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Research

Navigating the Clean Energy Transition: Market Dynamics and Performance Insights

Contributors

Abbie Zhang, CFA
Senior Analyst
Thematic Indices
abbie.zhang@spglobal.com

Jason Ye, CFA
Director
Factor and Thematic Indices
jason.ye@spglobal.com

Summary

The clean energy sector has undergone an extensive transformation over the past two decades, driven by a confluence of technological advancements, policy initiatives and heightened awareness of climate change. This paper explores the critical dynamics shaping the clean energy transition, emphasizing the role of international agreements such as the 2015 Paris Agreement, which has encouraged global efforts to reduce greenhouse gas emissions and promote clean energy adoption.

The S&P Global Clean Energy Index, launched in 2007, serves as a benchmark for measuring the performance of companies in global clean energy-related businesses, reflecting the sector's growth and increasing competitiveness. Notably, the adoption of clean energy alternatives globally has benefited from substantial cost reductions in renewable technologies, with solar photovoltaics (PVs)—the technology that converts sunlight directly into electricity using solar cells—witnessing an 82% decrease in costs from 2010 to 2019,[1] alongside notable reductions in onshore and offshore wind energy costs.[2] These trends have positioned renewables as economically viable alternatives to traditional fossil fuels, prompting a shift in investment strategies toward incorporating sustainable solutions.

[1] Feldman, David, Vignesh Ramasamy, Ran Fu, Ashwin Ramdas, Jal Desai and Robert Margoli, "U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: Q1 2020," National Renewable Energy Laboratory, January 2021.

[2] IRENA, "Key findings: Renewable Power Generation Costs in 2019," International Renewable Energy Agency, 2020.

However, the clean energy market is still facing challenges. Macroeconomic factors, including rising interest rates and supply chain disruptions, have introduced uncertainty and increased costs for clean energy projects. Despite these hurdles, the sector has shown resilience, with a growing commitment from governments and stakeholders to invest in clean energy solutions. This paper underscores the importance of ongoing collaboration and investment to achieve the goal of net-zero greenhouse gas emissions by 2050. As solar and wind are projected to dominate global electricity generation in the coming decades,[3] this transition represents not only a fundamental shift in energy production and consumption but also an opportunity for innovation and sustainable economic growth.

The S&P Global Clean Energy Index continues to play a crucial role in measuring the performance of businesses in this space, providing valuable insights into market dynamics and guiding investment decisions in the pursuit of a sustainable future.

Introduction: A Journey from Muscle Power to Clean Power

Over the past 200 years, the energy landscape has transformed dramatically, driven by pivotal innovations such as the steam engine, internal combustion engines and the widespread adoption of electricity. These advancements facilitated a shift from a primarily agrarian economy to an industrial one, which in turn demanded new, more efficient energy sources to support increased electricity production and urbanization. Today, the ongoing energy transition is propelled by a growing awareness of the urgent need to combat climate change, which requires a significant reduction in greenhouse gas emissions.

Prior to the Industrial Revolution, people used wood and dried manure for heating their homes and cooking. They relied on human and animal muscle power to produce and support daily life. The first energy transition began when Great Britain started mining coal in 1800s,[4] and the second significant energy transition occurred after the commercial discovery of crude oil in Pennsylvania in 1859.[5] However, it took several decades for fossil fuels to become the primary energy source, as the technologies used to transform coal, oil and natural gas to energy still needed to be developed.

Today, clean energy sources are central to the new phase of energy transition. Since the 1980s, the global community has increasingly recognized the impact of climate change,[6]

[3] International Energy Agency, "Net Zero by 2050 - A Roadmap for the Global Energy Sector," October 2021.

[4] Bhutada, Govind, "The 200-year history of mankind's energy transitions," World Economic Forum, April 13, 2022.

[5] Van Vactor, Sam, "Historical Perspective on Energy Transitions," University of Cambridge Faculty of Economics, March 2017.

[6] Institute of Climate Change and Sustainable Development of Tsinghua University et al. (2022). "Global Climate Governance and International Cooperation." In: China's Long-Term Low-Carbon Development Strategies and Pathways. Springer, Singapore. 2022.

leading to significant international commitment to address the challenge. The 2015 Paris Agreement represents a critical evolution in the UN climate change regime. By charting a new course in the global fight against climate change, the Paris Agreement aims to foster a sustainable future, encouraging countries to commit to reducing emissions and transitioning to clean energy sources.

S&P Global Clean Energy Indices

Recognizing the significant trend of energy transition worldwide, S&P Dow Jones Indices (S&P DJI) launched the S&P Global Clean Energy Index in 2007. It was the first index designed to measure the performance of companies in global clean energy-related businesses. The index encompasses not only companies that generate clean energy but also those engaged in related technologies such as PV and solar cell providers. As a result, it aims to reflect a wide range of businesses within the global clean energy ecosystem.

