA	Seafood, aquaculture with high ESG scores.	Norway	SF
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
Cargotec OYJ	Better Sustainability in Ports & Terminals.	Finland	GS
Ceres Power	H2 fuel cells, power ahead ports, shipping.	Britain	GS
Cia Pesquera Camanchaca	Seafood, aquaculture with high ESG scores.	Chile	SF
Corbion NV	Algae, sustainable alternative in aquaculture.	Netherlands	PP
CREE	LEDs Lighting.	USA	PP
CS Wind	Wind, tower structures.	S. Korea	CE
Ecopro	Battery cathodes, lithium, pollution reduction.	S. Korea	PP
EDP Renovaveis SA	Renewables, among world's largest in wind.	Spain	CE
Encavis AG	Renewable Energy, solar & wind in Europe.	Germany	CE
Eolus Vind AB	Wind power projects in Sweden, US, Estonia.	Sweden	CE
Essential Utilities (was Aqua)	Water and Wastewater Services.	USA	WT
Evoqua	Water, wastewater treatment.	USA	WT
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
Grenergy Renovables SA	Solar power parks, wind power.	Spain	CE
Grieg Seafood ASA	Seafood, aquaculture with high ESG scores.	Norway	SF
Gurit Holding AG	Wind, composites, also in transportation.	Switzerland	CE
Halma plc	Water analysis, monitoring, treatment.	Britain	WT
Idex	Water, pumps, flow meters, fluid systems.	USA	WT

Innergex Renewable	Run-of-river Hydro power, Wind, Solar.	Canada	CE
Intertek Group plc	Cargo and Trade services, quality assurance.	Britain	PP
ITM Power PLC	Electrolysis for green hydrogen, zero CO2.	Britain	PP
Itron	Smart Grid Power and Water Management.	USA	PP
Kingspan Group PLC	Building Insulation.	Ireland	PP
Kuehne und Nagel	Shipping Logistics, clean cargo group.	Switzerland	PP
Kurita Water	Water Treatment, wastewater systems.	Japan	WT
Leroy Seafood Group	Seafood, with high FAIRR Report score.	Norway	SF
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
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
Nomad Foods	Moving to 100% Certified-sustainable seafood.	USA	SF
Norway Royal Salmon ASA	Seafood, aquaculture with high ESG scores.	Norway	SF
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
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
Signify NV	LEDs, was Philips Lighting.	Netherlands	PP
Sino-American Silicon	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
Tassal	Seafood, aquaculture with high ESG scores.	Australia	SF
Terna SpA	Grid Efficiency for more Renewables.	Italy	CE
Tilt Renewables	Wind Farms, Australia & New Zealand, solar.	New Zealand	CE

Tomra Systems ASA	Recycling wastes, materials recovery.	Norway	PP
Veolia Environnement	Water and Wastewater Treatment.	France	WT
Verbund AG	Renewable Energy, hydropower.	Austria	CE
Vestas Wind Systems A/S	Wind power, in both products and services.	Denmark	CE
Wartsila OYJ	Ports, Terminals, energy with sustainability.	Finland	GS
Watts Water Technologies	Water quality, rainwater harvests, flow control.	USA	WT
Xebec Adsorption	Hydrogen, generation and purification.	Canada	PP
Xinjiang Goldwind Science	Wind, turbine manufacturer, also in services.	China	CE
Xinyi Solar Holdings Ltd	Solar glass, has spun off solar farms.	China	PP
Xpeng	Electric vehicles, connectivity.	China	PP
Xylem	Water Technologies.	USA	WT

For Rebalance for latter Q4 2020

Deletes: Landis+Gyr, Pure Cycle

Additions: Alfen, Amer. Superconductor, Azure, BYD, Ceres, Corbion, Ecopro, Flat Glass, Gurit, Geberit, Grenergy, Halma, Idex, Innergex, PNE, Royal DSM, Scatec, Solarpack, Xpeng.

