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Ethical Investing or Alpha Sacrifice: The U.S. Green ETF Performance Tradeoff

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ABSTRACT

This study examines the risk-adjusted performance of ten actively managed Green ETFs in the U.S. market over 13 years, using models such as the CAPM, Fama-French 3-factor, and 5-factor to measure abnormal returns. Results show a trend of underperformance, with eight out of ten funds displaying significantly negative alpha coefficients, indicating they did not generate excess returns compared to market benchmarks. This underperformance is linked to the sector's dependence on volatile government subsidies, lower inherent profitability, and the impact of negative screening methods. Notably, performance varies: funds focused on large-cap U.S. infrastructure and established sectors such as global energy and wind power tend to be more resilient, while those in small- and mid-cap technology, particularly solar energy, experience pronounced underperformance and volatility. The study also finds that the performance of Green ETFs is influenced by macroeconomic and policy environments, with negative returns during the Euro area crisis and positive returns during the COVID stimulus period, followed by a return to negative excess returns in the post-COVID phase. In conclusion, the returns of Green ETFs are heavily affected by market dynamics and policy decisions. These funds are characterized as high-risk, growth investments, suitable for investors who prioritize ethical values and sustainability over alpha generation. The study highlights the importance of policymakers establishing stable regulatory frameworks to mitigate the sector's vulnerability associated with short-term subsidies.

Keywords: Green ETF; Abnormal return; Euro area crisis; COVID.

INTRODUCTION

As natural disasters caused by abnormal weather patterns around the globe become increasingly frequent, society is gradually recognizing the significance of environmental protection and sustainable development. SRI (Socially Responsible Investment), ESG (Environmental, Social, Governance) investing, and green funds have become an indispensable driving force in global financial and economic development. Green investments are gaining popularity among investors, with awareness and emphasis on these issues continually increasing. Notably, the Paris Agreement, adopted by 197 countries worldwide in 2015, was officially brought into force on November 4, 2016. It established a legally binding international treaty dedicated to jointly mitigating global warming. As a result, the concept of ESG was introduced by the UN in 2004 and has garnered increased recognition within the public sphere. To align with this emerging trend, investment banks and asset management firms have started expanding their offerings of green funds and green ETFs, providing investors with opportunities to incorporate ESG-screened financial products alongside traditional investment portfolios.

With the rise of ESG concepts, investment strategies have evolved from simple negative screening (excluding 'immoral industries' such as tobacco, arms, gambling, and petrochemical industries) to positive screening (actively identifying companies with excellent ESG performance), then to ESG thematic integration (fully incorporating ESG factors into traditional financial valuation, portfolio construction, and risk management processes), as well as corporate engagement, shareholder activism (enhancing investor governance participation), and impact investing—complex approaches. Hamilton et al. (1993) and Renneboog et al. (2008) both empirically found that although SRI funds often have less diversification than traditional funds in the short term due to industry exclusions, and may even yield slightly lower returns during bull markets, subsequent studies such as Benson et al. (2006), Capelle-Blancard and Monjon (2012), Chang et.al (2012), and Ortas et al. (2013) emphasize that ESG and green funds do not perform significantly worse than traditional funds in the long run. Especially during market turbulence or downturns, they demonstrate better resilience and stability compared to the market. Overall, ESG investment performance is influenced by multiple factors, including investment strategy (active or passive management), screening criteria, regional/market maturity, asset classes, industry structure, and the standardization of ESG data and ratings. Climent and Soriano's (2011) research findings indicate that, on average, environmental mutual funds tend to underperform compared to traditional funds. However, this poor performance is mainly attributed to differences in characteristics such as fund size and expense ratios, rather than the 'environmental' factors themselves. After adjusting for these factors, the performance gap between the two narrows, suggesting that an environmental focus does not necessarily lead to lower investment returns. Friede et al. (2015), analyzing over 2,200 empirical studies, found that about 90% indicate a non-negative relationship between ESG and corporate financial performance (CFP), with most showing positive correlation; this effect is especially pronounced at the corporate level (non-portfolio), in bonds, green real estate, and emerging markets.