When the S&P Global Clean Energy Index was first launched in 2007, it only included 30 constituents. Since its launch, the clean energy sector has experienced substantial growth, particularly in emerging markets such as China, where investment and innovation have surged. Additionally, the availability of datasets enabling the construction of thematic indices has increased, providing a wider range of options for tracking clean energy companies and allowing for a more nuanced measurement of opportunities within the sector. Consequently, to better align with these advancements and the evolving landscape, the index underwent a major methodological change in 2021.

- Together with the GICS® classification system, FactSet's Revere Business Industry Classification System (RBICS) and S&P Global Trucost's power generation data were introduced to calculate an exposure score in order to measure the clean energy exposure for companies.
- The target number of constituents was increased from 30 to 100 to enhance capacity by selecting constituents based on their exposure score.
- The universe of stocks from developed markets was expanded to include emerging markets, highlighting the growth of clean energy companies in regions like China.
- Sustainability considerations, including business activities exclusions, United Nations Global Compact (UNGC) principles compliance and the results of the S&P Global Media and Stakeholder Analysis (MSA) were incorporated.

In April 2021, S&P DJI launched the S&P Global Clean Energy Select Index to measure the 30 companies with the highest exposure scores and largest market capitalizations in the S&P Global Clean Energy Index universe that are listed on developed market exchanges.

Additionally, the S&P North America and Europe Clean Energy Index and the S&P Developed Ex-Korea Clean Energy Index were launched in 2021 and 2022, respectively, expanding the S&P Clean Energy Index Series.

A Comprehensive Index Methodology

With this change to a more comprehensive methodology, the S&P Global Clean Energy Index now measures the performance of a diversified group of companies that are shaping the energy transition.

Starting with the S&P Global BMI universe, the S&P Global Clean Energy Index first applies some basic size and liquidity filters. Then, the index identifies a preliminary universe of clean energy companies based on specific revenue and operational criteria.

- Revenue Screen: Companies must derive at least 25% of their aggregate revenue from clean energy-related business activities, as defined by FactSet RBICS data.
- Utility Companies: For companies categorized under "General Utilities," they must generate at least 20% of their power from renewable sources, including wind, solar, hydroelectric, biomass and geothermal, as measured by S&P Global Trucost data. General Utilities includes the GICS sub-industries Electric Utilities, Multi-Utilities and Independent Power Producers & Energy Traders.
- Renewable Utilities: Companies classified under the GICS sub-industry Renewable Electricity are also included.

Within the preliminary universe, the index excludes companies involved in controversial weapons, small arms, military contracting, tobacco, coal, thermal coal, oil sands or tar sands, shale oil and gas, and arctic drilling-related business activities.

Companies that are not compliant with the UNGC are also excluded. The UNGC principles are a measure of controversial behavior and include matters involving human rights, labor rights, the environment and anti-corruption. In addition, the index committee monitors ESG risk incidents and controversial activities related to companies within the indices through the MSA overlay. The MSA includes a range of issues, such as economic crime and corruption, fraud, illegal commercial practices, human rights issues, labor disputes, workplace safety, catastrophic accidents and environmental disasters. A company may be excluded if it has been flagged by the MSA.

After passing through these screens, each company is assigned an exposure score based on FactSet RBICS with Revenue data and S&P Global Trucost's power generation data ranging from 0 to 1, with a 0.25 increment, to measure the strength of their link to clean energy businesses. The index iteratively selects stocks with the highest scores until a target of 100 constituents is reached. For companies that have the same exposure scores, the index selects those with larger float-adjusted market capitalization (FMC) first. The constituents are weighted by the product of FMC and exposure score, subject to weight capping rules to meet the diversification requirements.

For more information on the exposure score calculation and screens, please refer to the index methodology.

