Pickering Energy Partners Investments

SAILINGSTONE CAPITAL PARTNERS LLC

A Pickering Energy Partners Company

Renewable Constraints

The Energy Transition – A Realistic Look at the Path Forward

January 10, 2022

We cannot wait until the world's economy is powered entirely by renewables, if that is even possible; we need to mitigate greenhouse gas emissions right now. Combatting climate change means taking a pragmatic approach to what is feasible today and identifying and capitalizing the innovators who will deliver solutions for tomorrow. By encouraging the responsible production of key enabler commodities like natural gas, copper, lithium, and aluminum, investors and policy makers can both accelerate and lower the price tag of the Energy Transition.

See important disclosures at the end of this report.

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"If you define the problem correctly, you almost have the solution."

– Steve Jobs

INTRODUCTION

For many, the energy transition is synonymous with renewables. While it is true that wind and solar power will play a critical role in reducing carbon emissions, there are several important constraints that will likely limit renewables to roughly 20-40% of total power supply in most markets over the next several decades. This reality is not fully appreciated by many investors and policy makers today.

To be clear, we are not bearish about the growth prospects for renewables. In fact, using estimates from ThunderSaid Energy, capital spending on wind and solar projects will need to increase by at least 3x over the next 20 years, from about $0.3 trillion per year to $1.0 trillion per year or more, in order for renewables to grow to 20% of total energy supply and 40% of total power generated. A higher mix for wind and solar would require an even higher level of spending.

Like so many other facets of our polarized society though, the energy transition has unfortunately been characterized as an "all or nothing" proposition between fossil fuels and renewables. The reality, of course, is much more nuanced since both will be needed for many, many years.

The real question that needs to be answered with respect to the energy transition is what the optimal energy mix will be in each market that will allow for an adequate reduction in carbon emissions while also meeting global energy demand in the most cost-effective way possible. The debate needs to shift to addressing emissions, costs, and grid stability as soon as possible since CO_2 does not degrade over time in the atmosphere. Indeed, the timing and the magnitude of the absolute reduction in emissions matter far more than the extent to which fossil fuels remain part of the solution.

In this note, we discuss some of the real-world constraints associated with renewables. Then we outline a framework for evaluating potential solutions that address both carbon emissions and energy demand before concluding with a potential roadmap of what the energy transition will look like and what it will require from investors.

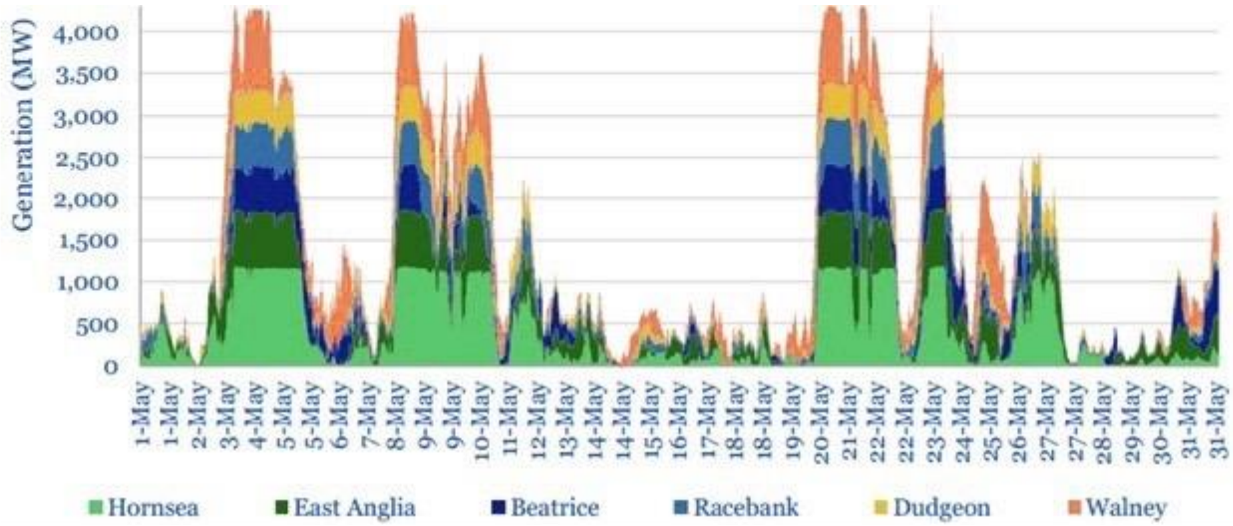
RENEWABLE CONSTRAINTS

In order to understand the future role for renewables and other sources of energy, investors need to appreciate how the grid works, the intermittent nature of wind and solar power, and the significant amount of both capital and land required for new renewable projects.

Variability

The most obvious and important constraint for renewables is the volatility of the power generated by wind and solar projects. Output can vary by the second, hour, day, and season, and variations in supply tend to be highly correlated within the same markets. The chart below highlights hour-by-hour power generated by the largest wind projects in the United Kingdom. These projects are hundreds of miles apart yet appear to be highly correlated. Weather conditions are far from a localized phenomenon.

Figure 1 - Wind Power Generation in the United Kingdom



Source: Thunder Said Energy

More broadly, capacity utilization for different assets ranges from 10-40%; with an average of around 20% for solar, and 30% for wind. There are times when wind and solar may supply 100% of the required power in a market and times when renewables supply 0%. The significant variability in power generated from wind and solar projects and the strong correlation in output between projects in a market means that other sources of energy are required to meet demand. While batteries and other forms of storage will meet a portion of power demand when renewable utilization rates are low, it is unlikely that renewable-backed energy storage projects will represent a meaningful portion of overall demand over the next 10-20 years given current costs and technical limitations, particularly for long-duration storage.