Further research by Leite et al. (2015), Ibikunle and Steffen (2017), and Nofsinger and Varma (2014) shows that during financial crises or market downturns, funds emphasizing ESG and responsible screening provide significant risk buffers and downside protection, partly because such companies tend to have better management mechanisms, brand reputation, stakeholder relationships, and lower capital costs, giving them inherent competitive advantages. Regarding screening strategies, negative screening has roots dating back to 18th and 19th-century religious groups excluding immoral industries, gradually extending to modern environmental and social issues. While negative screening can quickly draw clear moral boundaries, it may also overlook industry leaders with strong ESG transformation potential or excellent performance. In contrast, positive screening and 'best-in-class' selection focus on rewarding leading ESG performers within industries, guiding capital toward companies truly contributing to sustainable development. Comparative analyses by Capelle-Blancard and Monjon (2012) and Ortas et al. (2013) demonstrate that different screening strategies have a significant impact on portfolio risk, return, and diversification. Combining multiple strategies with active management can enhance risk-adjusted performance and capital efficiency. ESG integration strategies encompass both active and passive management. Active investing involves stock selection, bond picking, engagement, and deep industry insights to generate excess returns beyond the market and adjust for risk factors, demonstrating high control and foresight regarding ESG variables. Nofsinger and Varma (2014), Kanuri (2020), Pástor et al. (2021), Gonçalves et.al (2021), and Pavlova et.al (2022) confirm that active ESG funds perform notably resiliently during extreme market volatility periods (such as the 2008 financial crisis and COVID-19 pandemic). Silva and Ceu Cortez (2016) examined how green mutual funds in the United States and Europe tend to perform poorly during strong bull markets, but exhibit lower volatility and greater resilience during economic downturns, especially in Europe. Kanuri (2020) noted that ESG ETFs attract investors who expect long-term investment returns; however, their risk-adjusted performance does not always surpass that of traditional ETFs. Additionally, beyond financial returns, the study emphasizes that an important motivation for ESG ETF investors is the alignment of their investments with personal values and ethical considerations, highlighting the dual goals of achieving financial returns while supporting sustainable and responsible business practices. Further considering investment risk, Adamo et al. (2014) found that although green funds may perform slightly worse under certain market conditions, they generally have lower volatility and higher risk-adjusted returns over the long term. Rahat and Nguyen (2022) noted that while the initial returns of green portfolios may be poor, their risk-adjusted returns are excellent in the long run. In contrast, black portfolios tend to exhibit higher volatility and are more susceptible to policy shocks and changes in investor sentiment.

Regionally, Europe leads globally in ESG investment scale and depth, while the U.S. exhibits a trend driven by policies and industry, particularly in 'green technology' and the ESG investments of large tech companies. Many Asian markets are still in the catching-up and policy-driven phases. The United States market boasts the most mature and diverse development of ETFs, currently comprising over 3,000 products and accounting for more than half of the global ETF assets under management. Numerous asset management companies, such as iShares and Vanguard, have launched various ETFs covering different ESG themes, further enhancing the accessibility and popularity of sustainable investing. Based on these considerations, this paper focuses primarily on ETFs, which are more accessible in the market, selecting ten ESG ETFs as research subjects. The study utilizes ETFs issued in

the United States market as the primary sample, with daily data spanning from January 1, 2011, to June 30, 2024. Its main objective is to analyze the overall performance of green ETFs within the U.S. market under varying economic conditions. Numerous questions and empirical opportunities remain regarding whether ESG principles can be effectively implemented, and the performance of ESG ETFs is subject to various uncertainties. This research not only reflects the response and practice of the international capital market regarding sustainable investment issues but also helps investors understand the returns and risks associated with ESG investing.

Data

This study selected 10 ESG ETFs listed on U.S. exchanges, with a sample period from January 1, 2011, to June 30, 2024. Daily closing price data for this period were used, totaling 3,394 data points. The stock price data were all obtained from Yahoo! Finance, and daily Fama-French five-factor data for the U.S. market were sourced from Kenneth French's website. Among the 10 actively traded ETFs, GRID and SUSA mainly track U.S. companies. GRID focuses on electric grid infrastructure and clean energy-related companies, while SUSA emphasizes U.S. companies with a strong ESG focus. The remaining eight ETFs target global markets. ERTH primarily tracks companies focused on six environmental impact themes, including alternative energy, energy efficiency, green building, sustainable water, pollution control, and sustainable agriculture. These companies offer products or services that promote environmental sustainability by utilizing resources more efficiently. PBW mainly tracks clean energy, PBD focuses on solar energy, QCLN includes industries such as renewable energy, electric vehicles, and alternative power, ICLN tracks 30 companies dedicated to clean energy, covering renewable power generation and related electronic components and equipment. SMOG mainly tracks low-carbon energy, TAN focuses on solar energy, which primarily involves U.S. and Chinese companies, and FAN tracks wind energy. Detailed indices and information are summarized in Table 1.