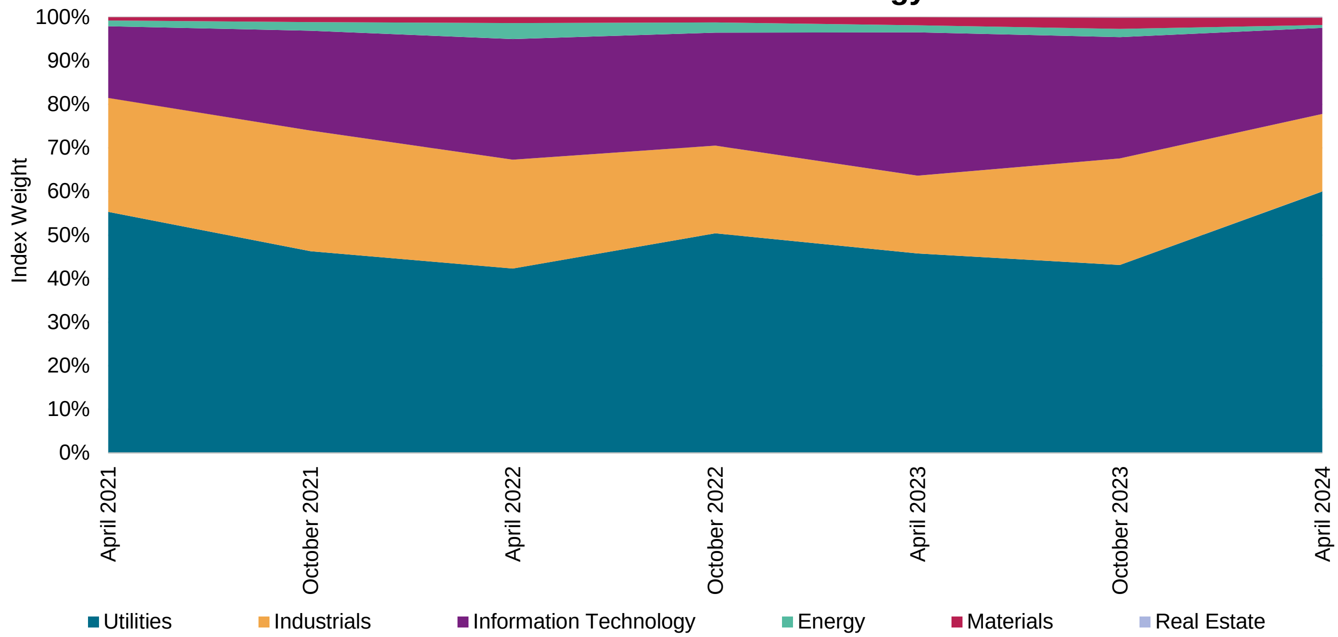
Change in Index Composition

In the S&P Global Clean Energy Index, the Utilities sector constitutes the largest portion (see Exhibit 1), underscoring the pivotal role of utility firms in generating energy from renewable sources. For example, in September 2024, a group of leading utilities companies announced a joint intent to invest more than USD 116 billion per year in clean power generation and power system grid infrastructure globally in the coming years.[7] From the regional perspective, the U.S. holds the largest weight in the index—regulatory support and investment incentives have fueled strong growth for clean energy companies in the country. Moreover, regions like Asia-Pacific (APAC) experienced an increasing weight (see Exhibit 2), driven by supportive governmental policies and a commitment to sustainable development.

The S&P Global Clean Energy Index reflects the performance of both clean energy technology firms and clean power generation companies (see Exhibit 3). Over time, the index has maintained a balanced distribution between these two segments, emphasizing the importance of both technological innovation and power generation in the transition to a sustainable future. This coverage helps market participants to gauge the overall performance of the clean energy value chain.

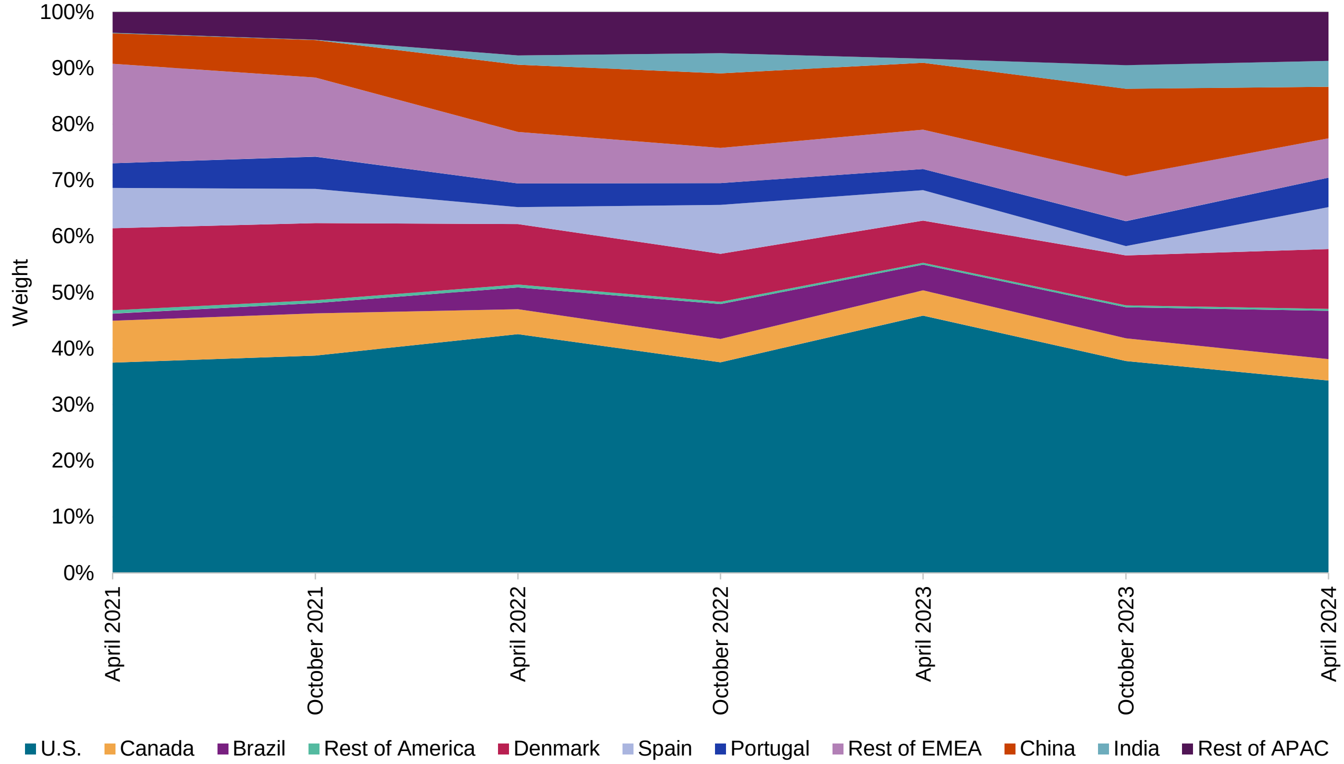
[7] IRENA, "Utilities Announce Joint Intent to Invest more than US$116bn Annually in Grids and Renewables," International Renewable Energy Agency, Sept. 24, 2024.