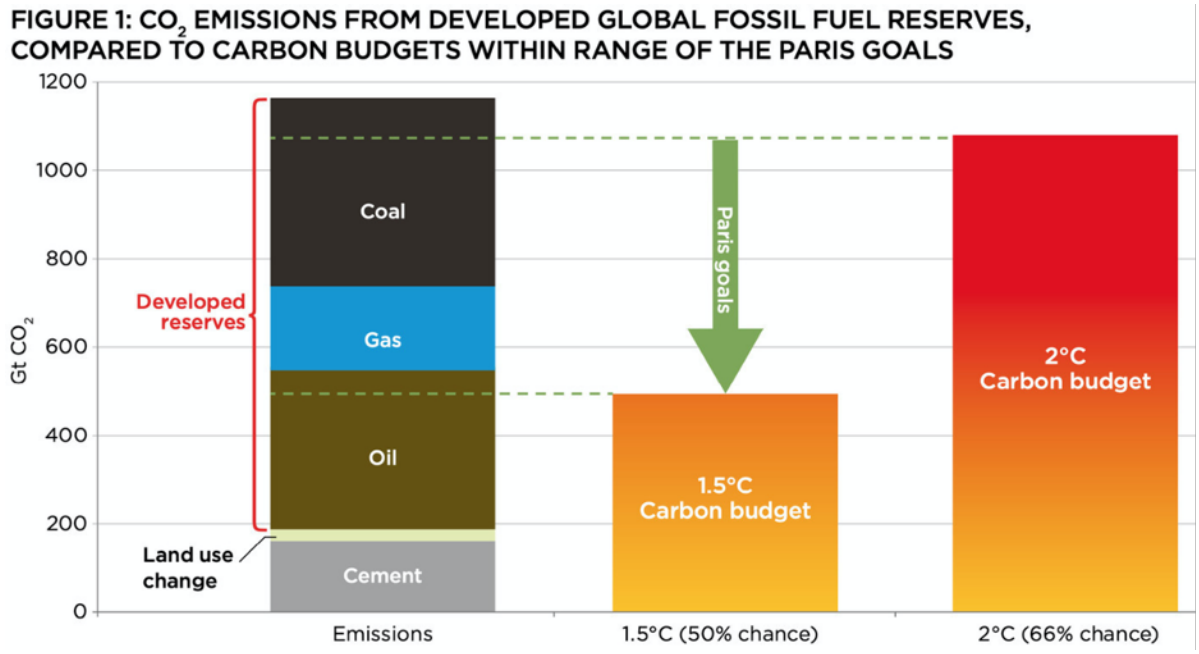
OCEAN Equal Weight for Q4 2020 = 88/100 = 1.1363636% each.

OCEAN Sector & Number for latter Q4 2020:	**Approx Weight**
GREENER SHIPPING (GS) = 9 =	10%
CLEAN ENERGY LOW CO2 (CE) = 30 =	34%
WATER TREATMENT (WT) = 16 =	18%
SUSTAINABLE FISHERIES (SF) = 12 =	14%
POLLUTION PREVENTION (PP) = 21 =	24%
TOTAL CONSTITUENTS = 88	

For how Dire CO_2 Facts & Trends may already be in 2021: consider this Carbon Budget Chart from Oil Change International (OCI) comparing what's likely to be burned fossil fuel reserves coal, oil, and natural gas - vs Earth's possible carbon budget. These data imply first, that for the Paris goal of just 1.5 C warming to be achieved – ALL 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 for instance are thinking seriously about becoming more 'energy companies' than in fossil fuels, majors in the U.S. and elsewhere seem more intent on marketing & promoting e.g. 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 a 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 a carbon budget keep to 'just' 1.5 C rise. It's simple physics & chemistry. Whatever oil companies might desire, nations may think, whatever leaders are prepared to 'promise' about a distant 2050 in a nod to demands, this budget if accurate puts a hard ceiling on fossil fuels right now, period.

To state our Planet/Oceans will likely realistically blow past it this decade of the 2020s is a hard truth. It scarily acknowledges where things are at the start of the vital 2020s. And yet, much might possibly look very different in 10 years' time at end of seminal 2020s:



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 the 1990s, antecedent WilderHill Hydrogen Fuel Cell Index, see, http://h2fuelcells.org

