Investing in Renewable Energy and Clean Technology

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January 31st, 2021

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Introduction

Traditional energy companies, exemplified by fossil fuel producers, servicers, equipment manufacturers, and infrastructure providers have become an ever-smaller percentage of major equity indices. As a sector, "Energy" only represents 2.3% of the S&P 500 as of December 31st, 2020,[1] the lowest level in 30 years.[2]

The quick conclusion is, because of their decreasing weight in major indices, energy companies have become less relevant in the global economy and therefore less important for Emerald to research. On the contrary, with the relatively recent growth of alternative and renewable energy companies, the actual concentration of energy and energy-related companies has grown to a material percentage of small and mid-cap growth indices.

The clean tech sector has an aggregate market cap of $760B (ex-Tesla) as of 12/30/2020. That is composed of 123 clean tech pure-plays with market caps ranging from $13M to $89B; refer to Figure 3 for more detail.

Some investors may be surprised to learn that clean tech energy companies were some of the best performing equities in 2020. According to FactSet, companies in the Russell 2000 Growth and Russell Mid-Cap Growth indices returned 606% and 207% respectively.

Emerald believes clean tech is a highly investable area that will continue to reward, but it will require stock picking on a highly individualized basis.

Emerald has worked hard to transition and broaden our research efforts to cover these renewable oriented energy companies, and we have stepped up our communication efforts between analyst coverage groups to ensure that companies that fall within areas of research that overlap, such as in Transportation, Industrials, Materials, and Technology are more fully covered and vetted. This transition and concentration of research resources has resulted in Emerald identifying, researching, and investing in what we believe are some of the fastest-growing alternative energy companies in the domestic equity universe.

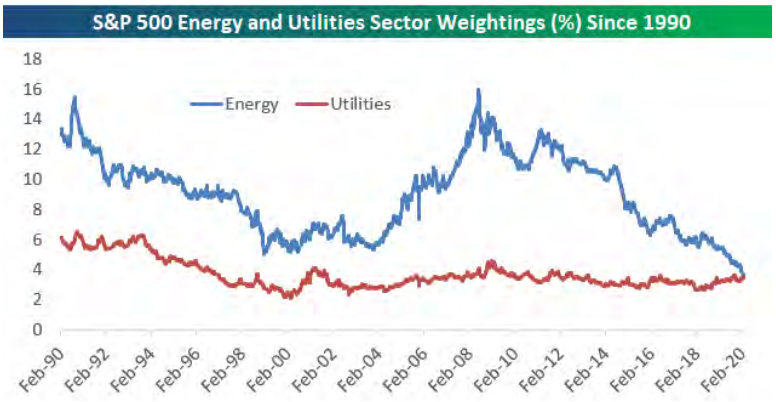

Figure 1: S&P 500 Energy and Utilities Sector Weightings (%) Since 1990

Figure 2: S&P 1500 Sector Weightings (%)

U.S.-Listed Clean Tech Universe

	Number of Companies	Market Cap ($ MM) Total	Smallest	Largest
Electric Vehicles	19	$941,152	$31	$733,377
Wind Power	14	$221,649	$148	$88,504
Solar Power	18	$98,563	$125	$24,104
Power Storage	12	$94,109	$102	$40,320
Water Technology	20	$54,134	$13	$18,167
Fuel Cells	5	$29,142	$2,980	$12,455
Energy Efficiency	6	$12,498	$30	$9,037
Bioindustrials	11	$11,385	$59	$4,136
Smart Grid	4	$7,914	$276	$3,929
Natural Gas Fuels	5	$6,878	$49	$4,268
Synthetic Fuels	1	$5,394	NA	NA
Geothermal Power	1	$4,490	NA	NA
Biopower	3	$4,274	$744	$1,769
EV Infrastructure	2	$1,908	$437	$1,472
Microturbines	1	$111	NA	NA
Wave Power	1	$64	NA	NA
Total	**123**	**$1,493,666**		
Total ex-Tesla	**122**	**$760,289**		

Source: FactSet, Raymond James research

Figure 3: U.S.-Listed Clean Tech Universe

Currently, it is a fossil fuel world, but in many ways that is rapidly changing. Our job at Emerald is to continually assess which energy sources will be the long-term market share gainers and which companies from producers to equipment and component manufacturers, to midstream and service companies will succeed in generating industry-leading sales and earnings growth. Most companies will fail to produce robust repeatable results; some will win regardless of the energy source; and a few will develop the scale, intellectual property, margins, and structures to be the potential long-term investable winners. Our challenge is to identify and invest in these companies, preferably before the rest of the market notices them. This is something we have strived to over the past 30 years and have already focused on in the renewable energy space over the recent past, through investments in selected high growth small and mid-cap renewable energy companies.

The following is our discussion on the current state of the energy market. We discuss the major sources and uses of energy both domestically and worldwide. We highlight some of the major climate change policies that are pushing some of the unprecedented renewable energy adoption. We also review some of the newer energy sources including costs, potential uses, some pros and cons of their production and uses, as well as potential market sizes.

In the following pages, we will include some of the facts, trends, predictions, constraints, limitations, and conditions that we consider when conducting our deep fundamental research on industries and companies.

What falls under the clean tech umbrella?

The formal label that Emerald uses is Renewable Energy and Clean Technology. *Renewable energy* is simply electric power and fuels/chemicals from renewable sources. This includes solar, wind, biopower, and bioindustrials. Within *clean technology,* we refer to natural gas fuels, electric vehicles, fuel cells, power storage, smart grid technologies, energy efficiency technologies, carbon capture, and water technologies.

Emerald's Perspective: *2020 has been a reminder if there is a generalization to be made about trading in the clean tech space, it is that these companies tend to trade emotionally. We believe that these stocks are high-beta, driven by sentiment and momentum, and are prone to relentless volatility, including sometimes for no apparent reason. We believe clean tech is a stock pickers market; it simply does not lend itself to making broad calls. Within each vertical – even the narrow ones – we still have to focus on each individual company's positioning (product mix, margin structure, industry partners, geographic footprint, etc).*

Commitments by companies and countries in renewable energy and clean technology

To keep global emissions flat, the developed world would need to reduce emissions by ~4% per year, which is 5x-6x faster than the current pace.[3] As a result, several major countries and dozens of the largest companies in the world have committed to reducing their environmental impact.

Some companies, like Honda and BMW, are adjusting their product portfolio and have committed to stop selling diesel vehicles.[4] [5] Recently, GM, the largest U.S. automaker, committed not only to carbon neutrality by 2040 but also to eliminating tailpipe emissions from new light-duty vehicles by 2035,[6] arguably the most ambitious pledge by any auto manufacturer. Other companies, like United Airlines, are committing to carbon neutrality by 2050. United is also investing previously unthinkable amounts of capital into researching new technologies such as a carbon capture technology called Direct Air Capture and Sustainable Aviation Fuel, which has 80% less lifecycle carbon emissions than conventional jet fuel.[7] Walmart is making similar commitments; committing to zero emissions from its global operations by 2040.

This includes powering all of its facilities with renewable energy, electrify its entire vehicle fleet and restore at least 50 million acres of land and one million square miles of ocean.[8] The companies shown above are relevant to this presentation because of their business dealings within the industrial sector only. They are listed for general discussion purposes. Their inclusion herein does not denote the recommendation of their purchase or sale.