Exhibit 1: Sector Breakdown of the S&P Global Clean Energy Index



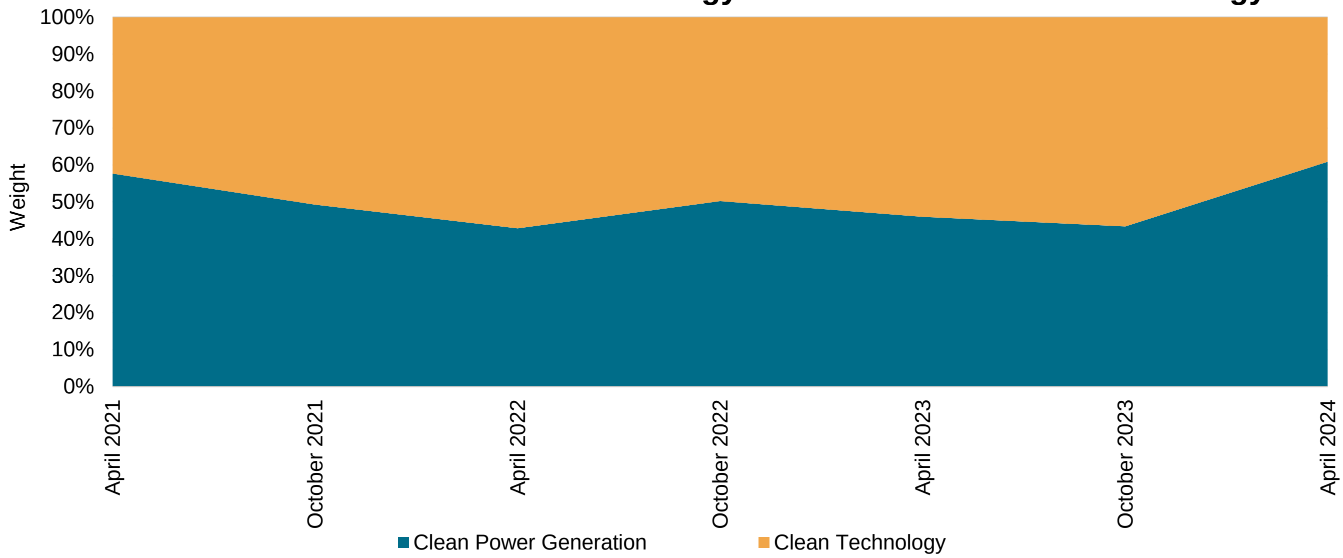
Source: S&P Dow Jones Indices LLC. Data from April 19, 2021, to April 22, 2024. Chart is provided for illustrative purposes.

Exhibit 2: Market of Domicile Breakdown of the S&P Global Clean Energy Index



Source: S&P Dow Jones Indices LLC. Data from April 19, 2021, to April 22, 2024. Chart is provided for illustrative purposes.

