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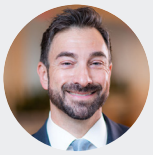
The solar coaster:

The twists and turns of an evolving investment opportunity set



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EXECUTIVE SUMMARY

Significant growth in electrification is required in the United States to meet decarbonization goals. According to the Department of Energy, the capacity of the existing U.S. grid will need to increase 57% by 2035.[1] To support this additional electrification, annual capacity additions of 58–115 GW of clean energy generation (enough to power 43–86 million homes) will be required through 2050.[2] For context in 2021, clean electricity installations in the U.S. peaked at 32.4 GW, with solar capacity contributing 19 GW, a new high for annual solar installation.[3] This underscores the tremendous need for investments in renewable energy and associated supporting infrastructure, which are estimated to be $200B–$500B annually in the U.S. alone.

We expect the acceleration of electrification will create a growing industry of supporting infrastructure and solutions to enable these renewables projects, specifically the current and increasing need for energy storage and onshoring of the infrastructure supply chain. For context, U.S. annual grid-scale storage has experienced a 69% CAGR since 2020, with 47 GWh deployed in 2023 and another 77 GWh and 115 GWh expected in 2024 and 2025 respectively.[4]

Before focusing on the tremendous investment opportunity set this decarbonization demand is creating, we examine how increased cost of capital and inflationary pressures are affecting these capital-intensive projects. These twin effects are placing stress in the system, delaying, and potentially negating some incentives from the Inflation Reduction Act (IRA) passed in August 2022. We discuss how this need for more renewables underscores the challenge of intermittency for the aging U.S. grid.

THE ROLE OF INCREASED COST OF CAPITAL AND INFLATION

The increased cost of capital and inflationary pressures are impacting the underlying economics of projects associated with the renewables ecosystem. These challenges are reflected in the equity valuations of clean energy companies

represented by the S&P Global Clean Energy Index. They finished 2023 down 21% while the S&P 500 was up 25%. Of note, the traditional energy index finished up 1%.

Clean energy projects require tremendous amounts of capital, which is challenging in an environment of increased cost of capital. On top of this, the IRA is estimated to have catalyzed $278 billion in new investments[5] during its first year while also creating 170,000 clean energy jobs.[6] This significant capital infusion is intensifying existing inflationary pressures in many areas such as wages for skilled labor, specialized inputs, and raw materials. Additionally, queues for permitting are increasing which can cause project delays lasting years, adding to increasing costs. In some of these situations, the IRA is creating pressures for the industry it was designed to support. According to the Berkeley National Lab "the passage of the Inflation Reduction Act … is likely to drive even further growth in interconnection requests in coming years." Notably, the queue at the end of 2022 represented over 2 Terawatts (TW), greater than current U.S. generating capacity of 1.25 TW, and more than six times larger than the queue in 2014.[7]

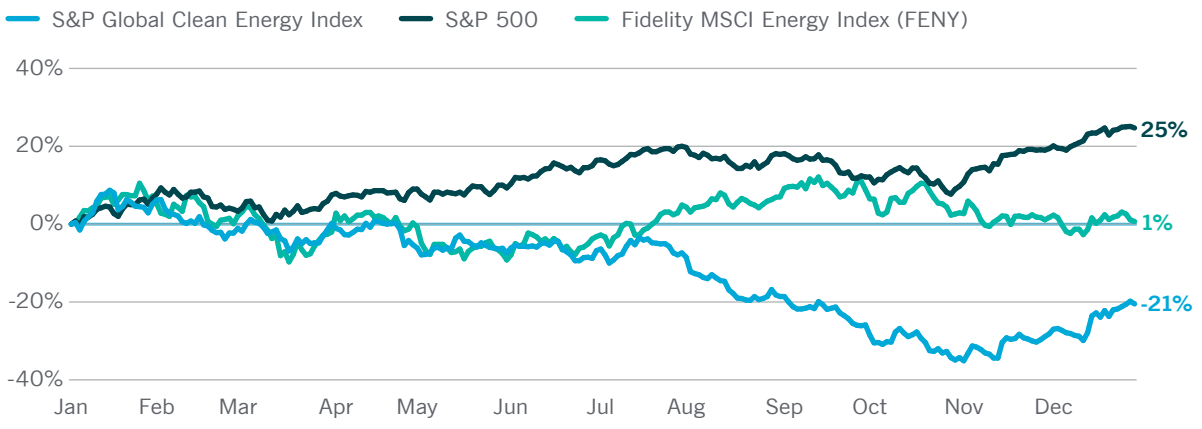
Utility scale projects such as offshore wind are not immune to these twin challenges. Greater than 50% of planned U.S. projects or ~9.7GW of offshore wind projects are either being renegotiated or cancelled due to inflationary pressures with Levelized Cost of Electricity currently reaching $114.20/MWh inclusive of the increased ITC of 40% vs $77.30/MWh in 2021 which included 30% ITC.[8]