Importantly, it is not just the private sector making these commitments. Dozens of countries around the world are making similar investments and pledges. Saudi Arabia, for example, is targeting 30GW of renewable power generation by 2025. The shift will reduce Saudi Arabia's consumption by 2mmbpd of oil equivalent by 2030, with a resulting power stack comprising 70% natural gas and 30% from renewables, compared to 42% oil in 2019.[9] Japan is committing to zero emissions and carbon-neutrality by 2050 including a "fundamental shift" in policy on coal use.[10]

One of the most important commitments made worldwide has been the entire European Union pledging carbon neutrality by 2050. In December 2020, leaders of the European Union rubber-stamped what was already widely accepted which is the 'European Climate Law,' committing to carbon neutrality in the next 30 years. Part of the legally binding commitment is also the reduction of emissions by at least 55% by 2030. EU emissions had already been trending down, but not at a rate that would have achieved carbon zero by 2050. Emissions are down 21% from 2005 to 2019. At that pace, the EU would reduce emissions by ~33% by 2050 to 2B tons. See Figure 4.

Figure 5 is a non-comprehensive list, compiled by Emerald, of countries that have made carbon neutrality a target.

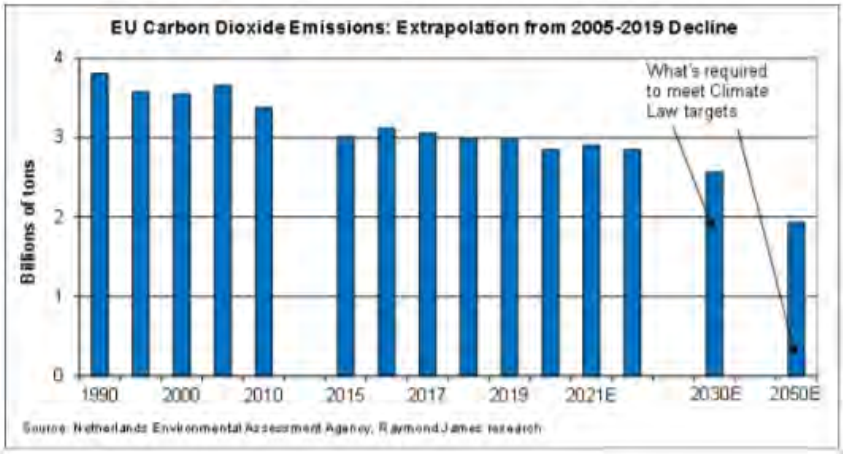

Figure 4: EU Carbon Dioxide Emissions: Extrapolation from 2005-2019 Decline

Country	Goal	By	Status
Argentina	Carbon Neutral	2050	Submitted to the UN
Austria	Carbon Neutral	2040	Policy Position
Bhutan	Carbon Negative	Achieved	--
Brazil	Carbon Neutral	2060	Submitted to the UN
Canada	Carbon Neutral	2050	Draft Law
Chile	Carbon Neutral	2050	Policy Position
China	Carbon Neutral	2060	Statement of Intent
Columbia	Carbon Neutral	2050	Submitted to the UN
Costa Rica	Carbon Neutral	2050	Submitted to the UN
Denmark	Carbon Neutral	2050	In Law
European Union	Carbon Neutral	2050	Submitted to the UN
Fiji	Carbon Neutral	2050	Submitted to the UN
Finland	Carbon Neutral	2035	Coalition Agreement
France	Carbon Neutral	2050	In Law
Germany	Carbon Neutral	2050	In Law
Grenada	Carbon Neutral	2050	Submitted to the UN
Hungary	Carbon Neutral	2050	In Law
Iceland	Carbon Neutral	2040	Policy Position
Ireland	Carbon Neutral	2050	Coalition Agreement
Japan	Carbon Neutral	2050	Statement of Intent
Maldives	Carbon Neutral	2030	Submitted to the UN
Marshall Islands	Carbon Neutral	2050	Pledged towards the Paris Agreement
Nepal	Carbon Neutral	2050	Submitted to the UN
New Zealand	Carbon Neutral	2050	In Law
Norway	Carbon Neutral	2050	Policy Position
Panama	Carbon Neutral	2050	Submitted to the UN
Portugal	Carbon Neutral	2050	Policy Position
Singapore	Carbon Neutral	2050	Submitted to the UN
Slovakia	Carbon Neutral	2050	Policy Position
South Africa	Carbon Neutral	2050	Policy Position
South Korea	Carbon Neutral	2050	Submitted to the UN
Spain	Carbon Neutral	2050	Draft Law
Suriname	Carbon Negative	Achieved	--
Sweden	Carbon Neutral	2045	In Law
Switzerland	Carbon Neutral	2050	Submitted to the UN
United Kingdom	Carbon Neutral	2050	In Law
United States of America	Carbon Neutral	2050	Statement of Intent
Uruguay	Carbon Negative	2030	Contribution to the Paris Agreement

Source: iisd.org, un.org, Emerald Advisers, LLC

Figure 5: Country Commitments to Carbon Neutrality

An important distinction is that carbon neutrality does not necessarily mean carbon zero. Raymond James reminds us, "[i]n other words, there will still be CO2 emissions in Europe in 2050, but they will need to be either (1) captured and sequestered (CCS); and/or (2) offset through reforestation or other initiatives, not necessarily located in Europe itself. This might seem like a technical point, but when thinking about very deep decarbonization, it will be crucial to have that flexibility."[11]

Current Energy Landscape in the U.S.

In 2019, the U.S. generated approximately 4.13 trillion kWh of electricity. Approximately 63% was from fossil fuels (coal, natural gas, petroleum, and other gases). About 20% was from nuclear energy, and about 17% was from renewable energy sources.[12]

The area chart in Figure 6 shows how the composition of energy generation has shifted over the last 70 years. Of note, total electricity generation has not moved much over the last 12 years; however, the source of electricity has shifted quite dramatically. In 2007, coal represented 48.5% of the 4.15 trillion kWh generated. By 2019, that percentage dropped to only 23.5% of the 4.13 trillion kWh of electricity generated, dropping in both relative and absolute measures.[13]

While in 2019, renewables (the green part of the area chart in Figure 6) only represented 17.5% of electricity generated, Emerald believes this is one area poised for significant growth in the coming decades. Consider this staggering statistic: the solar photovoltaic (PV) industry has accounted for approximately one-third of the world's total power generation new builds every year starting in 2017.[14] [15]The chart in Figure 7, from the EIA, shows that the solar will represent an estimated 39% of utility-scale new builds in the U.S. in 2021.

Renewable energy is energy from sources that are naturally replenishing but flow-limited; renewable resources are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time.

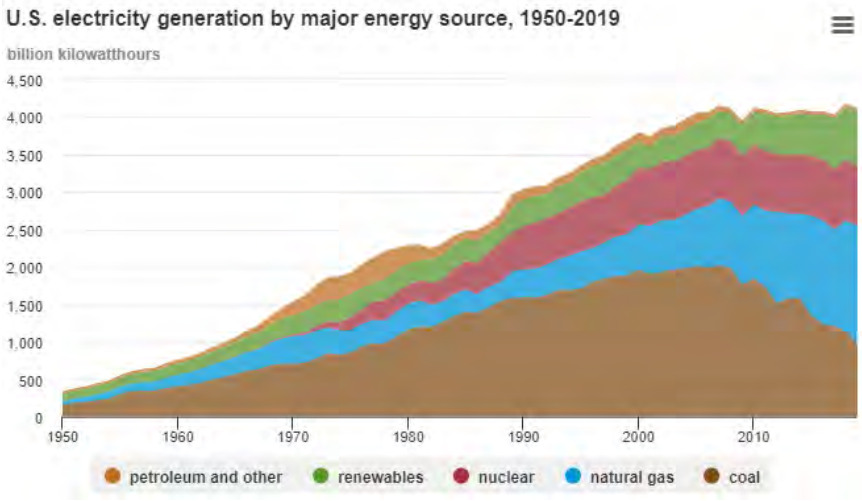

Figure 6: U.S. electricity generation by major energy source 1950-2019 (EIA.gov)