Table 1. Selected ESG ETF

	Full Name (Target)	Exchange	Listing date
GRID	First Trust NASDAQ Clean Edge Smart Grid Infrastructure Index Fund ETF (NASDAQ Clean Edge Smart Grid Infrastructure Index)	NASDAQ	2009/11/16
SUSA	USA ESG Select ETF (MSCI USA Extended ESG Select Index)	NYSE	2005/1/24
ERTH	Invesco MCSI Sustainable Future ETF (MSCI Global Environment Select Index)	NYSE	2006/10/24
PBW	Invesco WilderHill Clean Energy ETF (WilderHill Clean Energy Index)	NYSE	2005/3/3
PBD	Invesco Global Clean Energy ETF (MAC Global Solar Energy Index)	NYSE	2007/1/13
QCLN	NASDAQ Clean Edge Green Energy ETF (NASDAQ Clean Edge Green Energy Index)	NASDAQ	2007/2/8
ICLN	iShares Global Clean Energy ETF (S&P Global Clean Energy Index)	NASDAQ	2008/6/24
SMOG	VanEck Low Carbon Energy ETF (MVIS Global Low Carbon Energy Index)	NYSE	2007/3/3
TAN	Invesco Solar ETF (MAC Global Solar Energy Index)	NYSE	2008/4/15
FAN	First Trust Global Green Energy ETF (ISE Clean Edge Global Wind Energy Index)	NYSE	2008/6/16

METHODOLOGY

The Capital Assets Pricing Model (CAPM) is commonly applied to a variety of financial assets. It only requires a few parameters to estimate expected returns and remains widely used in finance. We employ three different factor

models to calculate the risk-adjusted abnormal performance of our EST ETFs: the CAPM, the Fama-French (1993) 3-factor model, and the Fama-French (2015) 5-factor model. Equations are provided as follows:

$$r_{i,t} - r_{f,t} = \alpha + \beta_M(r_{m,t} - r_{f,t}) + \eta_t \quad (1)$$

$$r_{i,t} - r_{f,t} = \alpha + \beta_M(r_{m,t} - r_{f,t}) + \beta_{SMB}SMB_t + \beta_{HML}HML_t + \eta_t \quad (2)$$

$$r_{i,t} - r_{f,t} = \alpha + \beta_M(r_{m,t} - r_{f,t}) + \beta_{SMB}SMB_t + \beta_{HML}HML_t + \beta_{RMW}RMW_t + \beta_{CMA}CMA_t + \eta_t \quad (3)$$

where $r_{i,t}$ is the return on green ETF *i* on day *t*, $r_{f,t}$ is the risk-free rate, $(r_{m,t} - r_{f,t})$ represents the market excess return. SMB_t and HML_t denote the size and value factors at time *t*, respectively. RMW_t and CMA_t indicate the profitability factor (the difference between returns of stocks with high and low profitability) and the investment factor (the difference between returns of stocks with conservative and aggressive investment firms). Standard errors are estimated using the Newey-West procedure.

This article focuses on analyzing the coefficient α in each model, which signifies the excess return of the asset, and assesses whether the asset can generate additional gains beyond the market benchmark. When the coefficient α in the equation is significantly different from zero, it indicates the presence of abnormal returns. A negative value suggests the asset's actual return is lower than expected, while a positive value indicates it will be higher than the anticipated return.

EMPIRICAL RESULTS

Descriptive statistics

The descriptive statistics for Green ETFs are comprehensively presented in Table 2. The analysis indicates that the majority of the indices demonstrate positive average returns, highlighting a general upward trend in the sector. However, two exceptions, the PBW and TAN, exhibit negative average returns, signaling potential challenges within those specific markets. Notably, PBW and TAN also exhibit the most significant standard deviations among the indices, suggesting that their price movements are more sensitive to market fluctuations and volatility. Additionally, the extreme return values predominantly emerged after 2020, a trend that can likely be attributed to the growing emphasis on sustainable investment strategies as investors became more conscious of environmental issues, particularly in the wake of the COVID-19 pandemic. This increased investor interest coincided with various external factors that have heightened market volatility, including substantial fund withdrawals, changes in policy support, delays in renewable energy initiatives, advancements in technology within the green sector, fluctuations in the prices of raw materials essential to green technologies, and significant shifts in overall market demand for sustainable assets. These dynamics contribute to a complex landscape for Green ETFs, characterized by both opportunities for growth and challenges arising from heightened price instability.