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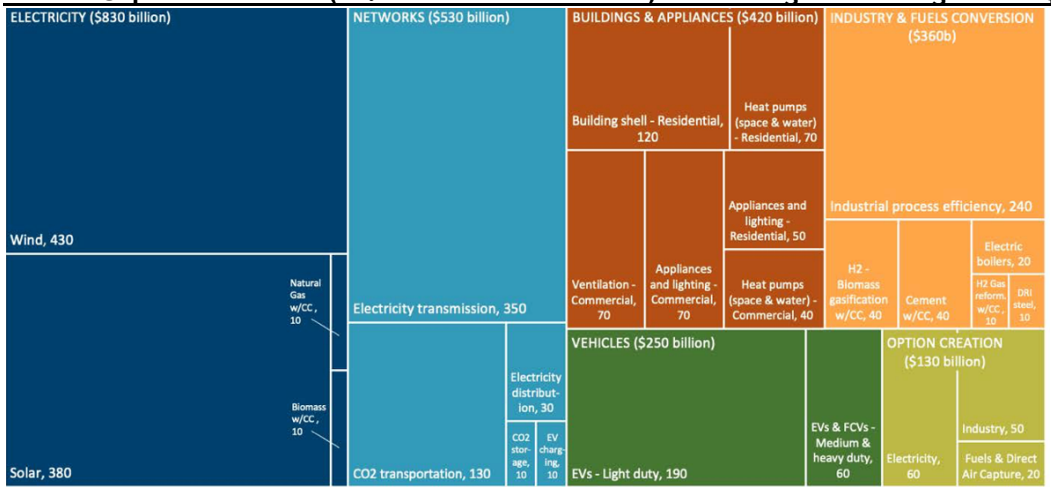
A Look at some important divergent Possibilities Ahead Over 2020s Decade:

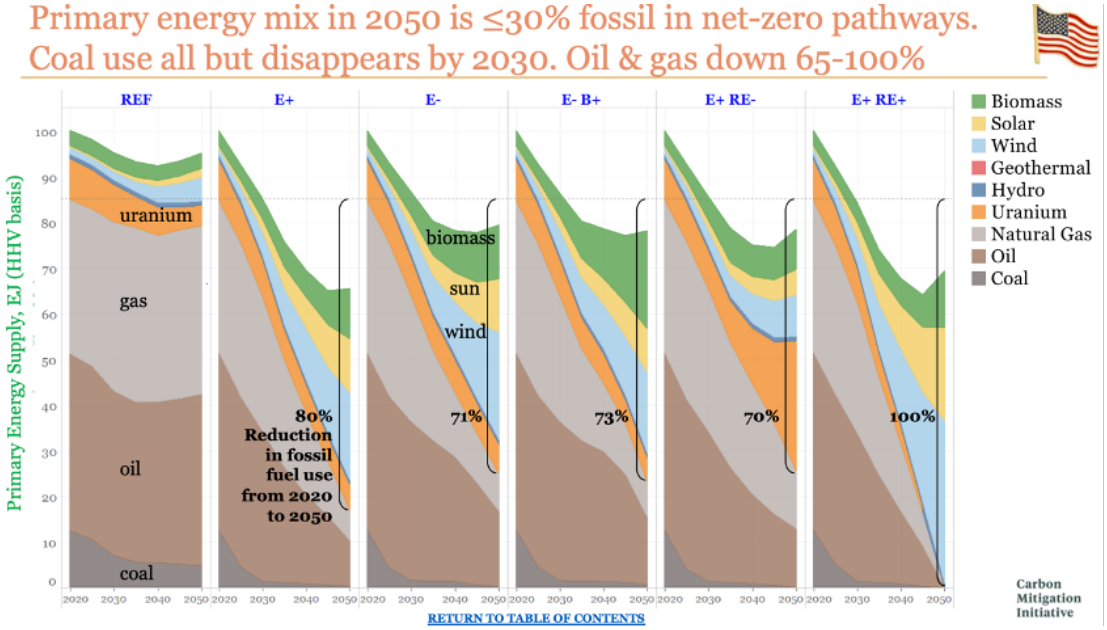
From: Interim Report. Net-Zero America: Potential Pathways, Infrastructure, and Impacts. By E. Larson, C. Greig, J. Jenkins, E. Mayfield, A. Pascale, C. Zhang, J. Drossman, R. Williams, S. Pacala, R. Socolow, EJ Baik, R. Birdsey, R. Duke, R. Jones, B. Haley, E. Leslie, K. Paustian, and E. Swan. Princeton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

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



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.



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

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