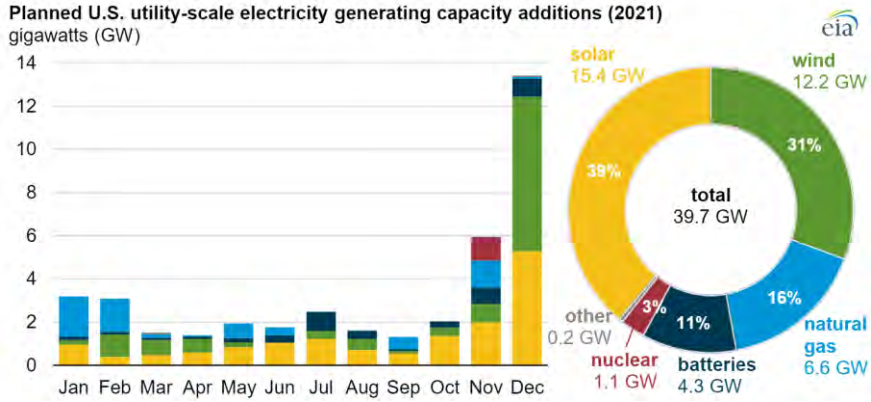

Figure 7: Planned U.S. utility-scale electricity generation capacity additions (2021)

	% of Energy Generation	
Energy Source	**% of Total US Energy**	**% of Renewables**
Wind	7%	42%
Hydropower	7%	38%
Solar	2%	11%
Biomass	1%	6%
Geothermal	1%	3%
Total Renewable	**~17.5%**	**100%**

Source: EIA.gov, Emerald Advisers, LLC

Figure 8: Energy source and percent of energy generation

The major types of renewable energy sources are biomass, hydropower, geothermal, wind, and solar. Hydropower plants use flowing water to spin a turbine connected to a generator. Wind turbines convert wind energy into electricity. Biomass is burned directly in steam-electric power plants, or it can be converted to a gas that can be burned in steam generators, gas turbines, or internal combustion engine generators. Photovoltaic (PV) and solar-thermal power are the two main types of solar electricity generation technologies. PV conversion produces electricity directly from sunlight in a photovoltaic cell. Most solar-thermal power systems use steam turbines to generate electricity. Geothermal power plants use steam turbines to generate electricity.[16]

Referring to Figure 9, renewable energy generation in the U.S. has increased seven-fold in the last 70 years. Much of that growth has been from the rapid adoption and proliferation of wind and solar. Wind and solar were virtually non-existent in the year 2000, and in less than 20 years now represent more than half of renewable energy generation in the U.S.

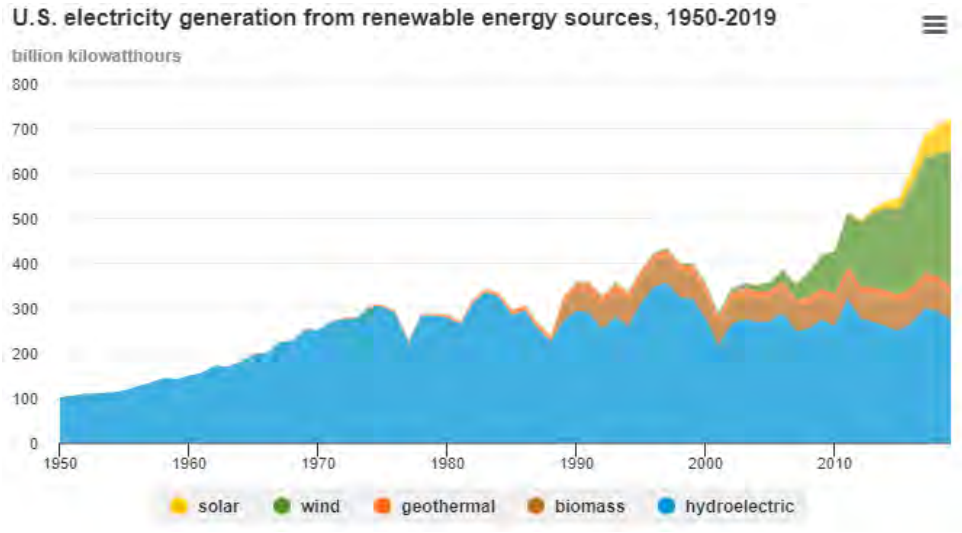

Figure 9: U.S. electricity generation from renewable energy sources, 1950-2019 (EIA.gov)

***Emerald's Perspective**: To resist a fundamental shift to renewable energy is to fight an increasingly uphill battle. What remains to be seen is what types of renewables will be the most cost-effective and which will be the most palatable for bipartisan legislative support. Wind and solar have long been highly investable and due in part to a large number of recent IPOs and SPACs, it is becoming easier to invest in power storage. Emerald keeps close tabs on emerging technologies as well as activity in Washington D.C. so we can understand changes in the energy landscape, and which industries may be poised for growth.*

Current costs of renewable energy

Wind and solar have increased as a part of total energy generation so dramatically, in large part, based on economic merit alone, with government subsidies and incentives acting as a boost.

Referring to the Levelized Cost of Energy (LCOE) in Figure 10 at the top of the next page, solar and wind are routinely the cheapest sources of energy globally. The LCOE compares different methods of electricity generation on a consistent basis. The AppliedEnergy Journal explains the LCOE as "a measure of the average net present cost of electricity generation for a generating plant over its lifetime. The LCOE is calculated as the ratio between all the discounted costs over the lifetime of an electricity generating plant divided by a discounted sum of the actual energy amounts delivered."[17]

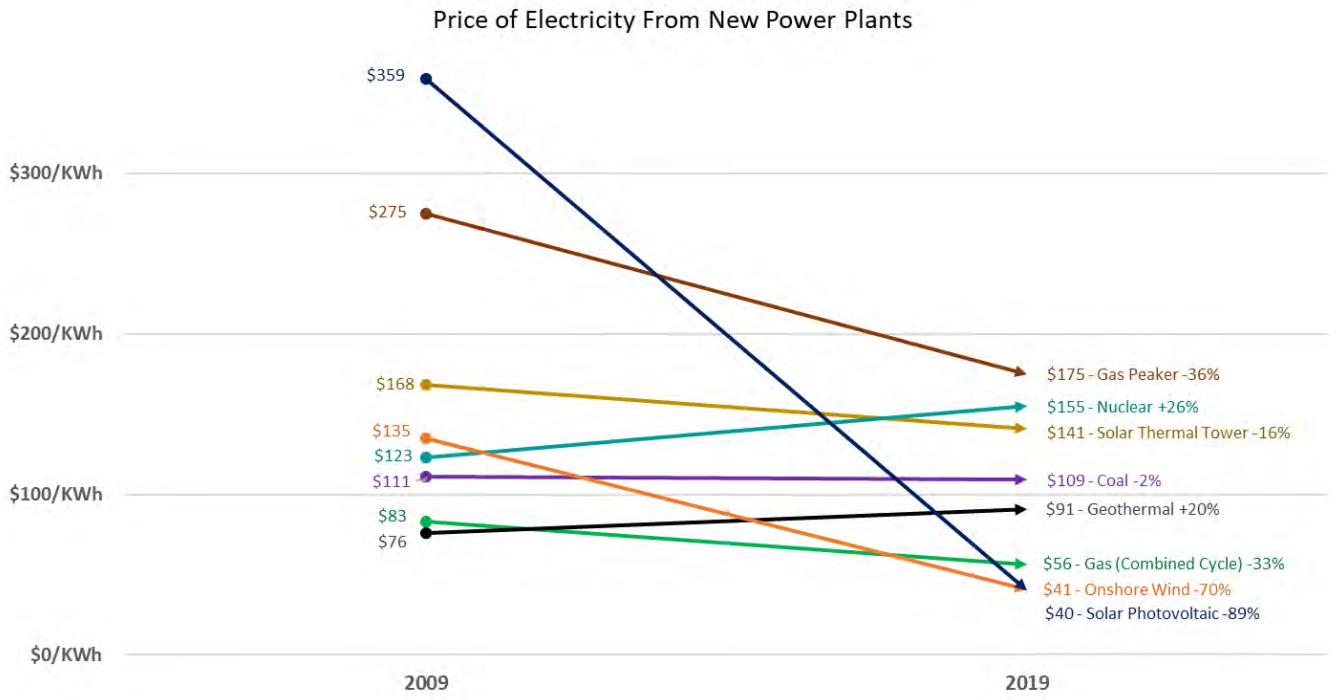

Figure 10: The price of electricity from new power plants
Source: Our World in Data, Emerald Advisers, LLC