Table 2. Descriptive Statistics of Green ETFs Returns (%)

	mean	Std. deviation	Min.	Max.
GRID	0.042	1.472	-13.935	10.410
SUSA	0.047	1.084	-10.915	9.983
ERTH	0.019	1.400	-11.595	7.671
PBW	-0.020	2.195	-15.637	13.503
PBD	0.005	1.643	-20.188	10.356
QCLN	0.024	2.028	-13.906	13.635
ICLN	0.003	1.713	-13.709	10.800
SMOG	0.018	1.649	-11.396	11.672
TAN	-0.009	2.510	-17.535	13.631
FAN	0.022	1.378	-12.337	9.859

Abnormal performance of Green ETFs

Table 3 provides a comprehensive analysis of the empirical results for Green ETFs. The majority of the target alphas are significantly negative, indicating that these funds generally underperform relative to the broader market benchmarks and are unable to generate excess returns. This underperformance can largely be attributed to

the clean energy sector's heavy dependence on government subsidies and policy support, which can create a fragile economic foundation. Any potential reductions in these subsidies or shifts in policy direction pose significant risks to the industry's growth and sustainability.

In the short term, the clean energy sector remains particularly susceptible to market fluctuations and broader economic cycles, resulting in increased volatility for Green ETFs. Additionally, the ongoing expansion of this industry results in relatively low profitability compared to established sectors. Analyzing performance metrics derived from a single-factor model reveals that all Green ETFs, with the exceptions of GRID and SUSA—both of which are primarily focused on larger U.S. companies—exhibit returns that fall below the market average. When applying a three-factor model that incorporates systematic risk factors, only GRID demonstrates no significant abnormal returns, suggesting relative stability or efficient pricing in that specific fund. The five-factor model presents a more detailed scenario, showing that GRID, QCLN, and FAN exhibit no excess returns, while all other Green ETFs display significantly negative coefficients. These metrics highlight the pervasive trend of underperformance across the majority of Green ETFs, illustrating that many struggle to keep pace with the market.

A closer examination of specific funds reveals that PBW and TAN exhibit particularly weak performance. PBW primarily invests in renewable energy companies focused on technologies such as solar, wind, and energy storage. However, these companies are generally smaller and possess lower market capitalizations, rendering them more vulnerable to market volatility. Moreover, the solar sector encounters considerable developmental challenges, including fluctuating raw material costs and an increasingly competitive landscape, which limit overall growth potential.

This analysis highlights the current challenges that ESG ETFs face, including limited profitability within the ESG and clean energy sectors, as well as a narrow range of investment opportunities. The restrictive negative screening methods employed by these funds can hinder their ability to capitalize on higher-return opportunities, leading them to exclude traditionally profitable industries such as fossil fuels, tobacco, and defense sectors, which are renowned for their higher emissions levels. This conservative investment approach may result in sustained negative alpha, further exacerbating underperformance during specific market conditions.

TAN, which tracks small- and mid-cap growth and technology stocks, typically produces lower average returns due to its focus on smaller entities that may lack the stability of larger firms. Conversely, FAN and ICLN, which focus on wind energy and have established global energy businesses, tend to demonstrate greater resilience. These firms often engage in long-term contracts that ensure consistent revenue streams, which may make them less sensitive to broader market volatility and contribute to improved alpha performance.

Overall, the influence of market dynamics and policy decisions plays a critical role in determining the returns of Green ETFs. As such, these financial products may be better suited for investors seeking growth opportunities or those with a higher risk tolerance. Although the clean energy sector is still in its nascent stages—requiring substantial investment and grappling with significant uncertainty—investor interest in sustainability initiatives has notably surged in recent years. Consequently, Green ETFs related to this sector have gained considerable attention. This evolving landscape warrants further in-depth analysis, particularly in light of the shifting market sentiments that emerged following the COVID-19 pandemic, which likely influenced the returns of related assets in multifaceted ways.