Grid Stability

In addition to providing more stable supplies of energy, conventional power turbines also stabilize the electrical grid by providing inertia, reactive power, and frequency responses that help to offset sudden changes in supply and demand.

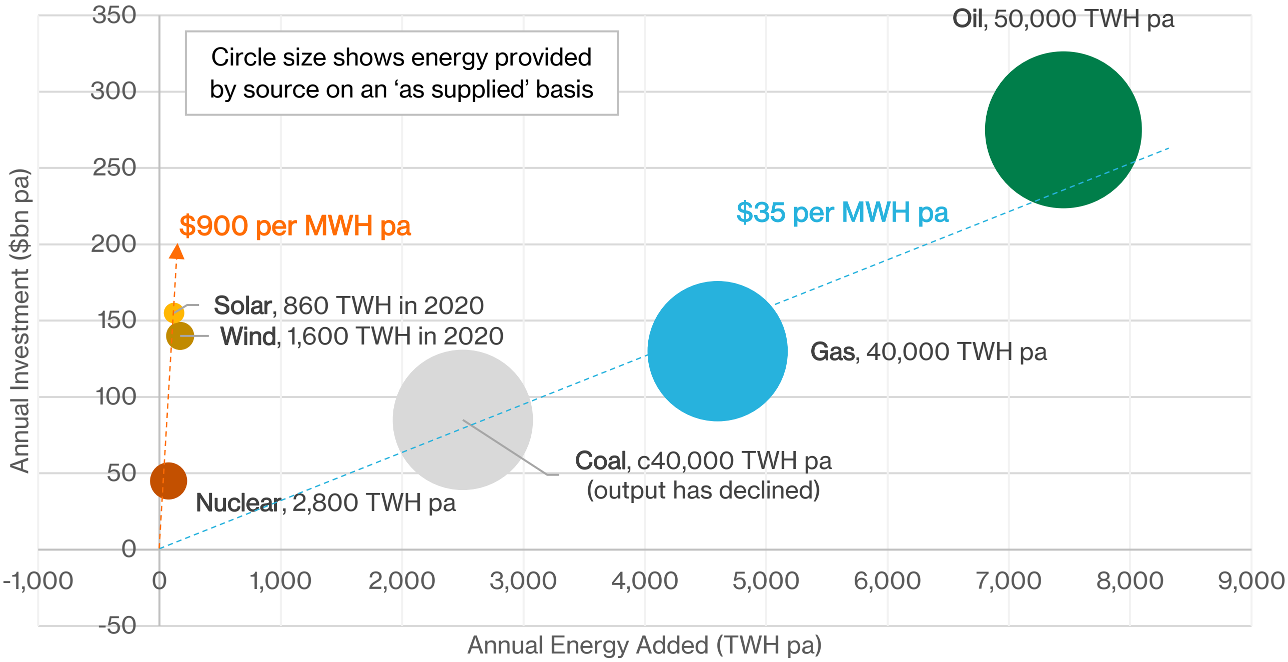
Renewables not only increase the volatility in electricity supply, but they also fail to provide the same level of inertia and reactive power as conventional power turbines. Given the sensitivity of most consumer and industrial equipment to sudden fluctuations in power generation (let alone the ability of the grid's infrastructure to handle input volatility), it is likely that grid stability will be a limiting factor for renewables in most markets, at least until new technologies are developed.

Costs

Although wind and solar projects are cost competitive on a per MWH basis, renewable projects are much more capital-intensive than other forms of energy and require significant investments in backup power in order to support the grid.

Whereas fossil fuels have a capital intensity of roughly $40-100 per MWH per year, renewable projects require $800-1,000 per MWH per year, as shown in the chart below from ThunderSaid Energy. Renewables are at least 10-20x more capital intensive than fossil fuels. For every dollar taken out of fossil fuels, $10-20 need to be reinvested in renewable projects. This alone will be a limiting factor in some markets where capital is relatively scarce.