Other asset classes such as residential solar are impacted disproportionately by increased cost of capital given the interdependence between customer financing cost and installations despite residential module costs decreasing 25% over the last year.[9] Additionally, these companies rely on the capital markets, predominantly asset-backed securities and loans, to fund their growth so this increased financing cost exacerbates the challenges.

Lastly, regulatory uncertainty regarding the continuation of tariffs and countervailing duties on solar equipment manufactured in certain southeast Asian countries, is causing delays in offtake contract execution for U.S. solar manufacturing projects and may contribute to eventual project attrition, undercutting the IRA's support for a domestic solar supply chain. More on this dynamic is discussed in the *Infrastructure supply chain* section below.

It is critical to understand these considerations of the Solar Coaster: how and where increased cost of capital and inflationary pressures can challenge project economics. Successful investment underwriting must include comprehension of the full capital needs of these projects, their timelines, and how the aforementioned dynamics affect

Figure 1: 2023 share price performance



Source: FactSet as of December 29, 2023

the risk and returns of an investment. Similarly, understanding global trade flows and competition is also necessary. With these considerations in mind, an experienced investor can appropriately price risk and structure investments to manage these dynamics. We view credit as the optimal strategy to support these projects due to credit's structural protections, contracted cash flows, collateral, and reduced reliance on equity valuations.

INTERMITTENCY CHALLENGES FOR THE AGING GRID

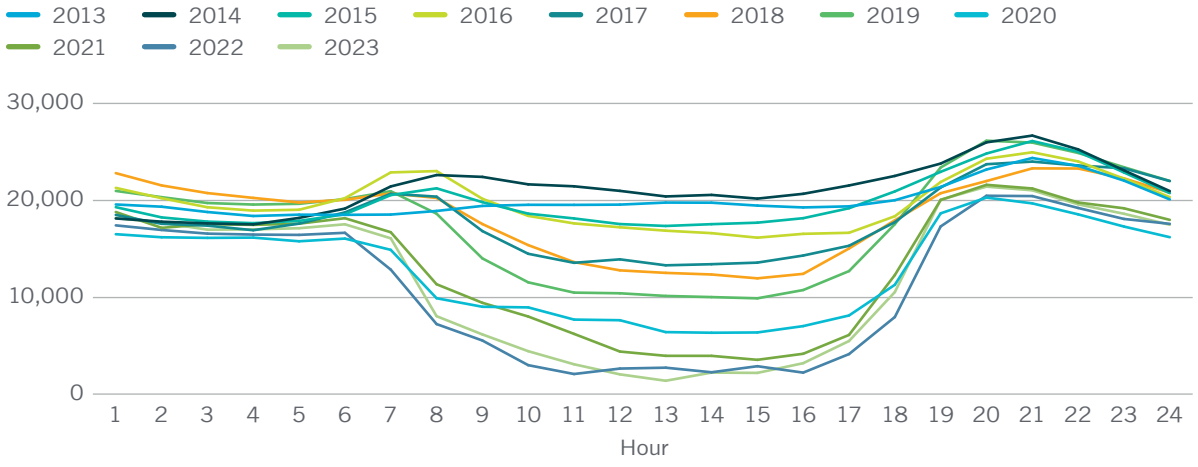
Over the past five years, the increased rate of installation of wind and solar has exposed challenges in renewable power generation. The U.S. grid is over 100 years old and was not built to accommodate the intermittency inherent in renewable-generated electricity. Grid operators, who balance electricity supply and demand, must manage mismatches between the two. These are exacerbated by the increase in solar installations which can only generate electricity during daytime hours, with peak production occurring in the afternoon. This dynamic is illustrated by the duck curve exhibit below.