Table 3. Abnormal performance of Green ETFs

	CAPM α	FF3 α	FF5 α
GRID	-0.0136 (0.0162)	-0.0087 (0.0158)	-0.0091 (0.0158)
SUSA	-0.0057 (0.0041)	-0.0067 (0.0040)*	-0.0090 (0.0039)**
ERTH	-0.0396 (0.0128)***	-0.0324 (0.0119)***	-0.0273 (0.0117)**
PBW	-0.0983 (0.0254)***	-0.0805 (0.0217)***	-0.0649 (0.0209)***
PBD	-0.0577 (0.0177)***	-0.0501 (0.0169)***	-0.0402 (0.0163)**
QCLN	-0.0515 (0.0225)**	-0.0387 (0.0200)*	-0.0266 (0.0194)
ICLN	-0.0573 (0.0205)***	-0.0508 (0.0200)**	-0.0413 (0.0195)**
SMOG	-0.0463 (0.0174)***	-0.0388 (0.0165)**	-0.0303 (0.0161)*
TAN	-0.0852 (0.0116)**	-0.0731 (0.0323)*	-0.0570 (0.0317)*
FAN	-0.0291 (0.0161)*	-0.0271 (0.0160)*	-0.0227 (0.0158)

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. The standard errors are reported in parentheses.

Robustness check: Abnormal performance in specific sub-periods

Based on the Fama-French 5-factor model, this paper explores the detailed relationship between major environmental changes and the performance of Green ETFs, carefully dividing the analysis into four separate sub-periods: 2011-2012, coinciding with the Euro area crisis and its reverberating effects on the global financial landscape; 2013-2019, a period marked by gradual market stabilization; 2020, during the unprecedented peak of the COVID-19 pandemic; and finally, 2021-2024, in the aftermath of vaccine development and the transition into a post-pandemic phase. The empirical findings, systematically presented in Table 4, reveal several noteworthy patterns that highlight the dynamics of Green ETFs amidst these economic fluctuations.

During the Euro area crisis, a majority of ESG ETFs exhibited pronounced negative alpha values, indicative of the turbulent market conditions that prevailed. Investment in high-volatility sectors, particularly those focused on clean energy and innovative technologies, saw a marked decline as investors gravitated towards safer assets amidst prevailing uncertainty. Clean energy assets, which were still maturing, found themselves significantly impacted by volatile market conditions, coupled with fluctuating policies and funding. Their reliance on subsidies and debt financing rendered them particularly vulnerable during this crisis, as heightened financing costs and a decrease in government support significantly escalated market risk for these firms. Consequently, the situation often resulted in substantial capital outflows and the emergence of short-term arbitrage opportunities that capitalized on price discrepancies.

In the aftermath of the Euro area crisis, the market began to gradually stabilize. During this recovery phase, no unusual returns were recorded across the spectrum of assets. Market participants responded by rebalancing their portfolios, favoring large-cap, low-volatility companies with robust cash flows, thereby contributing to a reduction in systemic risk. Additionally, key central banks, notably the European Central Bank (ECB), implemented loose monetary policies that effectively alleviated market panic. As a result, the overall stock market regained stability, risk premiums diminished, and technological advancements within clean energy sectors—particularly in solar and wind power—contributed to significant cost reductions. The enhanced profitability of clean energy firms bolstered investor confidence and diminished stock price volatility, leading to a notable decrease in market sensitivity for the clean energy sector during the recovery.

The onset of the COVID-19 pandemic had a sudden and pronounced impact on all Green ETF assets, culminating in an increase in returns across the board. Notably, six ETFs achieved markedly positive abnormal returns, while the others also experienced an average uptick in performance. During this period, government policies that championed green energy initiatives, coupled with substantial capital inflows into various clean energy investments, resulted in remarkable excess returns. In both the U.S. and Europe, governments enacted extensive fiscal and monetary easing measures to stimulate stock market recovery. Amidst the dual crises of public health and climate change, the appeal of ESG and clean energy investments surged, attracting heightened investor interest. This remarkable market enthusiasm contributed to increased volatility and a higher correlation among assets.

Nonetheless, as investors began to place greater importance on sustainability, they simultaneously became more aware of the inherent challenges associated with sustainable development. While the economic recovery persisted, rising inflation and escalating market interest rates started to weigh on investor sentiment regarding Green ETFs, leading to diminished growth expectations and resulting in a notable shift, with many assets reflecting negative excess returns as the optimism waned.