Figure 2 - Capital Intensity of Energy Projects

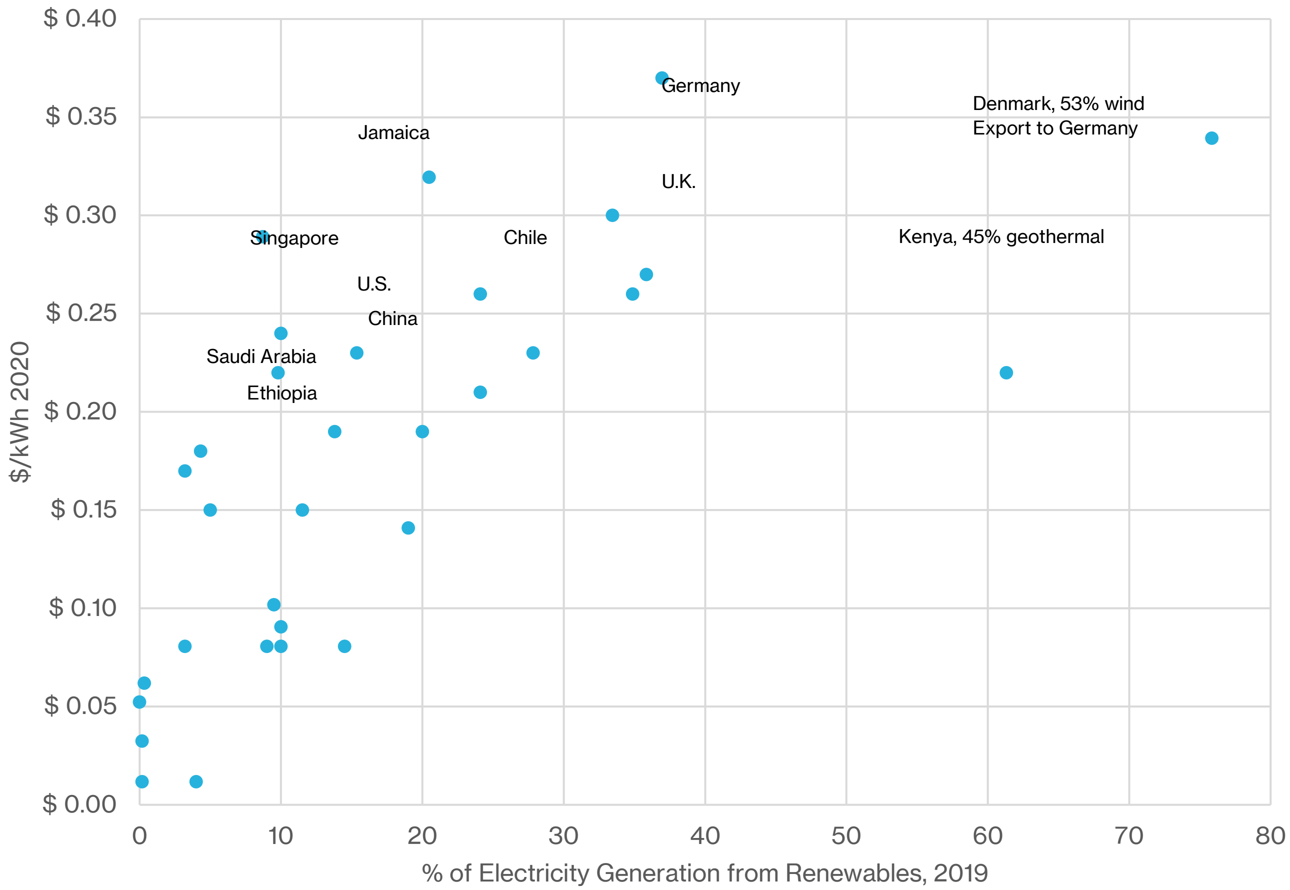


Source: Thunder Said Energy

In addition, renewable projects require a significant amount of backup power in order to stabilize the electrical grid due to the tremendous amount of variability inherent in wind and solar energy. This backup power comes from batteries, other forms of energy storage, including hydrogen, and the cycling of conventional power turbines, including both natural gas-fired power plants and nuclear power plants. Whereas renewable energy has zero variable costs and low fixed costs, conventional power supplies have high fixed costs. When renewables only partially displace conventional plants, those high fixed costs are amortized over lower volumes resulting in higher costs. Contrary to conventional wisdom, increased renewable penetration leads to higher, not lower power prices.

Traditional levelized cost analyses of renewables do not adequately incorporate the significant costs associated with providing backup power and grid support services. This explains why power prices increase as the share of renewables rise.

Figure 3 - Electricity Prices Correlated with Renewable Penetration

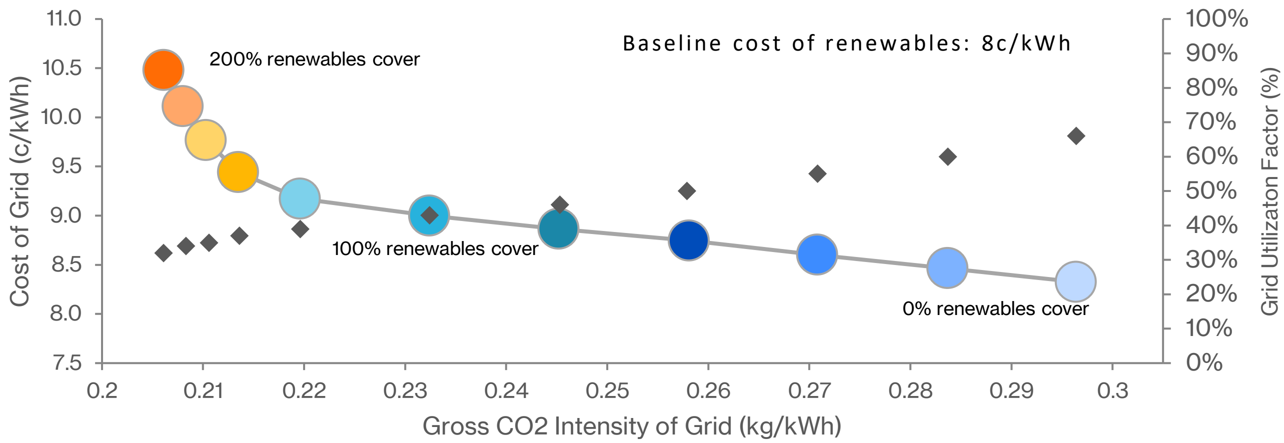


Source: SailingStone Capital Partners, https://ourworldindata.org/grapher/share-elec-by-source?time=latest, https://www.statista.com/statistics/263492/electricity-prices-in-selected-countries

Levelized cost analyses are to renewables what half-cycle economics are to the shale oil industry. Much like the disconnect between half-cycle and full-cycle costs, the disconnect between levelized costs and power prices reflects the omission of the significant amount of capital required to backup renewables and support the grid.

Importantly, electricity costs increase exponentially when renewable capacity moves much beyond 100% of total power demand, or 20-30% of total power generated. In addition, reductions in emissions become more marginal beyond 100% renewable cover. This makes sense since increases in renewable capacity beyond 100% of total power demand do not meaningfully reduce the amount of backup power that is needed to support the market when wind and solar are not available.