Exhibit 3: Balanced Distribution between Energy Generation and Clean Technology

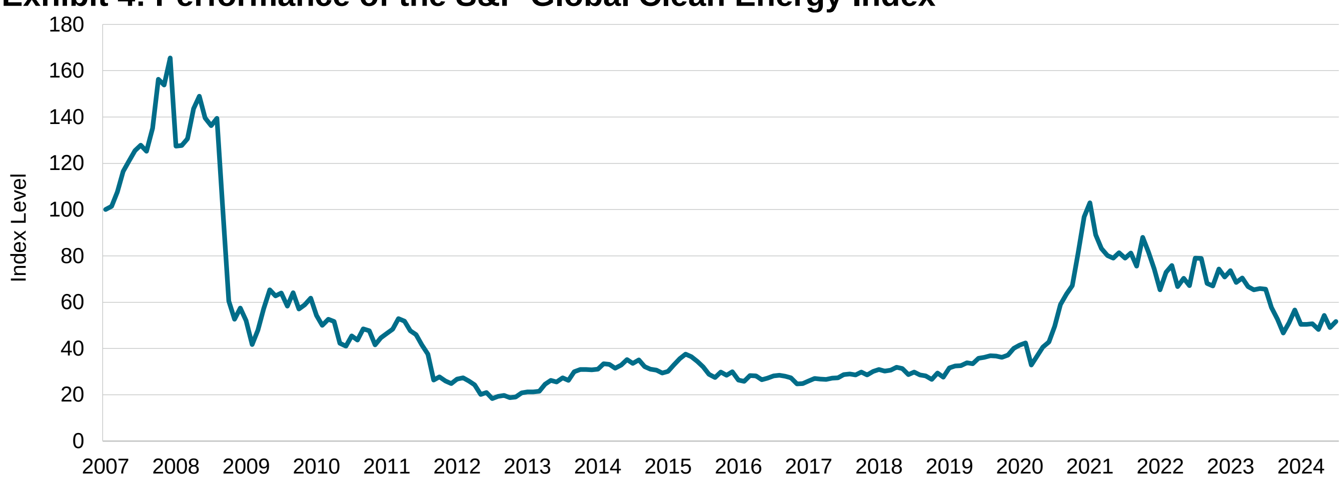


Source: S&P Dow Jones Indices LLC. FactSet. Data from April 19, 2021, to April 22, 2024. Chart is provided for illustrative purposes.

S&P Global Clean Energy Index Performance Review

Clean energy resources could offer an affordable and sustainable power supply while lowering greenhouse gas emissions relative to traditional energy sources. The clean energy space is quickly evolving, with new companies and technologies continuously replacing existing ones. Since its launch in 2007, the S&P Global Clean Energy Index has exhibited notable regimes in its performance (see Exhibit 4).

Exhibit 4: Performance of the S&P Global Clean Energy Index

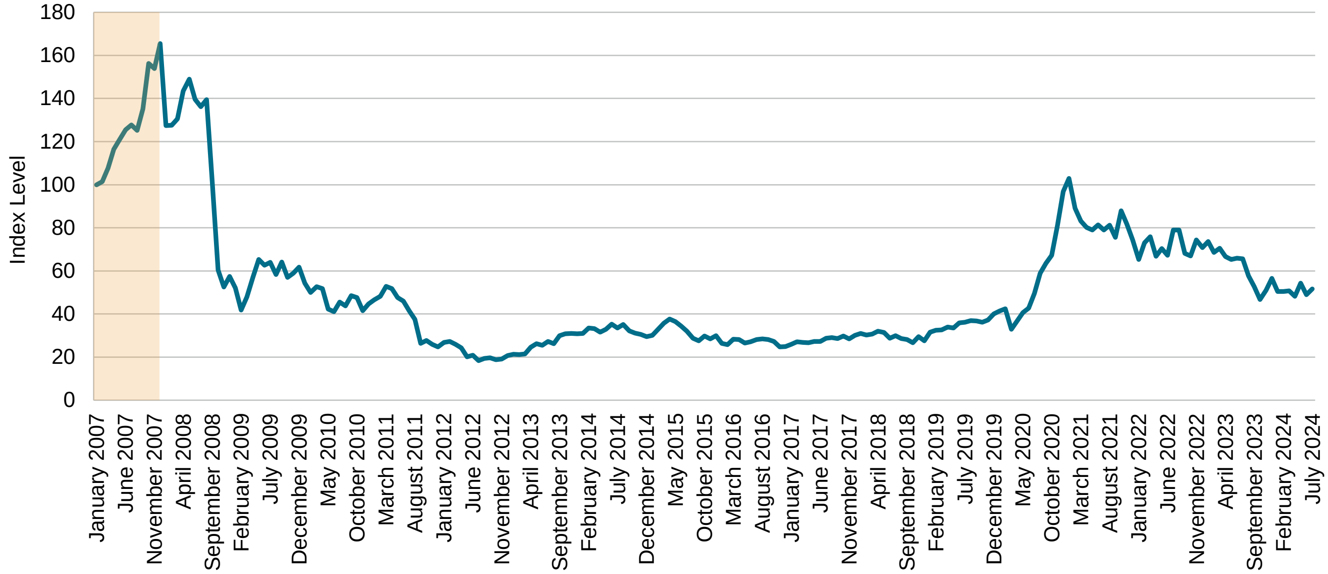


Source: S&P Dow Jones Indices LLC. Data from Jan. 31, 2007, to July 31, 2024. Index rebased to 100 on Jan. 31, 2007. The S&P Global Clean Energy Index was launched Feb. 22, 2007. All data prior to such date is back-tested data. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of the document for the inherent limitations associated with back-tested performance.