Forecasting U.S. Energy Generation Going Forward

Renewable sources will likely continue to grow as a part of overall energy generation in the U.S. Goldman Sachs estimates there will be 640 GW of renewables online by 2035.[18] Goldman Sachs, in Figure 11, estimates an 8.4% CAGR in renewable GWs deployed from 2019 to 2025. That growth is likely to be driven by on-shore and offshore wind and solar photovoltaic. Goldman breaks down the 640 GW as follows: 241 GW onshore wind, 229 GW utility-scale solar, 141 GW DG solar, and 29 GW offshore wind. Hydrogen will likely emerge as a player in the rush to decarbonize, but its contribution will likely be after 2030.

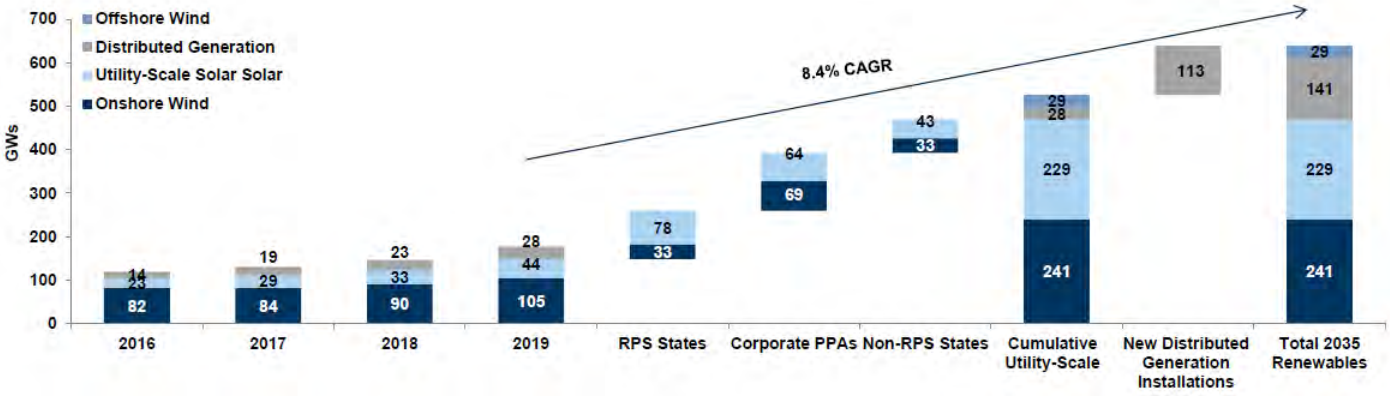

Figure 11: Goldman Sachs Renewable Forecast, 2019YE - 2035

In one of his first acts in the Oval Office, President Joe Biden signed an executive order to have the United States rejoin the Paris climate agreement, the largest international effort to curb global warming.

NPR notes, "[a]s a candidate, Biden made a bold pledge to cut all greenhouse gas emissions from the nation's electric sector by 2035 and to make the country carbon-neutral by 2050. Carbon emissions have been decreasing from the country's electricity sector as coal plants have been retired over the last decade and utilities ramp up their reliance on renewable energy sources like wind and solar."[19]

In the last year, several states have materially increased their renewable portfolio standards (RPS) targets. Four of the most notable include:

100% Renewable / Clean Power Targets				
State	**Type**	**Year**	**Status**	**Approval**
California	Clean	2045	Law	Sep - 18
District of Columbia	Renewable	2032	Law	Jan - 19
Hawaii	Renewable	2045	Law	Jun - 15
Maine	Renewable	2050	Law	Jun - 19
Nevada	Clean	2050	Law	Apr - 19
New Jersey	Clean	2050	Executive Order	May - 18
New Mexico	Clean	2045	Law	Mar - 19
New York	Clean	2040	Law	Jul - 19
Puerto Rico	Renewable	2050	Law	Apr - 19
Virginia	Clean	2045	Law	Mar - 19
Washington	Clean	2045	Law	May - 19

Source: EIA.gov, Emerald Advisers, LLC

Figure 12: State-level renewable and clean power targets

- Maryland raised its RPS to 50% by 2030 *(versus 25% by 2020 prior)*
- Nevada raised its RPS to 50% by 2030 *(versus 25% by 2025 prior)*
- New York raised its RPS to 70% by 2030 *(versus 50% by 2030 prior)*
- Virginia raised its RPS to 100% by 2045 *(versus 15% by 2025 prior)*

A current list of states with carbon neutrality goals, assembled by Emerald, can be found in Figure 12, at the top of this page.

In 2018, 10,435 fossil fuel-fired power plants produced 63% of U.S. electricity with 841 GW of capacity. More than 100GW of capacity is already past its typical lifespan. As seen in Figure 13, by 2035 more than half of that capacity will need to be retired and by 2066 all current fossil fuel plants will reach the end of their useful life.[20]

As these fossil-fuel-powered plants go offline, we believe solar and wind generators will likely replace much of the gap in capacity. Paradoxically, as solar and wind energy enters the grid, the cost of operating the remaining gas plants actually goes up because gas plants are forced to cycle on and off much more frequently which adds wear-and-tear, and shortens their lifetime.[21]

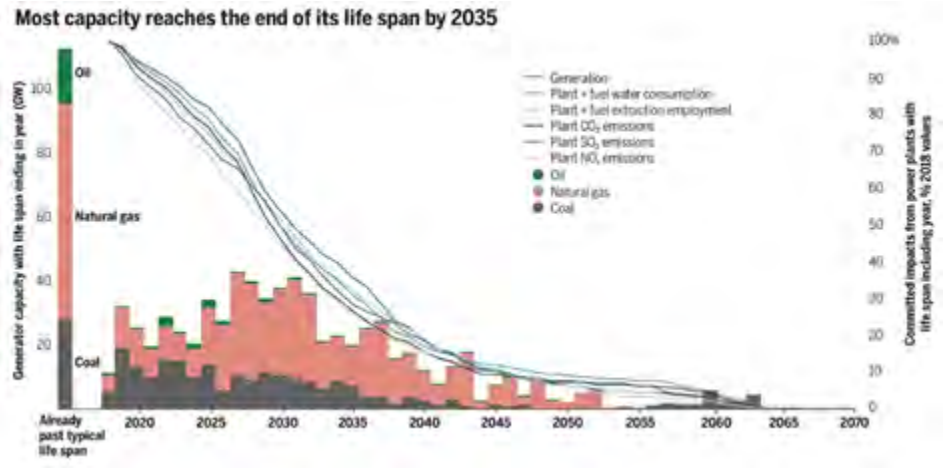

Figure 13: Retirement of fossil-fuel plants over time

These old plants may not simply be abandoned and unused. Australia is currently testing a pilot program in which an unused underground coal mine will be converted to a pumped hydro facility. The Australian Renewable Energy Agency is hopeful that this pilot will serve as a blueprint for dozens of mines that are scheduled to be decommissioned in the coming decade.[22] Even if repurposing these retired plants does not work, the US will have to invest significantly in renewables to replace the retirement of coal plants over time.