Figure 4 - Energy Cost and Grid CO_2 Intensity Based on Renewable Penetration



Source: Thunder Said Energy, Power Grids: Tenet?, September 20, 2021

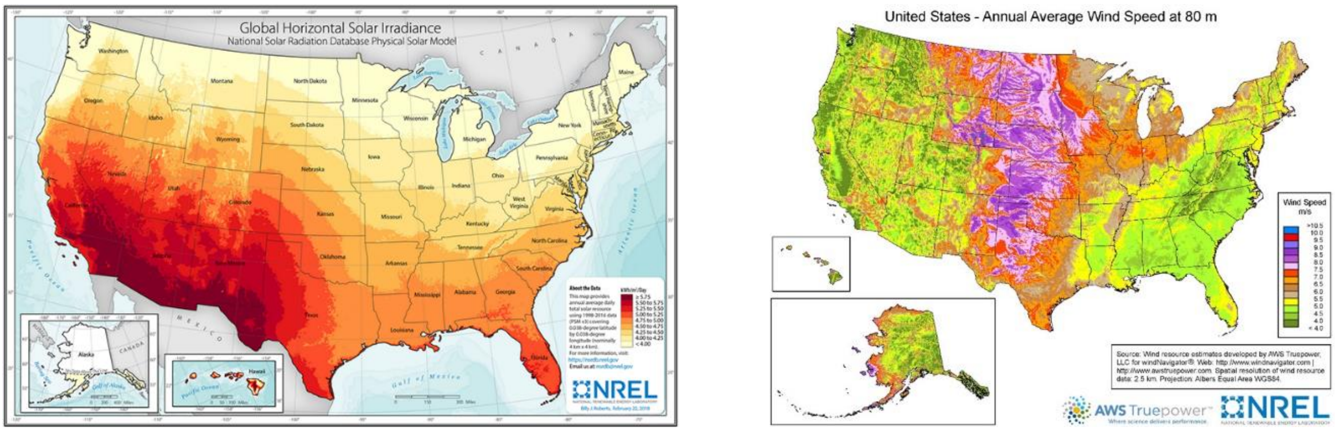
In many markets, the higher capital intensity of renewables and the higher consumer electricity costs will likely limit renewable penetration rates, especially beyond 100% of total capacity, or 20-30% of total power generation.

Land

Wind and solar power require about 10x the land per MWH produced than traditional energy sources. Furthermore, wind and solar resources vary tremendously by region and tend to be concentrated in certain areas. For instance, in the U.S. solar resources are more abundant in the southwestern portion of the country while wind resources tend to be concentrated in the Midwest and offshore. As a result, the availability of land with abundant wind and solar resources will be a constraint in some markets.

In addition, land rights issues and the ecological impact associated with renewable projects in environmentally sensitive areas are likely to become greater constraints for wind and solar energy. Communities have started to push back against new renewable developments and, at the same time, there is increasing attention being paid to the ecological damage created by wind and solar projects with large land footprints. We expect land availability to become a greater issue over time.

Figure 5 - Availability of Solar (left) and Wind (right) Resources in the United States



Source: EIA, NREL

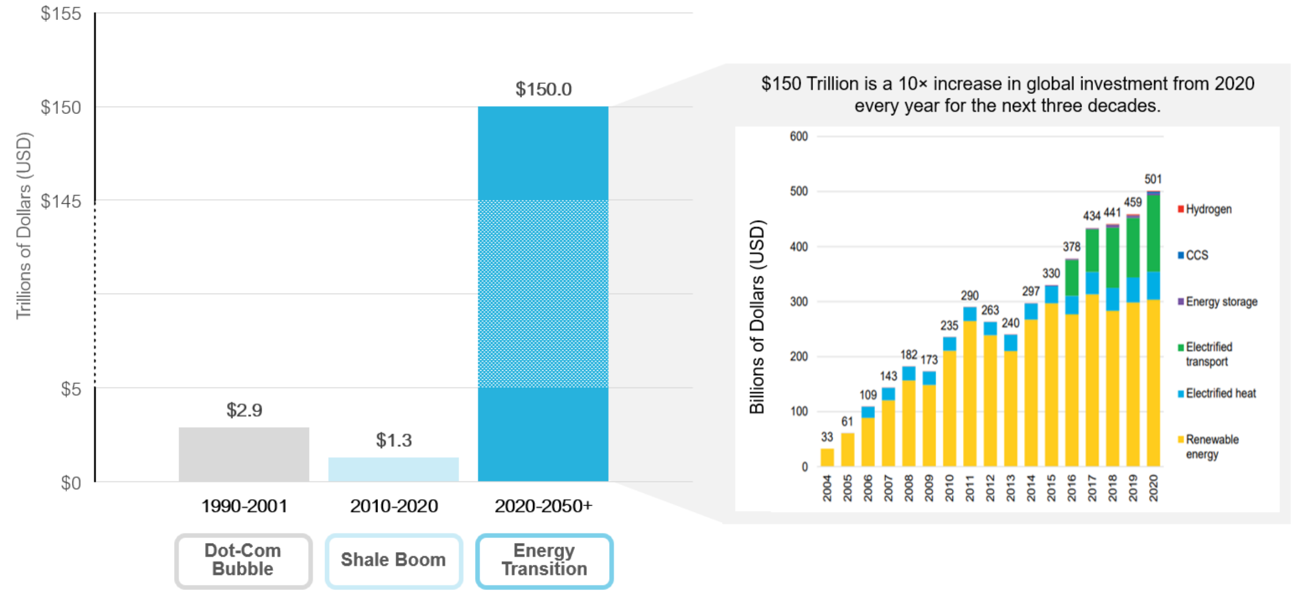
The point isn't that renewables won't play a meaningful role in decarbonizing the planet. Rather, the key takeaway is that there are a number of real-world constraints that will likely limit renewables to roughly 20-40% of total power generated in most markets over the next several decades.