First Peak (2007)

Since its launch, the S&P Global Clean Energy Index reached its peak level in 2007 (see Exhibit 5). According to the United Nations Environmental Program (UNEP), in 2008, 56% of total Energy sector investments—amounting to USD 140 billion—were directed toward green energy, compared to USD 110 billion for fossil fuel technologies. This was the first time that investments in wind, solar and other alternative energy sources surpassed those in traditional coal-, oil- and carbon-based energy.[8]

Exhibit 5: First Peak of the S&P Global Clean Energy Index



Source: S&P Dow Jones Indices LLC. Data from Jan. 31, 2007, to July 31, 2024. Index rebased to 100 on Jan. 31, 2007. Yellow shaded section represents the period to first peak of index performance. The S&P Global Clean Energy Index was launched Feb. 22, 2007. All data prior to such date is back-tested data. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of the document for the inherent limitations associated with back-tested performance.

This growth happened alongside rising oil prices, which highlighted the need for clean energy alternatives. Additionally, government support through policies, subsidies and incentives played a crucial role in fostering the clean energy sector.[9] These initiatives not only encouraged investment but also stimulated innovation in clean energy technologies. Technological advancements further enhanced the viability of renewables, such as solar panels[10] and wind turbines.[11] This created a favorable environment for the clean energy industry, attracting both institutional and private market participants. Collectively, these dynamics contributed to the strong performance of the clean energy sector during this period.

[8] Kanter, James, "Clean Energy Funding Trumps Fossil Fuels," The New York Times, June 3, 2009.

[9] International Energy Agency, "Toward a Clean, Clever and Competitive Energy Future 2007," 2007.

[10] U.S. Department of Energy, "Solar Energy Technologies Program Newsletter," July 2007.

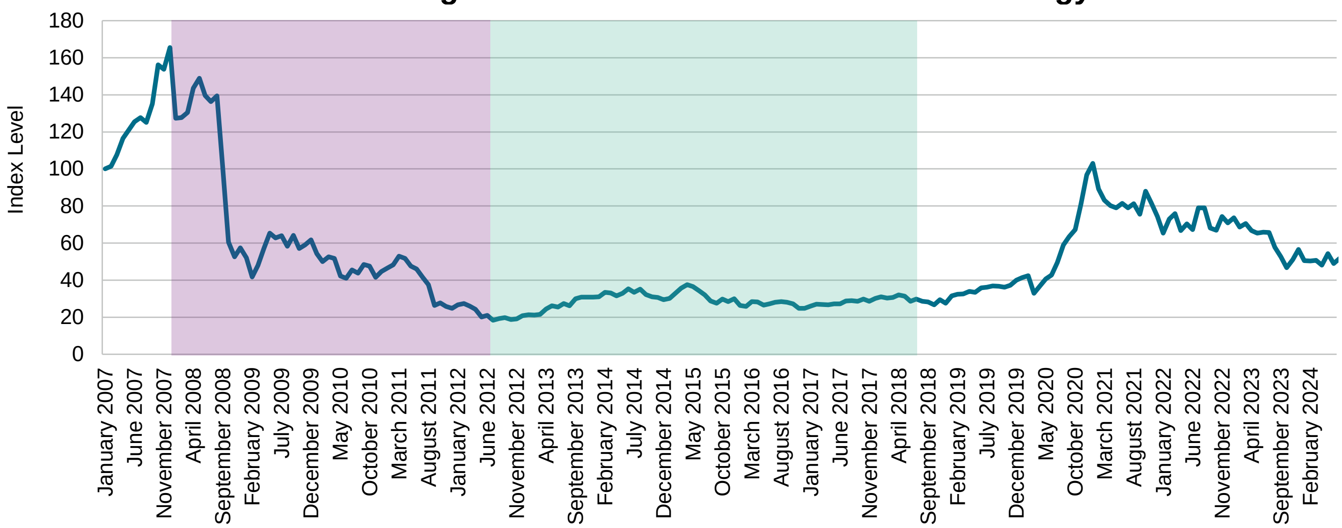
[11] Global Wind Energy Council, "Global Wind 2007 Report," May 2008.

Downturn Following the Peak (2008-2018)

Following its peak, the S&P Global Clean Energy Index faced a substantial decline from its 2008 high to its 2012 low (see Exhibit 6). This downturn was influenced by a multitude of factors. Fluctuating silicon prices,[12] which are critical for solar panel production, contributed to instability in the market. The rapid decline in oil prices, coupled with the emergence of cheap natural gas,[13] made traditional energy sources increasingly appealing.

Additionally, the 2008 financial crisis created widespread economic uncertainty, leading to reduced investments in clean technologies. China's rapid advancement in the solar industry intensified competition, making it difficult for other players to keep up.[14] This fallout affected nearly every segment of the clean tech sector—solar, wind, biofuels, electric vehicles and fuel cells—resulting in significant setbacks in investment and market confidence. Back then, the index did not include companies listed in emerging markets like China; as a result, China's clean energy industry growth during this period was not reflected.