Also from Goldman Sachs in Figure 14: "Overall, assuming $1,350/kW for onshore wind, $1,000/kW for utility-scale solar, $2,500/kW for DG solar and $3,500/kW for offshore wind, our forecasts imply $147bn, $212bn, $283bn, and $101bn in spend, respectively, on these renewable types in the US by 2035, or a total of $743bn." Assuming that new renewables or even gas-fired generation would earn a utility like return, in a scenario where all coal generation gets retired over time we could see an investment opportunity of ~$600-$850bn and incremental earnings power of ~$27-$38bn.

Figure 14: Total renewable capex ($'s in billions)

Of note, on December 27th, 2020 Congress passed the Omnibus Appropriations and Coronavirus Relief Package. This mega-bill contained many items, but as it relates to clean tech and renewable energy, the omnibus legislation will extend the Production Tax Credit (PTC) and Investment Tax Credit (ITC). The PTC will extend for land-based wind for one year at 60% of the project's full value. The ITC will extend for solar for two years at 26% and cover offshore wind projects for the first time with a 30% tax credit, given the projects start before 2025. The omnibus bill also extends the tax credit for carbon capture by two years. We will discuss the potential impacts of the PTC and ITC extensions below in the wind and solar sections respectively.

***Emerald's Perspective**: In several renewable industries, like wind, there has been so much consolidation that the few remaining companies are too large for Emerald's small-cap portfolio. Or, also in the case of wind, none of the main wind turbine manufacturers are U.S. domiciled. As a result, Emerald has taken a "Picks and Shovels" approach to wind and solar. Identifying companies up- or down-stream that are poised to benefit from a rise in the industry but agnostic to who wins share further downstream.*

Wind

Using estimates from the U.S. Energy Information Administration (EIA), 2020 could be a record year for U.S. wind turbine installations. Project developers expect more than 23 gigawatts (GW) of wind turbine generating capacity to come online in the United States in 2020, far more than the previous record of 13.2 GW added in 2012. Only 5.0 GW of capacity has come online in the first eight months of this year, but as is typical with wind turbine installations, most of the annual capacity additions come online in the final months of the year. Another 18.5 GW plan to come online in September through December, according to project timelines reported to EIA by power plant owners and developers.

The 5.0 GW of capacity added in the first eight months of 2020 is already more than the capacity added in the first months of any year except 2009. Developers expect to add another 18.5 GW in the final four months of 2020: 8.9 GW in September through November and 9.6 GW in December. December is typically the month with the most wind turbine capacity additions. In the previous 10 years, 41% of the annual wind capacity additions came online in December.[23]

The Production Tax Credit (PTC) is a federal incentive that provides financial support for the development of renewable energy facilities. Companies that generate electricity from wind, geothermal, and "closed-loop" bioenergy (using dedicated energy crops) are eligible for a federal PTC, which provides a 2.3-cent per kilowatt-hour (kWh) incentive for the first ten years of a renewable energy facility's operation.

As discussed above, the PTC was extended one year at the end of 2020. Now, the PTC is set to phase-out at the end of 2021 with wind turbine projects coming online through 2023 that began construction in 2021 qualify for lower values of the PTC.[23] We expect more capacity additions than average this year, just as previous tax credit reductions led to significant wind capacity additions in 2012 and 2019.

***Emerald's Perspective**: Wind has a combined market cap of $200B almost completely driven by the three largest players, all OTC-Listed. Emerald believes that energy generation is likely going to continue to shift toward wind power based on economic merit alone, with Biden administration policies acting as a boost. As mentioned above, wind is difficult for Emerald to invest in because of the few remaining players, Emerald has identified and invested in companies that are suppliers to all major wind turbine manufacturers and therefore are agnostic to who wins market share.*

Solar

China has been the world's number-one photovoltaic (PV) market for eight consecutive years. In 2020, the U.S. and Europe were approximately tied for a distant second.

On the supply side, China plays an even more disproportionate role; see Figure 15. Seven of the top ten PV module firms, in terms of MW shipped, were Chinese. JinkoSolar led in 2019 with 12% market share, and the top ten collectively had 70%, with the concentration increasing over time. According to Raymond James, China is currently producing close to three-quarters of the world's modules – approximately double its share of demand.

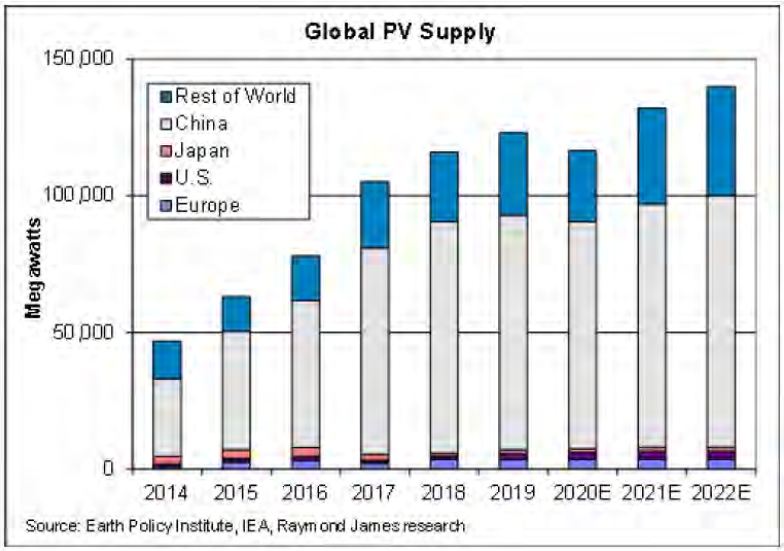

Figure 15: Global PV supply

The PV value chain has a historical pattern of periods of overbuilds followed by proverbial "hangovers." Overbuilds tend to occur when developers are rushing to get their projects connected in advance of subsidy cuts. History appears ready to repeat itself again. The U.S. is poised to experience a similar phenomenon in 2023. The federal Investment Tax Credit (ITC) was extended for two years at the end of 2020 and then will step down to 10% (for utility-scale projects and commercial systems) and 0% (for residential systems) after the end of 2022. There is certain to be some demand pull-in in 2021, but it is not expected to be as dramatic as in periods past.

2021 also stands to benefit from the post-pandemic catch-up in installations around the world. Many companies had to halt to slow installations either due to lockdowns or based on precautionary measures, 2021 should have a comparatively normal operational tempo.

As part of Emerald's 10-Step Process, we look at an individual company's customers, suppliers, distributors, and competitors. As an example, one thing we have our eye on in the solar market is reports of bottlenecks due to a glass shortage. The world's largest solar power company by market capitalization is citing a shortage of glass as the reason for rising costs and delayed production of new solar panels.

According to a recent article in the Philadelphia Inquirer, "[p]rices for glass that coats photovoltaic panels have risen 71% since July, and manufacturers are struggling to produce it fast enough to keep more

than a week's worth of sales in inventory… The shortage comes as the solar industry turns toward bifacial panels, which increase both power output and glass requirements."[24]

For panel makers, glass now accounts for about 20% of the total cost of production, up from about 10%. Because glass factories take so long to build, the solar industry could be 20% to 30% short of the glass it needs next year, with the market not being back in balance until 2022.