Importantly though, the current constraints associated with renewables do not mean that countries will not be able to meet their emission targets. We believe that it is possible to decarbonize the global economy through a mix of renewables, energy storage, zero-carbon conventional power, natural gas, and carbon removal projects, including carbon sequestration and nature-based solutions. We discuss the investment implications in the next section.

A FRAMEWORK FOR EVALUATING SOLUTIONS

It is estimated that capital spending will need to increase by 10x from current levels to meet energy demand and carbon emissions targets. In total, roughly $150 trillion in investment will be required to support the energy transition over the next 30 years alone, making the energy transition one of the most capital and resource-intensive endeavors in history.

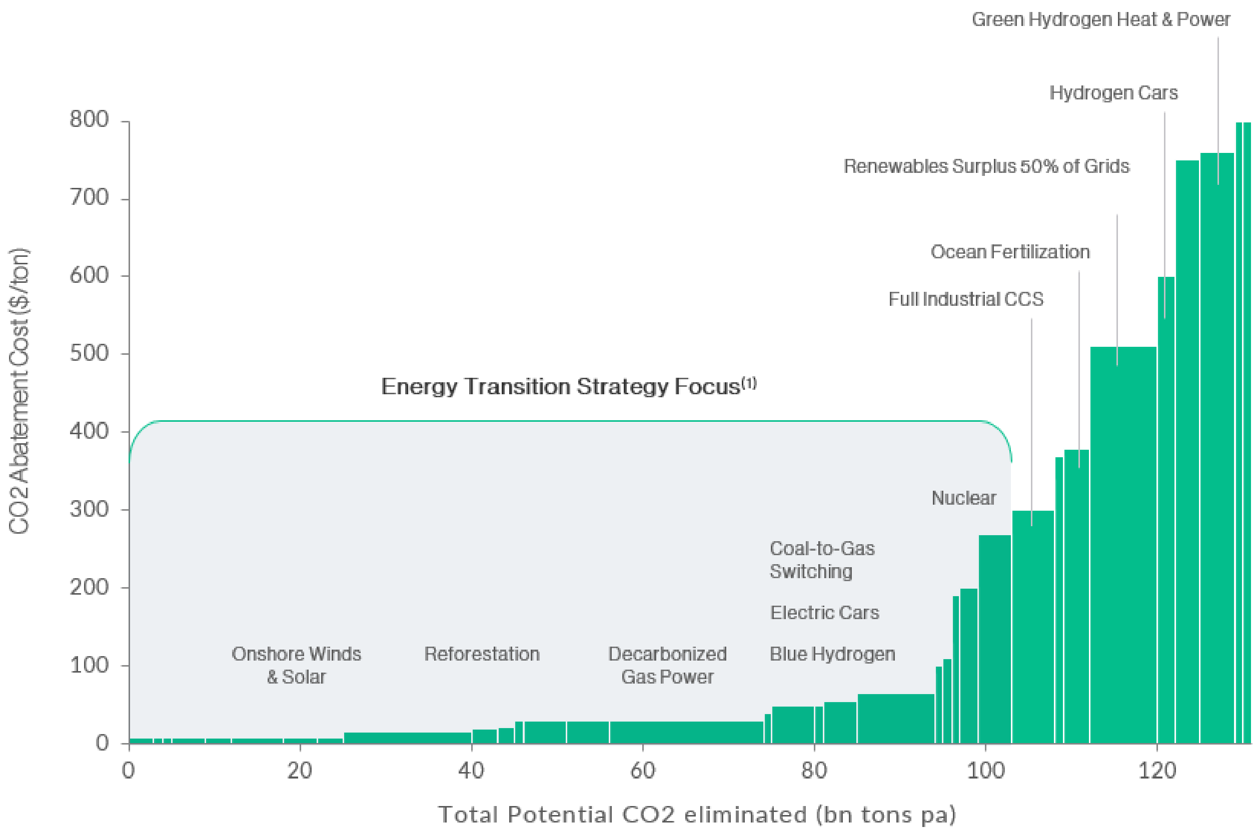
Figure 6 - The Energy Transition in Context



Source: CNNfn and Birinyi Associates, Rystad Energy, and the International Renewable Energy Agency (IRENA)

Nonetheless, few investors, and even fewer policy makers, have a framework for allocating capital to the solutions that will be necessary facilitate the transition to a lower carbon economy. As long-time investors in commodity businesses, we have always relied on supply cost curves to identify those projects that can supply the market in the most cost-efficient and lowest-risk way. Carbon abatement should be no different. The cost curve below shows the estimated magnitude and cost of the potential carbon abatement solutions that are available.