Exhibit 6: Downturn Following the Peak of the S&P Global Clean Energy Index



Source: S&P Dow Jones Indices LLC. Data from Jan. 31, 2007, to July 31, 2024. Index rebased to 100 on Jan. 31, 2007. Purple shaded section represents the period from the first downturn to stabilization of index performance. Green shaded section represents a period of relative stability. The S&P Global Clean Energy Index was launched Feb. 22, 2007. All data prior to such date is back-tested data. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of the document for the inherent limitations associated with back-tested performance.

From 2012 to 2019, the index remained relatively stable, reflecting a period of consolidation in the clean energy sector. This stability was characterized by steady investments and a cautious market approach as stakeholders reassessed the evolving landscape.

[12] Bernreuter Research, "Polysilicon Price Trend," accessed November 2024.

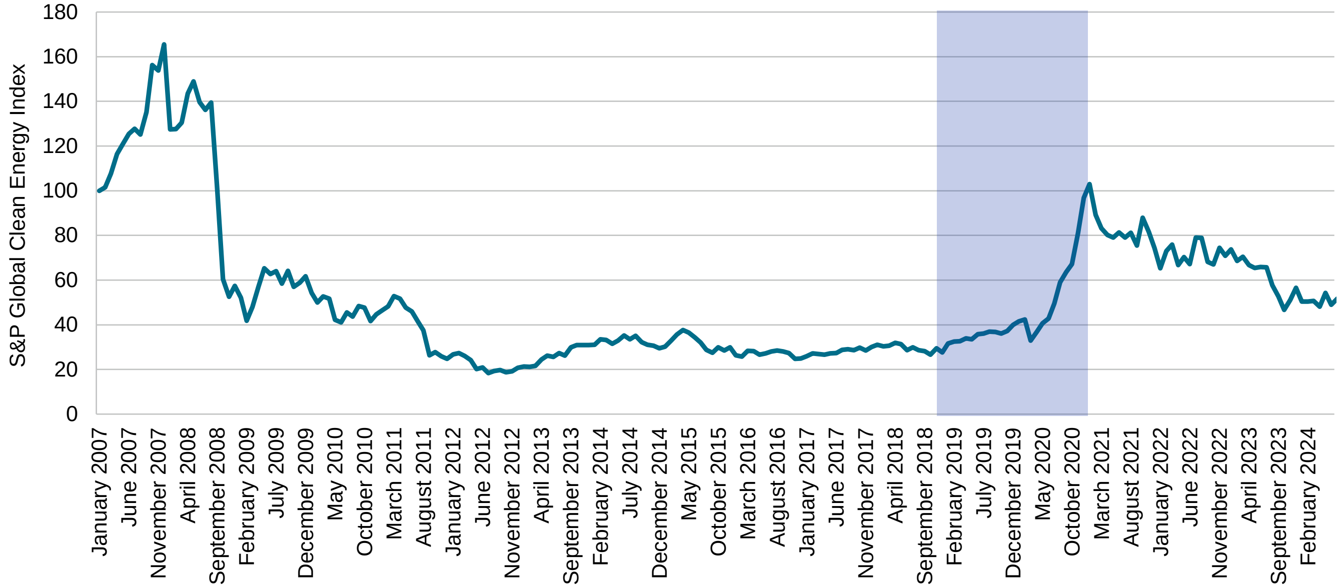
[13] Investopedia, "The 2008 Financial Crisis and its Effects on Gas and Oil," Sept. 28, 2022.

[14] EnergyTrend, "The Rise of China's Solar Industry in 40 Years," May 20, 2024.

Second Peak (2019-2021)

Starting in 2019, the index experienced a notable upward trend. This momentum accelerated dramatically in 2020 and 2021 (see Exhibit 7). The clean energy market experienced significant growth as the costs of clean energy sources became comparable to those of fossil fuels in 2019. This milestone not only made clean energy more accessible but also encouraged wider adoption among consumers and businesses. Additionally, favorable policies, such as government incentives and regulatory support, played a crucial role in promoting the transition to cleaner energy solutions. These factors collectively created a favorable environment for clean energy, which resulted in strong index performance and propelled further advancements in clean energy technologies.