Also from the Philadelphia Inquirer, "[t]he shortage is coming at an inopportune time as solar developers are rushing to finish projects by the end of this year to secure government subsidies. It also threatens to halt momentum just as the Chinese government considers increasing renewable power additions as the country aims to rein in pollution and become carbon neutral by 2060."[24]

***Emerald's Perspective**: For residential solar systems, in particular, we expect 2021 to be a markedly strong year, ticking downward slightly in 2022.*

The solar market has approximately $100B combined market cap but nearly half of it comes from three players. Similar to wind, Emerald considers all aspects of the solar supply chain as investment opportunities. PV trackers, for example, represent a below-the-radar category of hardware. Used principally in utility-scale projects, trackers enable modules to move with the sun, minimizing the angle of incidence vis-a-vis sunlight, and thereby improving the energy yield. Most trackers are single-axis, but there is also the more sophisticated dual-axis variety.

Further, Emerald has been an investor in companies that engage in the design, development, and manufacture of micro-inverter systems for the photovoltaic industry, as the industry has largely been able to resist losing market share to Chinese technology players.

Energy Storage

One of the biggest concerns with a rise in wind and solar is that energy generation fluctuates over time; the sun is not always shining and the wind is not always blowing. So, how can you balance the grid with these instabilities? First, nature does some of the balancing automatically; solar power generation is highest in the summer and lowest in the winter. Wind power is greatest in the spring and fall and wind turbines work at night when solar panels are dormant.[25]

It is possible to design a system that has excess capacity, approximately 150% of the base, that is capable of powering the entire U.S. with only wind and solar. While possible, that is not likely to be the scenario for several years, if ever. Our current best alternative is to focus on storage. Any excess power generated on a particularly bright day would be stored and then distributed to the grid while the sun is down. The same logic applies to wind power. Power can be stored in several ways, for example in batteries or by pumping water into elevated tanks and then letting the water fall at night and turn a turbine.

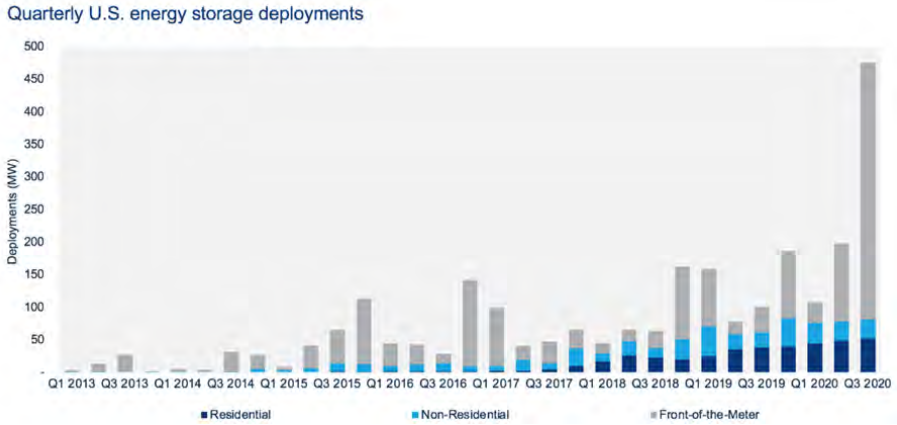

Figure 16: Quarterly U.S. Energy Storage Deployments

Large-scale battery storage has exploded over the last several years and is expected to continue to grow at a very fast clip. Large-scale battery storage doubled in 2020 and is expected to grow more than 6x in the next five years.

In 2013, The California Public Utilities Commission (CPUC) set a target of 1.325 gigawatts of storage to be commissioned for the state's grid by 2020. The goal has been surpassed as over 1.5GW of projects are now approved and 500MW are already installed.

As a whole, the US's utility-scale battery power is set to grow from 1.2 gigawatts in 2020 to nearly 7.5 gigawatts in 2025, according to Wood MacKenzie, a natural resources research and consulting firm.[21]

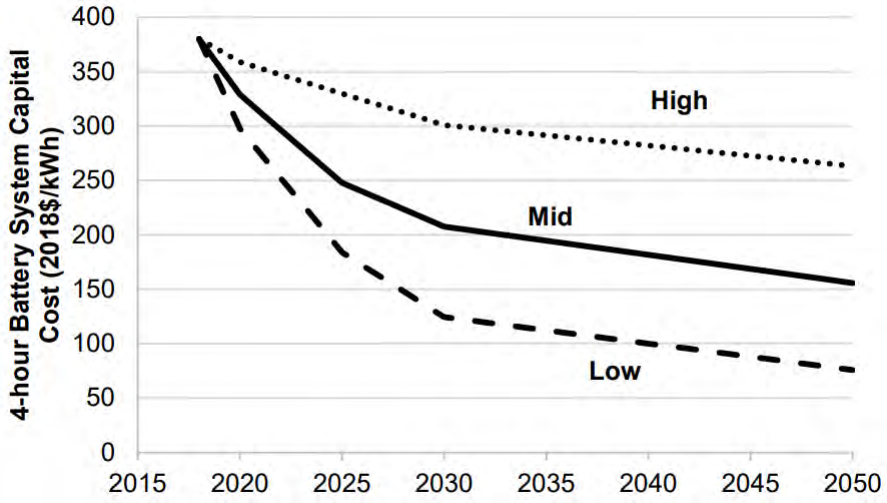

Figure 17: Capex to produce a 4-hour battery system

Only a few years ago, utility-scale battery storage was a pipe dream, mainly because of the prohibitively high costs. That is no longer the case. The average energy capacity cost of utility-scale battery storage in the United States has decreased nearly 70% between 2015 and 2018 from $2,152 per kilowatt-hour (kWh) in 2015 to $625/kWh in 2018.[26] What's more, mid-range costs for lithium-ion batteries are projected to fall an additional 45% between 2018 and 2030.[27]

***Emerald's Perspective**: Power storage is also close to a combined $100B market cap. Power storage comprises EV battery suppliers as well as companies providing storage for the grid. Historically, just about the only U.S.-listed names in this value chain had been lithium suppliers. In 2020 there were a few notable special purpose acquisition companies (SPACs) with a few more set to begin trading in 2021. Power storage is a new and rapidly evolving industry and Emerald has invested in companies involved in the design and manufacture of power generation and storage products.*

Hydrogen

Hydrogen is a colorless and odorless gas and is the most abundant element in the universe. Hydrogen is very versatile, both in its production and in consumption: it is light, storable, has high energy content per unit mass, and can be readily produced at an industrial scale. The key challenge comes from the fact that hydrogen (in its ambient form as a gas) is the lightest element and so has a low energy density per unit of volume, making long-distance transportation and storage complex and costly.

Hydrogen can be brown, gray, blue, or green depending on feedstock and carbon intensity.

- Brown hydrogen uses coal as a feedstock,
- Gray uses natural gas,
- Blue uses a fossil fuel feedstock coupled with carbon capture and storage to reduce greenhouse gas emissions, and
- Green uses renewable electricity in the production process.[28]

After decades of hope, we believe the "green hydrogen economy" is still a while away. Green hydrogen is often touted as the ideal because neither production nor use of hydrogen generates carbon

emissions. Foundational in the green hydrogen economy is that electrolysis can split water into its component molecules to produce oxygen and hydrogen and that renewable electricity can be used to power the electrolysis required. This is currently uneconomical due to the high costs of electrolysis. Approximately 95% of commercially available hydrogen is currently produced via steam methane reformation (SMR) of fossil fuels.

Clean hydrogen is currently costly to produce, 1.3-2x higher for 'blue' and 2-7x for 'green', compared to 'grey.'[29]

Blue hydrogen has a strong cost advantage in the near and medium-term but green hydrogen may become cost-competitive by the end of the decade in low-cost renewable locations thanks to higher electrolyzer utilization and lower cost of electricity.