Figure 7 - Carbon Abatement Cost Curve



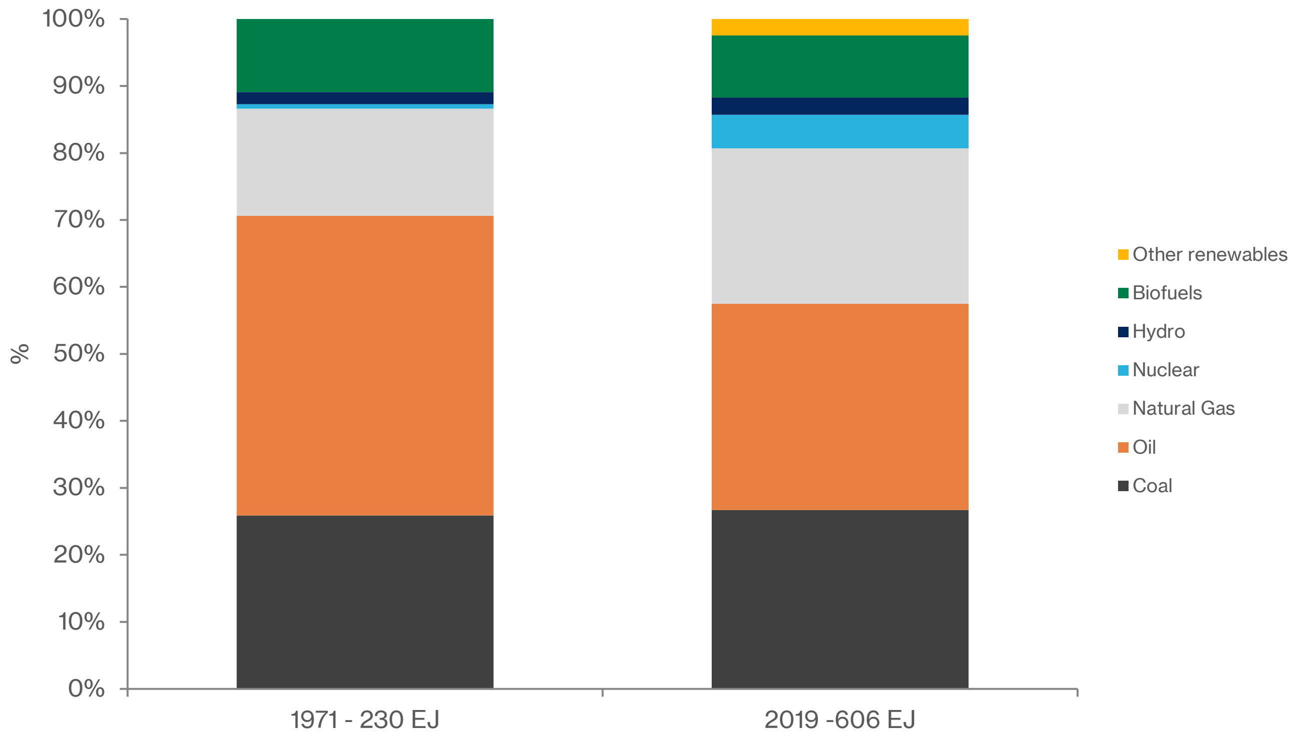
Source: Thunder Said Energy, Roadmap to Net Zero

The carbon abatement cost curve highlights how important renewables will be in the future. Wind and solar projects sit at the low end of the cost curve and represent one of the largest potential ways to reduce carbon emissions.

However, the cost curve also highlights the important role that other sources of energy and abatement solutions will need to play in the energy transition. For the reasons discussed above, renewables alone will not be sufficient to meet energy demand and address carbon emission given the scope of the problem.

Electric vehicles, nuclear power, carbon sequestration, and nature-based offsets will become increasingly important solutions given their low costs and scalability. Furthermore, replacing coal-fired power generation with natural gas (particularly when coupled with carbon sequestration and nature-based solutions) can help accelerate the reduction in carbon emissions, since coal still represents roughly 25% of total primary energy supply and long-duration storage is many years away from being commercial. Given that CO2 does not degrade in the atmosphere, the timing of the carbon abatement solution deployment matters as much as the cost and scale. Many of the higher-cost solutions on the cost curve, such as green hydrogen, are likely to be developed further out in time.

Figure 8 - Global Primary Energy Supply by Fuel



Source: IEA, Total primary energy supply by fuel, 1971 and 2019, IEA, Paris
https://www.iea.org/data-and-statistics/charts/total-primary-energy-supply-by-fuel-1971-and-2019