The increase in solar generation from 2013 to 2023 and the impact on the grid can be tracked by observing the intraday net load of electricity demand in the California Independent System Operator region (CAISO), which has the highest penetration of solar. The net load is the demand for electricity remaining after subtracting the variable renewable generation. The larger the drop or more pronounced the duck shape of the graph, the more renewables are contributing to the electricity needs during peak daylight. To manage peak solar electron production, grid operators curtail conventional electricity that would have been produced during the day in favor of solar production. Once the sun sets, the operators then call on these conventional power plants to produce the needed electricity. This causes extremes in daily operations at the individual plant level rendering some uneconomic due to receiving reduced revenue from evening-only electricity generation. This can force early plant retirements without dispatchable replacement generation which introduces further instability to the grid.

The obvious mitigant to this variability is energy storage, which can store excess electricity produced during the day and be called on to support peak electricity demand during the evening hours. We believe battery energy storage systems (BESS) will play an integral role in mitigating the challenge of intermittency and enabling the increased adoption of renewable generation.

Figure 2: California's duck curve is getting deeper

CAISO lowest net load day each spring (March–May, 2013–2023) MW



Source: 2013–2019 based on IEA data: https://www.iea.org/commentaries/more-of-a-good-thing-is-surplus-renewable-electricity-an-opportunity-for-early-decarbonisation. 2020–2023 based on approximate EIA data: https://www.eia.gov/todayinenergy/detail.php?id=56880

AN INCREASED NEED FOR ENERGY STORAGE

The need to invest in energy storage to tackle intermittency and facilitate the adoption of renewables is substantial and growing. According to the U.S. Department of Energy Solar Futures Study, storage capacity must increase to more than 1,600 GW by 2050 from an installed base of 3 GW as of 2020.[10] Even in the near term (defined as 2023 to 2026), it is estimated that 22 GW of planned power capacity may be added with approximately 14 GW of that capacity co-located with solar photovoltaic generators.[11] Between now and the end of the decade this anticipated overall demand for storage installation will require annual investment of $8Bn in the U.S. and $35Bn globally, underscoring the significance of the opportunity.[12]

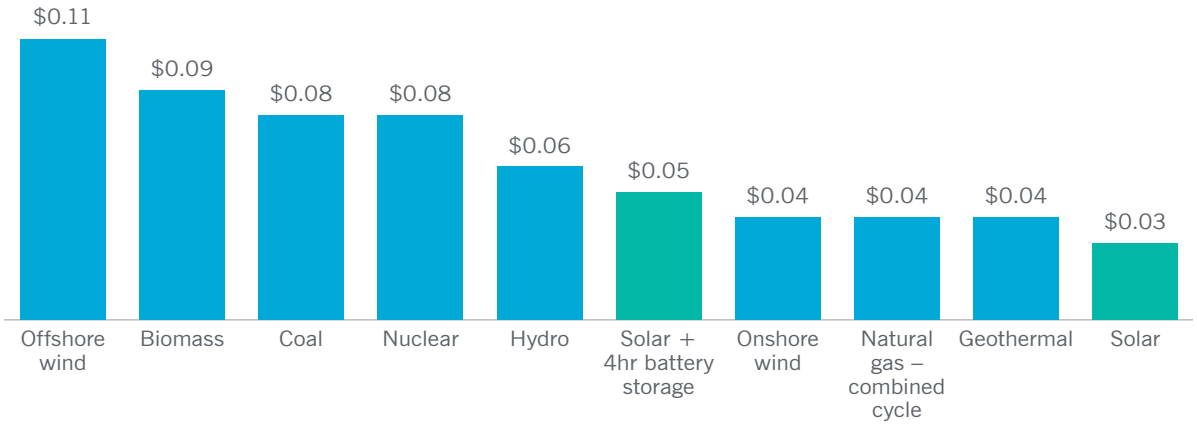
Additionally, there is regulatory support for storage. At the federal level through the IRA, standalone BESS now qualify for 30% investment tax credits through 2032, when previously only storage systems paired with solar qualified. Also, many states have initiated various programs on storage including commissioning studies and investigations, creating incentives, and writing policies. Some have enacted energy storage deployment targets such as California, Oregon, Nevada, Maine, New York, Connecticut, New Jersey, Maryland, and Virginia.[13] From the residential perspective, Bloomberg New Energy Finance believes that time-based retail electricity tariffs will become more common.[14] If so, this could encourage more pairings of batteries with existing and new solar projects.