***Emerald's Perspective**: We believe Emerald has extensive experience investing in companies involved in the manufacture of engineered equipment to the industrial gas and energy industries including hydrogen. We also have experience investing in some of the leaders in designing and constructing a large percentage of the current hydrogen production facilities worldwide. These companies are likely to be leaders in the production of green hydrogen.*

The US Department of Energy released a study in February of 2020 on the potential for Hydrogen using electrolysis rather than SMR. Even assuming lower electricity costs and 30%-60% declines in upfront electrolyzer capital costs as production increases, the DoE estimates future costs of $4.5 - $5.0/kg of green hydrogen. That is still significantly higher than current state-of-the-art SMR hydrogen costs of just $1.15 per kg using current natural gas prices.[3]

J.P. Morgan explains, "[i]f electricity costs fell to 3 cents per kWh (i.e., in the range of current wind and solar PPAs but without incorporating utility costs for transmission infrastructure), the DoE estimated that hydrogen production costs could fall to $2.0 - $2.5 per kg of hydrogen, which is closer to but still above current SMR costs. This scenario would require co-located renewable energy dedicated to hydrogen production."[3]

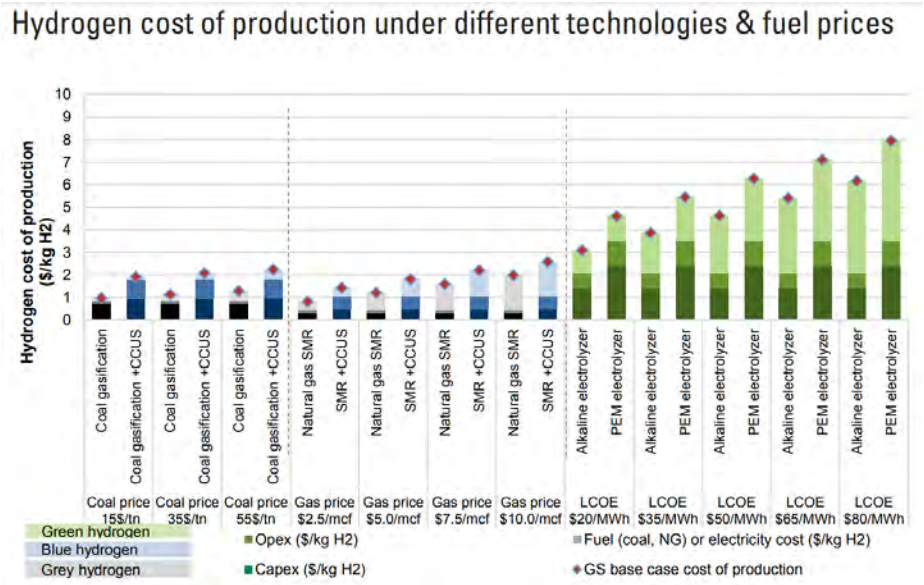

Figure 18: Hydrogen cost of production under different technologies & fuel prices

Hydrogen may inject life into midstream companies. Midstream companies may benefit from a transition to hydrogen due to their involvement in the storage and transportation of hydrogen as well as from CCS in the generation of blue hydrogen.

According to RBC Capital Markets, "[e]xisting natural gas transportation and storage infrastructure will be key in making green hydrogen economics viable (eliminating the high initial cost of building an entirely new and expensive hydrogen pipeline system; costs to build a hydrogen pipeline system could decline as hydrogen production increases in scale)."[28]

***Emerald's Perspective**: In the near term, natural gas-focused midstream companies may benefit as their pipelines and storage facilities can accommodate some level of hydrogen with minimal modification. Over the long term, midstream companies could re-purpose existing pipelines to hydrogen or build networks of hydrogen pipelines given their pipeline expertise.*

RBC Highlights three additional opportunities for midstream companies.

(1) Hydrogen can provide a new growth opportunity for midstream companies. Hydrogen could extend the life of the existing assets and provide an opportunity to build new assets, which could enhance midstream valuations and change investor perception of midstream terminal values.
(2) Hydrogen can help midstream companies participate in the energy transition as more countries, states, and corporations strive to lower GHG emissions. Midstream companies can play a bigger role in global decarbonization, and as such, could access a new pool of investor capital.
(3) Hydrogen could help lower midstream companies' methane emissions. Hydrogen has no GHG emissions and midstream companies could lower their methane emissions by lending hydrogen into natural gas pipeline systems or converting some natural gas pipelines or storage to hydrogen.[28]

We believe that hydrogen is extremely well-suited for some applications and a terrible fit for others. Hydrogen's main use at the moment is in industrial applications. Essentially all hydrogen is currently generated from fossil fuels; less than 0.1% of dedicated hydrogen production comes from water electrolysis. The appeal of hydrogen is that it potentially has wide applicability given falling renewable electricity prices and falling costs of electrolysis.

Hydrogen can store energy, which allows it to function as a battery to complement renewable electricity. RBC explains, "[i]t also has potential to help decarbonize areas in which electricity has limitations such as heavy trucking, long-range road transport, aviation, and industrial processes such as steel making."[28]

We believe one of the end-uses of hydrogen with the most research, and likely the most hype, is mobility. While current research shows Hydrogen's feasibility in many modes of transport, some, like aviation, need more research to overcome potential safety concerns around flammability and pressurization. Hydrogen is a better energy storage option than batteries from a weight perspective and can also take less space if stored in compressed form.

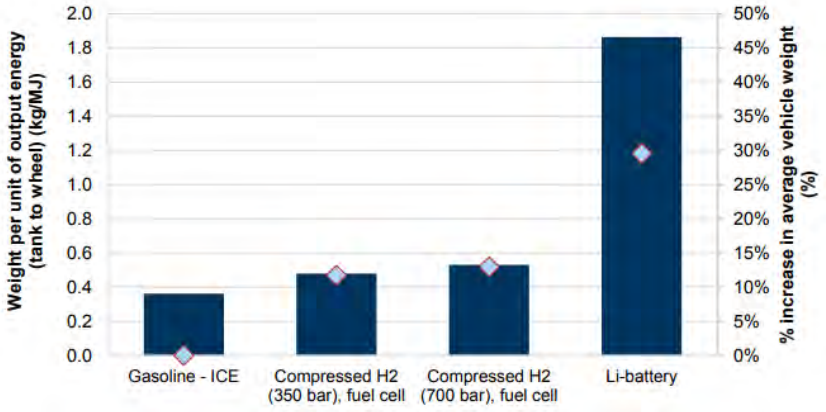

Figure 19: Weight per unit of output energy (tank-to-wheel) and % increase in average vehicle weight

Compressed hydrogen becomes more cost-competitive for long-haul transport given its high energy content per unit mass (and need for less frequent refueling) but one of its primary weaknesses remains its low overall well-to-wheel efficiency.

We believe the trucking industry stands out as one with a very strong hydrogen use case. Battery electric technology is better developed and suited for use in shorter-haul routes where trucks make their runs and then return to a central charging depot overnight. This implies best end-uses as garbage, busses, last-mile delivery, etc.

Over larger distances, however, batteries may not be as suitable. First, batteries degrade which impacts the economics of the truck and truck route. Second, batteries are heavier than hydrogen fuel cell storage. This could be a 3,000-5,000lb difference. Payload and vehicle capacity are two of the most important drivers of the economics of transportation. The weight of a battery limits payload and hauling capacity and thus impacts the potential revenue a truck can generate. Finally, to fully charge an electric battery truck may take several hours, however, a fuel cell truck can be recharged in approximately 15 minutes, on par with diesel.

Despite all of these benefits, energy density, faster charge times, resiliency, and ability to operate in colder temperatures, adoption isn't necessarily right around the corner. The technology is still relatively new and unproven compared to batteries, plus the fueling infrastructure is very limited.