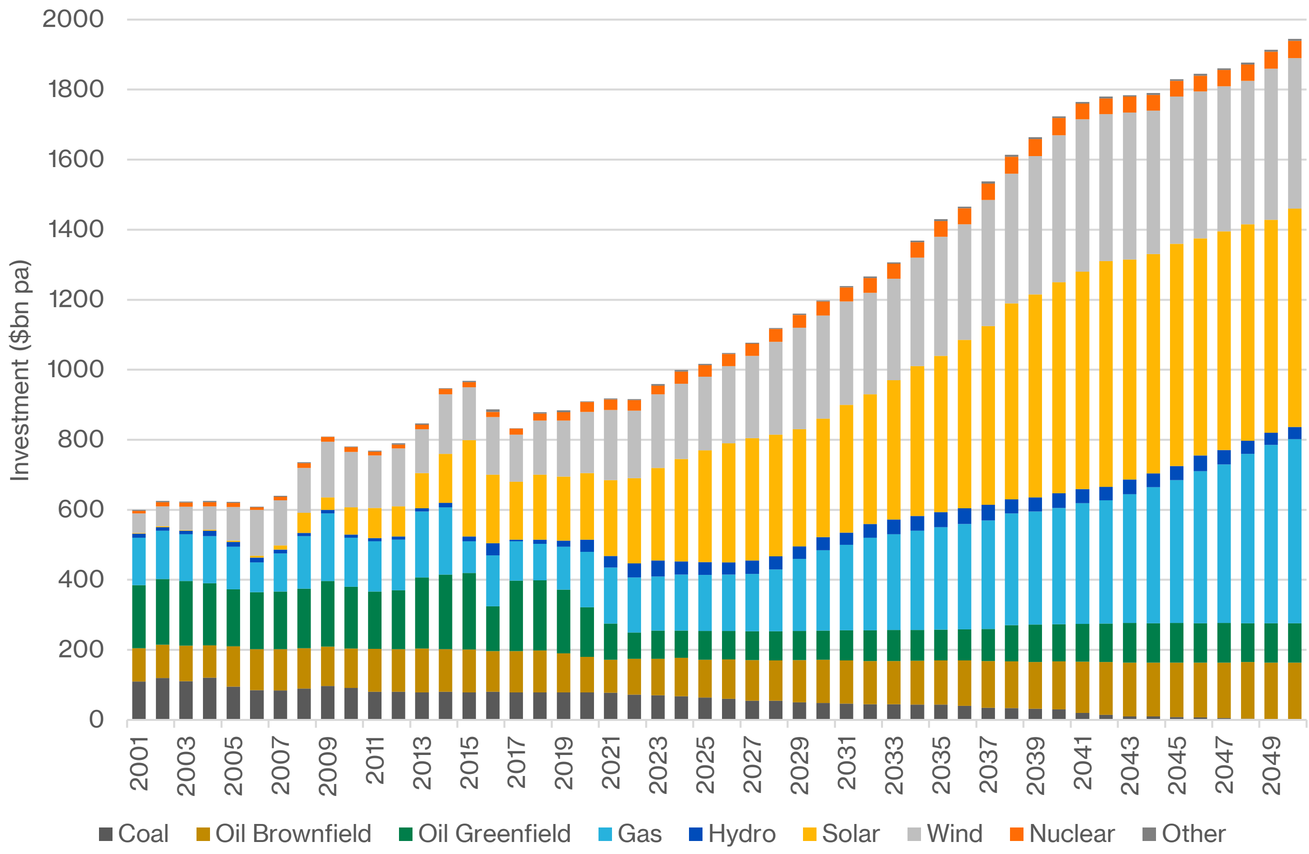
While the cost curve will change over time as new technologies are developed, we believe that investors and policy makers should use this framework when making capital allocation decisions. Investments should be based on how much the solutions reduce carbon emissions, their costs, and the timing of the abatement. The current "all or nothing" approach toward renewables and fossil fuels obfuscates the critical role that renewables and natural gas will both play for many years and risks delaying practical carbon-reducing solutions and causing energy shortages in the interim.

THE ENERGY TRANSITION ROADMAP

An understanding of the carbon abatement cost curve and the limitations of renewables help to provide a roadmap for what the energy transition may look like and what will be required of investors. If investors are serious about addressing both carbon emissions and global energy poverty, a significant amount of capital will need to be allocated to ALL of the economic carbon abatement solutions.

It is estimated that total upstream spending will need to increase from just over $0.8 trillion per year to nearly $2.0 trillion per year by 2050. While capital spending for renewables will be required to grow by at least 3x over the next few decades, it is important to point out that investments in natural gas will have to increase by 2-3x as well. It is also worth noting that while coal is phased out, there will be a need to continue to invest in oil projects to support those end markets that cannot be electrified.

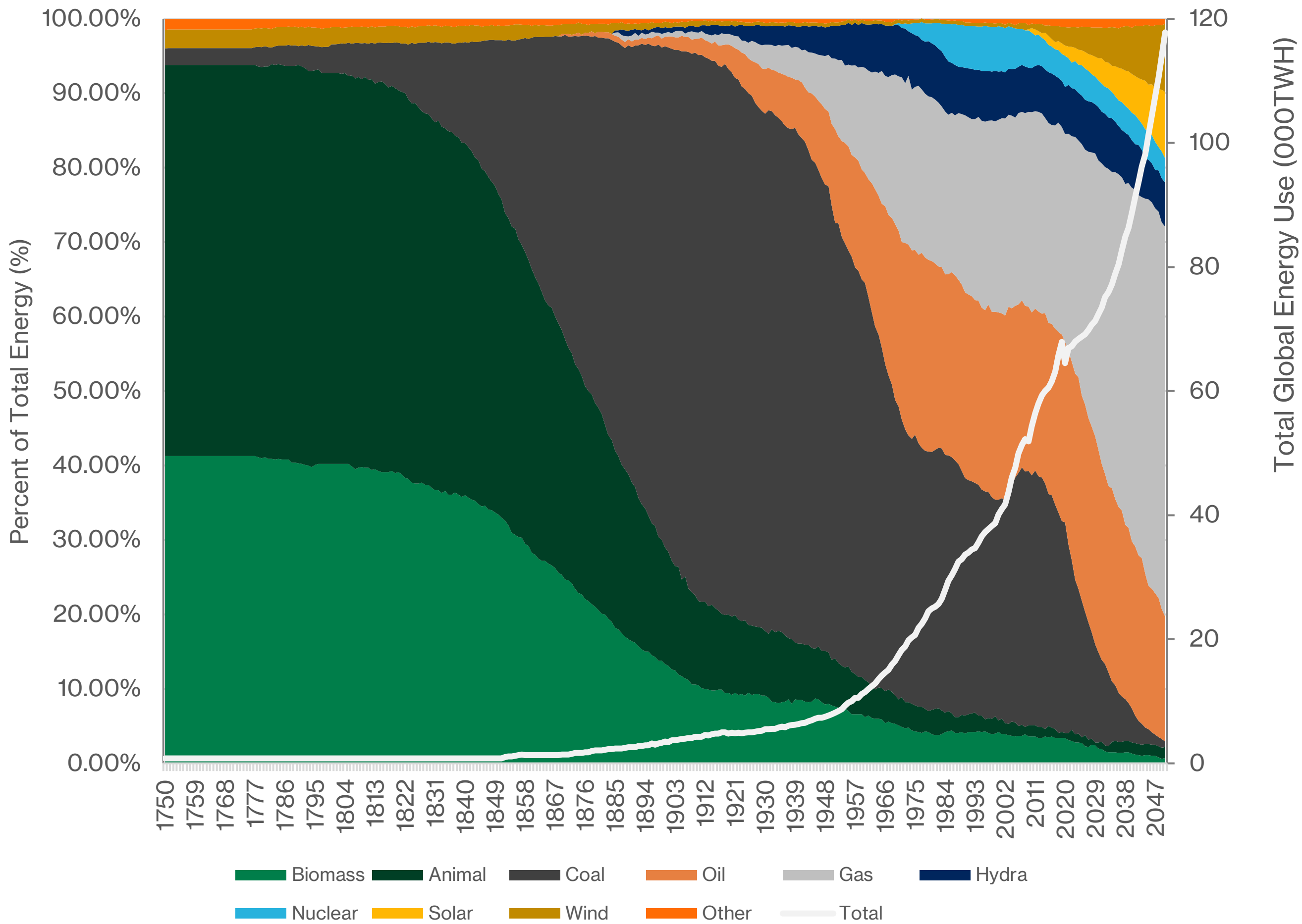
Figure 9 - Global Energy Spending Forecast