Table 4. Abnormal performance of Green ETFs in sub-periods

	Euro Area Crisis 2011/1/1 ~2012/12/31	Recovery 2013/1/1 ~2019/12/31	COVID crisis 2020/1/1 ~2021/12/31	Post-COVID 2022/1/1 ~2024/6/30
GRID	-0.0543	-0.0106	0.0397	-0.0021
	(0.0406)	(0.0249)	(0.0671)	(0.0218)
SUSA	-0.0123	-0.0021	-0.0179	-0.0050
	(0.0168)	(0.0049)	(0.0166)	(0.0058)
ERTH	-0.0712***	-0.0099	0.0549	-0.1025***
	(0.0266)	(0.0132)	(0.0618)	(0.0337)
PBW	-0.2318***	-0.0358	0.2971**	-0.2510***
	(0.0464)	(0.0251)	(0.1283)	(0.0689)

PBD	-0.1573***	-0.0146	0.2346***	-0.1567***
	(0.0364)	(0.0192)	(0.0833)	(0.0451)
ICLN	-0.1924***	-0.0195	0.2330**	-0.1317***
	(0.0534)	(0.0222)	(0.0940)	(0.0503)
QCLN	-0.1617***	-0.0147	0.2791**	-0.1528***
	(0.0542)	(0.0219)	(0.1130)	(0.0579)
SMOG	-0.1609***	-0.0163	0.1957**	-0.1107***
	(0.0420)	(0.0194)	(0.0915)	(0.0400)
TAN	-0.3345***	-0.0355	0.3453**	-0.1689**
	(0.0945)	(0.0408)	(0.1452)	(0.0739)
FAN	-0.1185***	0.0047	0.0917	-0.0748**
	(0.0448)	(0.0192)	(0.0638)	(0.0360)

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. The standard errors are reported in parentheses.

CONCLUSION

This study aimed to provide a thorough, factor-adjusted analysis of the financial performance of actively managed Green ETFs in the U.S. market from 2011 to 2024. Using the Capital Asset Pricing Model, the Fama-French 3-factor model, and a 5-factor model, it developed a solid method to isolate risk-adjusted abnormal returns. This method extends beyond simple return comparisons by controlling for systematic factors, including market trends, size, value, profitability, and investment strategies. The study makes a significant contribution by offering detailed, updated insights into the U.S. green investment sector, highlighting how sector performance heavily depends on macroeconomic and policy conditions.

The main finding is that most Green ETFs examined failed to generate positive abnormal returns, with all three models showing significantly negative alpha coefficients. This persistent negative alpha indicates widespread underperformance relative to expected returns, even after adjusting for risk exposures. Since many clean energy companies prioritize growth over immediate profits, their performance is often penalized when this factor is taken into account. The sector is also vulnerable to economic cycles and commodity price risks, such as raw material costs for green technologies. A notable result is the significant difference in fund performance based on asset class and contractual stability. ETFs like PBW and TAN, which target small- and mid-cap solar tech, experienced sharp declines and high volatility due to limited market size and exposure to fluctuating material costs and competitive pressures. Conversely, ETFs emphasizing stability, such as GRID, FAN, and ICLN, showed greater resilience, suggesting that success in the green sector may depend more on stable deployment and infrastructure rather than solely on innovative technologies.

A robustness check, which divided the analysis into four macroeconomic periods, confirmed that abnormal returns are heavily dependent on market liquidity and the policy environment. The study also found that Green ETF performance was affected by macroeconomic and policy shifts, with negative returns during the Eurozone crisis and positive returns during the COVID stimulus period, followed by a return to negative excess returns afterward. This indicates that the temporary surge in alpha was driven more by policy-induced capital flows and market enthusiasm than by actual improvements in company profitability. Viewed through the lens of alpha generation, the clean energy sector behaves more like a leveraged bet tied to government support and liquidity, rather than a traditional equity investment. This policy-driven alpha was inherently unstable.

Overall, the evidence suggests that Green ETFs are not typically sources of alpha but are mainly growth assets with high volatility and policy sensitivity. As a result, they are best suited for investors with high risk tolerance and a long-term perspective. Investors should accept the potential for prolonged negative alpha as the cost of aligning their capital with urgent societal and ethical sustainability goals. The analysis indicates that assets with contractual stability, such as wind and grid infrastructure, tend to outperform more volatile pure-play technologies, influencing portfolio decisions toward assets with predictable, long-term revenue streams.

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