Natural Gas

Natural Gas is still technically a fossil fuel which some investors say immediately disqualifies it from a clean tech conversation. Emerald disagrees for two reasons. First, natural gas is assisting in the shift from petroleum, and second, in the conversation about carbon intensity, renewable natural gas (especially from dairy farms) has the lowest GHG emission profile possible, registering at ~-300 vs. +100 for diesel.

A single LNG cargo can displace 140-200 metric tons of carbon, as compared to coal (this includes all emissions, from production, liquefaction, transport, and the ultimate consumption of gas).[30]

According to a Raymond James Report, "CNG is a gasoline substitute, used in passenger cars, light trucks, and buses. LNG is a diesel substitute, used in buses and heavy-duty trucks. LNG can also be used in "high horsepower" applications – railroad locomotives and marine vessels – but these are early-stage end markets. Relative to LNG, CNG is much more mainstream, due to its lower cost structure and also the fact that it can be easily produced on-site at fuel stations."[14]

As it refers to Clean Tech, Emerald believes the most interesting piece is RNG, renewable natural gas. Renewable natural gas is a catch-all term for both CNG and LNG derived from bio-based gas, sourced from landfills and agricultural operations. RNG comprised 39% of the natural gas fuels in the U.S. in 2019. RNG's growth rate - volumes nearly tripled since 2015 - is outpacing the conventional variety, despite RNG's generally higher costs.

Electric Vehicles and Autonomous Vehicles

Within the clean tech sector, the EV vertical by far has the highest market cap and the number of stocks doubled in 2020, largely due to SPACs. In 2019 there were 10 pure-play EV companies. By the end of Q1 2021, there will be 24.[31] This reflects numerous IPOs and especially SPAC transactions, the latter including several high profile names. Similarly, EV charging companies will increase from two to five as three SPACs start trading.

EV Adoption is Much Lower than Estimates from 5-10 Year Ago Predicted. The current size of the EV market is smaller than many might think. However, as Raymond James notes, "the long-term opportunity is much more needle-moving, which explains the willingness of all major automakers to participate in the market, even if sales to date have not impressed."[14]

There were 82 distinct EV models available in the U.S. during the 2020 model year, nearly tripling from the level of 2015. OEMs in Europe and China have numerous brands that are available only in those geographies, so the worldwide total is at least twice the U.S. figure. Raymond James forecasts a 50% increase in the number of U.S. models by 2023.

It is safe to assume that some of the EV startups of late will not succeed in scaling up operations or at least take longer than planned. However, that will not change the fact that this is already an intensely competitive market, and it will assuredly become even more crowded over the next three to five years.

Global EV sales in 2019 totaled 2.2M. 2020 is expected to increase approximately 16% to 2.6M, which of course needs to be taken within the context of COVID, shutdowns, and wavering consumer confidence. Raymond James forecasts a 40% increase to 3.6M in 2021 which includes the "post-crisis catch-up." Their forecast ends at 11.5M in 2025.

EV market share is dramatically different by country. Generally, adoption is highest in Europe, but it is not at all uniform. Norway, for example, is the highest by far. EV represented nearly 70% of sales in 2020. Raymond James details that "[t]he Netherlands, Sweden, Finland, and Denmark were also well into the double-digits. The top European economies were considerably lower, with Germany near 10%, France near 9%, and Italy near 3%. Looking at other major economies, China was near 6%, the U.S. near 3%, and Japan near 1%. On a worldwide basis, EVs topped 1% for the first time in 2016, reaching 2.5% in 2019 and an estimated 4% in 2020 - the latter, of course, in the context of a COVID-depressed auto market overall."

Raymond James' forecast of 11.5 EV vehicles sold in 2025 would represent 12% global market share within an overall auto market of 95 million.

Changing Consumer Preferences

Improving economics is a large driver behind the growth of renewable energy, but there are other drivers. There is a subset of customers willing to pay more for renewable power as a way of being "green." Similarly, distributed generation with battery storage can provide many customers with peace of mind. Residents of communities in areas that have experienced significant power outages are more inclined to favor self-generation and backup power. California is a great example due to a history of earthquakes and worsening wildfires but the trend is present in Texas, Florida, and Puerto Rico.

What does Emerald look for in traditional and renewable energy stocks?

This paper only begins to scratch the surface of the amount of research Emerald has done in the renewable energy and clean technology space. *We will end with a few points on how we identify investable companies in this space.*

While some investment firms use a rigorous screening process, we are trying to find companies before they appear on screens. Our preference is always under-covered and under-followed stocks, although this is becoming a bit harder. Emerald is looking for companies with large and growing TAMs, that are gaining market share and have a fairly clear path to continue taking share. We are looking for companies with proven technologies and are either profitable or have a path to profitability. We are not interested in investing in "science fair projects," though we will certainly keep our eye on them.

Our view is that major players in this space are generally not small-cap companies for long, if they ever were. As a result, Emerald looks up and down the value chain to find companies that fit our criteria. Some of our favorite investments have been of the "picks and shovels" strategy, that is to supply an industry with an in-demand good but to be agnostic of wins share further downstream.

Within the energy space, we are looking for commodity price beneficiaries who are price leaders, not price takers. Negative gross margins and "story stocks" are generally a big red flag. Ideally, we like companies helping to drive down the energy cost curves and who will be leaders in the renewable energy sector, in that they are fuel stock agnostic.

Works Cited

[1] S&P Global – S&P500 Sector Breakdown
[2] Bespoke Investment Group - Utilities Now Larger Than Energy — S&P 500 Sector Weightings
[3] JPM – 10th Annual Energy Paper
[4]Reuters - Honda to cease diesel vehicle sales in Europe by 2021
[5] CNET - BMW will discontinue diesels in the US for 2019
[6] General Motors Investor Relations - General Motors, the Largest U.S. Automaker, Plans to be Carbon Neutral by 2040
[7] PR Newswire - United Makes Bold Environmental Commitment Unmatched by Any Airline; Pledges 100% Green by Reducing Greenhouse Gas Emissions 100% by 2050
[8] Bloomberg - Walmart Aims to End Emissions From Global Operations by 2040
[9] S&P Global - Saudi Arabia expects more than $20 bil investment in renewables over a decade
[10] The Philadelphia Inquirer - New leader vows Japan will be carbon-neutral by 2050
[11] Raymond James - The EU Mandates Carbon Neutrality by 2050... How Exactly Will That Work?
[12] EIA - What is U.S. electricity generation by energy source?
[13] EIA - Electricity in the United States
[14] Raymond James - Clean Tech Primer 2021: Climate Mitigation, Adaptation, and Investing
[15] EIA - Renewables account for most new U.S. electricity generating capacity in 2021
[16] EIA - Electricity in the United States
[17] AppliedEnergy Journal - Volume 190, Pages 191-203
[18] Goldman Sachs - Americas Clean Energy: Headed to 640 GWs of US renewables by 2035
[19] NPR - Biden Moves To Have U.S. Rejoin Climate Accord
[20] ScienceMag - Fossil electricity retirement deadlines for a just transition
[21] BBC - The batteries that could make fossil fuels obsolete
[22] Bloomberg - Old Coal Mines Can Win a Second Life as Green Energy Hotspots
[23] EIA - 2020 could be a record year for U.S. wind turbine installations
[24] The Philadelphia Inquirer - Glass shortage threatens solar supplies
[25] American Energy Action - Study: Wind and Solar can power most of the United States
[26] EIA - Utility-scale battery storage costs decreased nearly 70% between 2015 and 2018
[27] National Renewable Energy Laboratory - Cost Projections for Utility-Scale Battery Storage
[28] RBC – Hydrogen is the new Green
[29] Goldman Sachs – Carbonomics The Rise of Clean Hydrogen
[30] Cheniere Energy - 2019 Corporate Responsibility Report
[31] Raymond James - After 2020's 200% Surge, Sector Market Cap at $760 Billion - And That's Without Tesla