Source: Thunder Said Energy

With the forecasted level of spending above, it is estimated that the global economy can be decarbonized by 2050 while meeting energy demand. The resulting energy mix is shown below. It is possible that an even higher level of investment in renewables could increase the share of wind and solar power at the expense of natural gas, though we believe that renewables will be limited in many markets.

Figure 10 - Total Net Energy by Fuel Source: 1750-2050



Source: Thunder Said Energy, Power Grids: Tenet?, September 20, 2021

Divestment is not a solution; in fact, it is counterproductive. The energy transition will only be successful in reducing carbon emissions if trillions of dollars of capital are invested across multiple low-carbon energy sources and carbon abatement solutions.

More specifically, we believe that investments will need to be made in three verticals that are integral to the energy transition: renewables and energy storage, zero-carbon conventional power, and natural gas and carbon sequestration. The table below shows the three energy verticals and supporting businesses/commodities that are critical to the energy transition.

Figure 11 – SailingStone Capital Partners Energy Transition Verticals

We target specific components of the three energy systems that are central to the Energy Transition

Energy Systems	Renewable Power & Long-Duration Storage	Natural Gas and Carbon Capture & Sequestration	Zero Carbon Conventional Power
Energy System Sources	Solar Power Wind Power Green Hydrogen(1)	Natural Gas & LNG(*) Blue Hydrogen(2),(*) Combined Cycle Gas Turbine Power(*)	Geothermal Power Hydroelectric Power Nuclear Power
Upstream Commodities	Cobalt(*) Copper(*) Lithium(*) Nickel(*) Platinum(*) Rare Earth(*) Metals(*) Solar Salts(*) Silicon(*) Silver(*) Water(*)	Natural Gas(*) Waste Gas(*) Natural Carbon Sinks(*)	Geothermal Wells(*) Thorium(*) Uranium(*) Water(*)
Infrastructure Businesses	Hydrogen Transport & Storage(*) Power Transmission	Gas Transport & Storage(*) Gas Liquification & Transport(*) Regasification(*) Hydrogen Transport & Storage(*) Carbon Sequestration(3),(*)	Power Transmission
Downstream Businesses	Long-Duration Storage Technologies(*)	Carbon Capture (*) Direct Air Capture Ammonia Manufacturing & Storage(*) Industrial Gases(*)	Power Transmission
Applications	EV Manufacturing Electrolyser EV Charging Infrastructure Fuel Cell Manufacturing	Distributed Power Grid Optimization Software Residential Power Management Battery Manufacturing	BTM Software Demand Management THERE ARE 100's MORE

(*): SSCP Area of Interest/Expertise

Capital Availability: High Medium Low

Source: SailingStone Capital Partners, 2021

CONCLUSION

Any serious approach to investing in and supporting the energy transition requires an understanding of the carbon abatement cost curve. This provides investors and policy makers with a framework for making capital allocation decisions and a roadmap for what the energy transition will look like in terms of capital spending requirements and energy mix.

Renewables are a critical part of the solution. However, constraints related to the variability of wind and solar generation, grid stability, costs, and land mean that other sources of energy and other carbon abatement solutions will be required as well.

We believe that natural gas, nuclear power, carbon sequestration, and nature-based solutions will all be an important part of the solution, alongside renewables, in addressing carbon emissions and global energy poverty over the next several decades.

Timing is important as well. In order to eliminate the use of coal as quickly as possible, switching to natural gas is key. We do not see natural gas as just a "bridge fuel" over the next 20-30 years. We believe that decarbonized gas will play a critical role in the energy transition for many years.

Divestment, therefore, is counterproductive. Investment and owner engagement are the only ways to decarbonize the economy while meeting energy demand. Uniformed efforts to divert capital away from the areas that are needed to reduce carbon emissions will only lead to higher levels of emissions and higher prices for consumers.

We cannot wait until the world's economy is powered entirely by renewables, if that is even possible; we need to mitigate greenhouse gas emissions right now. Combatting climate change means taking a pragmatic approach to what is feasible today and identifying and capitalizing the innovators who will deliver solutions for tomorrow. By encouraging the responsible production of key enabler commodities like natural gas, copper, lithium, and aluminum, investors and policy makers can both accelerate and lower the price tag of the Energy Transition.