This increased capital and regulatory support and broad recognition of the need for additional BESS has accelerated their development. This brings certain considerations to the forefront such as how the increasing interconnection queues mentioned in *The role of increased cost of capital and inflation* section are affecting project completion timelines and impacting costs, sometimes resulting in project attrition. Experienced developers are buying some projects that are further along in the interconnection queue to supplement their greenfield pipelines. This underscores the importance of identifying the right partners from an investment and lending standpoint.

Even with the aforementioned dynamics, the overall costs have become competitive for solar plus storage solutions which offer stable energy output for approximately four hours. This lays the groundwork for a robust investment opportunity set.

Figure 3: Estimated Levelized Cost of Electricity

LCOE - $/KWh



Source: "Clean Energy Monthly Outlook: September 2023", Wells Fargo Equity Research. September 21, 2023.

CASE STUDY

Project Trident

Project Trident is a $200 million debt financing to support the capital needs of a company focused on developing, constructing, owning, and operating battery energy storage systems across North America.

Founded in 2022 by the current management team with equity sponsorship from a reputable energy and power trading firm, the company deploys storage projects to reduce grid volatility and support decarbonization via renewable energy adoption. Partnership with the sponsor provides the company with visibility into energy and power trading markets. This insight can be leveraged to inform site selection for energy storage projects. It also establishes a consistent counterparty for offtake agreements which solidifies the company's cash flow profile. The company further benefits from monetary incentives provided by the 2022 Inflation Reduction Act.

Investment highlights

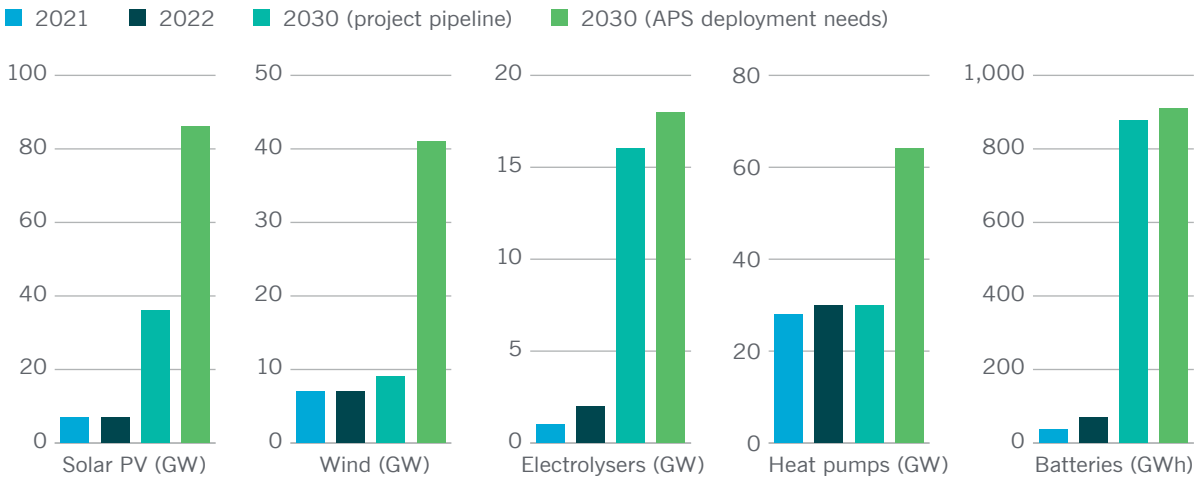
- Attractive risk-adjusted returns with opportunity for additional upside from warrant participation
- Completion of the first 150 MW project in December 2023, largely within budget and with contracted cash flows
- Substantial near-term operating asset portfolio of 3 GW offers downside protection and bolsters asset coverage via increasing collateral base
- Sponsor provides visibility into power markets by leveraging an extensive database of nodes and curtailed assets from congestion
- The company's credit profile is enhanced by partnership with the sponsor which provides contracted cash flows via tolling agreements

INFRASTRUCTURE SUPPLY CHAIN AND THE "SOLAR COASTER"

Given the buildout of energy storage as standalone and alongside solar, the obvious corollary is investing in the supply chains which serve these sectors. We anticipate the investment opportunities to support the onshoring of the infrastructure supply chain to be robust given the significant support from the IRA in the form of production tax credits and other economic benefits like the domestic content adder, which increases in value as more U.S.-manufactured inputs and components are part of the end products. This provides a tailwind to U.S. manufacturing while also supporting domestic job creation. As discussed earlier, this IRA-driven enthusiasm with an estimated $110 billion in manufacturing investments during the IRA's first year also creates inflationary pressures.[15]

Also stoking demand for domestically manufactured products are the existing tariffs and countervailing duties on solar cells and panels manufactured in China, the top global producer accounting for 95% of polysilicon and wafer manufacturing and 90% of cell manufacturing in 2023.[16] As mentioned in the section *The role of increased cost of capital and inflation*, the tariff uncertainty on panels from certain southeast Asian countries is causing an unwillingness among solar developers to enter into long-term offtakes with domestic solar manufacturers as they can currently procure less costly panels from those countries, even with the IRA credits and incentives. Moreover, utility-scale solar module

Figure 4: Current and projected manufacturing output for key clean technologies and domestic deployment in the Announced Pledges Scenario in the United States



Source: International Energy Agency

APS: Announced Pledges Scenario; PV: photovoltaic. "Project pipeline" refers to the sum of current installed capacity and all announced manufacturing capacity additions (as of end-Q1 2023) through to 2030. An average utilisation rate of 85% is applied to all existing and announced capacity in 2030.

prices halved to $0.12 per watt in late 2023 in some markets as Chinese manufactured panels that previously would have been directed to the U.S. market have been forced to look for new markets due to U.S. imposed trade restrictions. These module prices are approximately one third of the actual module production costs incurred by European and U.S. manufacturers.[17] For that matter, even leading Chinese solar manufacturers have struggled to maintain profitability at these levels as rapid expansion since 2020 has led to over-capacity with 817 GW planned or operating module capacity at the end of 2022 vs 310 GW at the end of 2020.[18]

This uncertainty and bargain basement pricing dynamics are creating challenges and delays in offtake contract execution, a customary prerequisite for financing. These delays are in turn increasing project costs. The tariff uncertainty may be resolved by June, if not before and this shorter-term uncertainty may delay and ultimately cancel the least profitable projects. Additionally, the pricing dynamics are not likely to persist long-term as demand for solar continues to grow globally, reducing the current glut. Accordingly, an International Energy Agency (IEA) study completed last year forecasted that the U.S. demand for domestically produced solar photovoltaic equipment will be more than double the U.S. manufacturing capacity.[19] Over the longer-term horizon there are significant investment opportunities as demand for U.S. manufactured product grows and as the IRA incentives and support begin to make a material impact.

Given the potential manufacturing build-out in the U.S. and the associated timing and potential inflationary pressures, some challenges likely may persist. The IEA study also examined supply / demand dynamics of domestic manufacturing for other clean energy sectors, predicting that some subsectors could be under-supplied. We are monitoring these potential trends to determine if they could become investment opportunities.

CONCLUSION

Nuveen's Energy Infrastructure Credit (EIC) team believes there are and will be attractive risk-adjusted investment opportunities across energy storage and the onshoring of the infrastructure supply chain underpinned by the trends and dynamics discussed. When evaluating investments in sectors undergoing significant transformation like the U.S. electricity ecosystem, the twists and turns described as the "solar coaster" should be expected, do create opportunity, and will provide an advantage to investors experienced in underwriting and pricing complexity in investments. The importance of thorough due diligence and deep experience underwriting and structuring across cycles cannot be overstated. Amid the global push to decarbonize the economy through increased electrification, we believe that energy infrastructure credit investments will be an effective means of capitalizing on these opportunities while simultaneously providing downside protection amid higher costs of capital and inflationary risks.

For more information, please visit our website, nuveen.com/infrastructure.

Endnotes

1 "Draft 2023 National Transmission Needs Study" Grid Deployment Office, Department of Energy, April 2023 https://www.energy.gov/gdo/national-transmission-needs-study
2 https://www.whitehouse.gov/wp-content/uploads/2021/10/US-Long-Term-Strategy.pdf. Conversion 1GW = 750,000 homes.
3 https://www.energy.gov/sites/default/files/2022-03/Solar-Energy-Technologies-Office-PV-End-of-Life-Action-Plan_0.pdf
4 Source: Wood Mackenzie Ltd., US Energy Storage Monitor Q4 2023 Report.
5 https://climatepower.us/wp-content/uploads/sites/23/2023/07/Clean-Energy-Boom-Anniversary-Report-1.pdf
6 https://www.whitehouse.gov/briefing-room/statements-releases/2023/08/16/fact-sheet-one-year-in-president-bidens-inflation-reduction-act-is-driving-historic-climate-action-and-investing-in-america-to-create-good-paying-jobs-and-reduce-costs/
7 https://emp.lbl.gov/news/grid-connection-requests-grow-40-2022-clean
8 https://www.energy.gov/sites/default/files/2022-08/land_based_wind_market_report_2202.pdf
9 https://www.seia.org/solar-industry-research-data
10 https://www.energy.gov/eere/solar/solar-futures-study
11 "Electricity Explained: Energy Storage for Electricity Generation" US Energy Information Administration, September 27, 2023.
12 https://www.iea.org/energy-system/electricity/grid-scale-storage
13 "50 States of Power Decarbonization Q2 2023 Quarterly Report" https://www.dsireinsight.com/publications
14 "BNEF Theme: Tapping the Huge Global Rooftop Solar Potential", Bloomberg. May 11, 2023.
15 https://www.energy.gov/sites/default/files/2023-09/September%2013%202023%20HEC%200E%20Legislative%20Hearing%20Final%20Testimony.pdf
16 https://www.rystadenergy.com/news/Europe-chinese-solar-panels-imports-installations-storage
17 https://www.bloomberg.com/news/articles/2024-01-20/europe-s-climate-push-fails-to-stem-crisis-in-solar-industry
18 https://www.bloomberg.com/news/articles/2024-01-18/china-s-solar-manufacturers-face-fraught-2024-after-output-boom
19 https://www.iea.org/reports/energy-technology-perspectives-2023/technology-manufacturing-and-installation#abstract

A word on risk

All investments carry a certain degree of risk and there is no assurance that an investment will provide positive performance over any period of time. Equity investing involves risk. Investments are also subject to political, currency and regulatory risks. These risks may be magnified in emerging markets. Diversification is a technique to help reduce risk. There is no guarantee that diversification will protect against a loss of income. Investing in municipal bonds involves risks such as interest rate risk, credit risk and market risk, including the possible loss of principal. The value of the portfolio will fluctuate based on the value of the underlying securities. There are special risks associated with investments in high yield bonds, hedging activities and the potential use of leverage. Portfolios that include lower rated municipal bonds, commonly referred to as "high yield" or "junk" bonds, which are considered to be speculative, the credit and investment risk is heightened for the portfolio. Credit ratings are subject to change. AAA, AA, A, and BBB are investment grade ratings; BB, B, CCC/CC/C and D are below-investment grade ratings. As an asset class, real assets are less developed, more illiquid, and less transparent compared to traditional asset classes. Investments will be subject to risks generally associated with the ownership of real estate-related assets and foreign investing, including changes in economic conditions, currency values, environmental risks, the cost of and ability to obtain insurance, and risks related to leasing of properties. Investors should be aware that alternative investments including private equity and private debt are speculative, subject to substantial risks including the risks associated with limited liquidity, the use of leverage, short sales and concentrated investments and may involve complex tax structures and investment strategies. Alternative investments may be illiquid, there may be no liquid secondary market or ready purchasers for such securities, they may not be required to provide periodic pricing or valuation information to investors, there may be delays in distributing tax information to investors, they are not subject to the same regulatory requirements as other types of pooled investment vehicles, and they may be subject to high fees and expenses, which will reduce profits. Alternative investments are not appropriate for all investors and should not constitute an entire investment program. Investors may lose all or substantially all of the capital invested. The historical returns achieved by alternative asset vehicles is not a prediction of future performance or a guarantee of future results, and there can be no assurance that comparable returns will be achieved by any strategy. Impact investing and/or Environmental, Social and Governance (ESG) managers may take into consideration factors beyond traditional financial information to select securities, which could result in relative investment performance deviating from other strategies or broad market benchmarks, depending on whether such sectors or investments are in or out of favor in the market.

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