Exhibit 7: Second Peak of the S&P Global Clean Energy Index



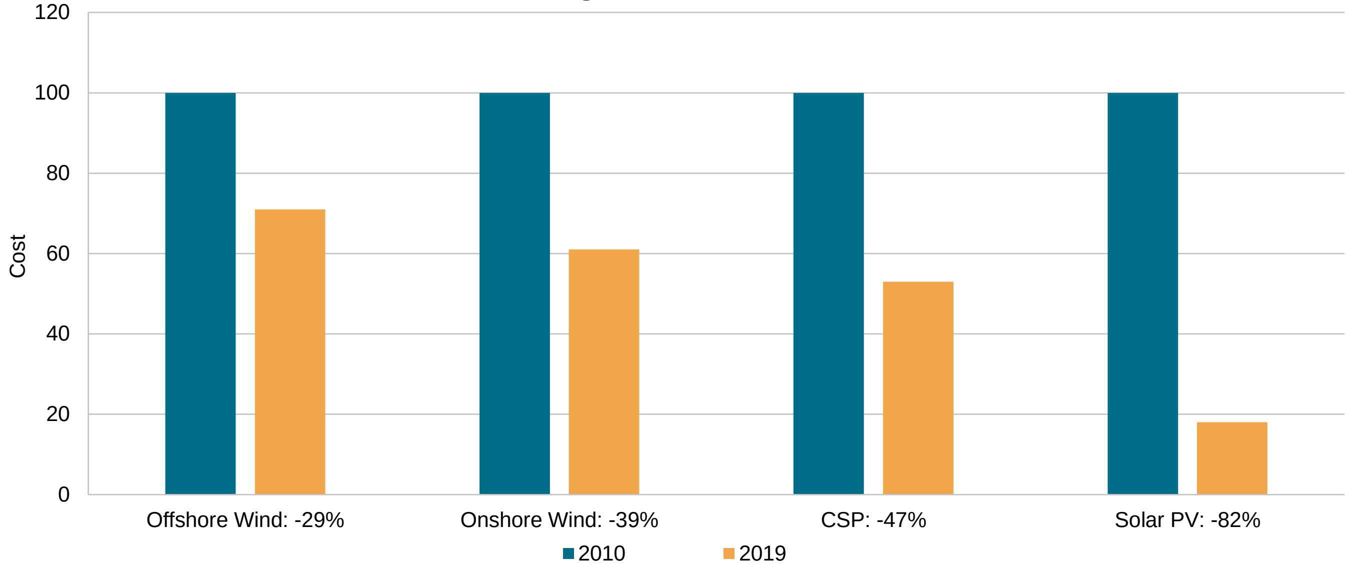
Source: S&P Dow Jones Indices LLC. Data from Jan. 31, 2007, to July 31, 2024. Index rebased to 100 on Jan. 31, 2007. Blue shaded section represents the period of growth to the second peak of index performance. The S&P Global Clean Energy Index was launched Feb. 22, 2007. All data prior to such date is back-tested data. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of the document for the inherent limitations associated with back-tested performance.

From a cost-reduction perspective, the competitiveness of clean energy improved during the period of 2010-2019 while costs fell sharply, reaching a milestone in 2019. According to cost data collected by the International Renewable Energy Agency (IRENA) in 2019, the cost of solar PVs had seen a dramatic decline of 82% since 2010. Examining the U.S. solar PV market more closely, a substantial part of the reduction is linked to overall hardware costs, which include modules, inverters and balance of system components. Notably, module prices fell by 85% during this timeframe.[15] This significant reduction in cost positions PV as a leading option in the clean energy sector. Concentrating solar power (CSP) had also experienced a

[15] Feldman, David, Vignesh Ramasamy, Ran Fu, Ashwin Ramdas, Jal Desai and Robert Margoli, "U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: Q1 2020," National Renewable Energy Laboratory, January 2021.

notable cost decrease of 47%, while onshore wind energy costs had fallen by 39% and offshore wind by 29% (see Exhibit 8).[16] This trend indicated a broader shift toward more economically viable clean energy sources. In fact, for 56% of all newly commissioned utility-scale renewable power generation capacity in 2019, the costs were lower than those of the cheapest fossil fuel-fired energy options.[17] This transition not only highlighted the competitiveness of clean energy but also suggested a potential pivot in energy investment strategies at that time, as the market increasingly favored sustainable solutions.

Exhibit 8: Renewable Power Technologies – Cost Decreases from 2010 to 2019



2010 level = 100%
Source: S&P Dow Jones Indices, IRENA: Key Findings: Renewable Power Generation Costs in 2019. Data from 2010 to 2019. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.

From a policy perspective, both the U.S. and the EU came up with strong policies to promote the adoption of clean energy initiatives.

In 2019, several U.S. policies went into effect that supported the clean energy sector. Seven states, along with Washington, D.C., and Puerto Rico, enacted laws that established the goal of reaching a clean energy production threshold of 50% or higher.[18] These targets were part of broader efforts to transition the U.S. economy to more clean energy sources. Congress extended tax credits for various clean energy technologies, including wind and solar power. The federal government auctioned offshore wind development leases along the East Coast, paving the way for what was anticipated to be the first U.S. large-scale offshore projects.[19]

[16] IRENA, "Key findings: Renewable Power Generation Costs in 2019," International Renewable Energy Agency, 2020.

[17] IRENA, "Key findings: Renewable Power Generation Costs in 2019," International Renewable Energy Agency, 2020.

[18] Bird, Lori, and Tyler Clevenger, "2019 Was a Watershed Year for Clean Energy Commitments from U.S. States and Utilities," World Resources Institute, Dec. 20, 2019.

[19] BloombergNEF and The Business Council for Sustainable Energy, "2019 Sustainable Energy in America Factbook Bloomberg Finance," 2019.

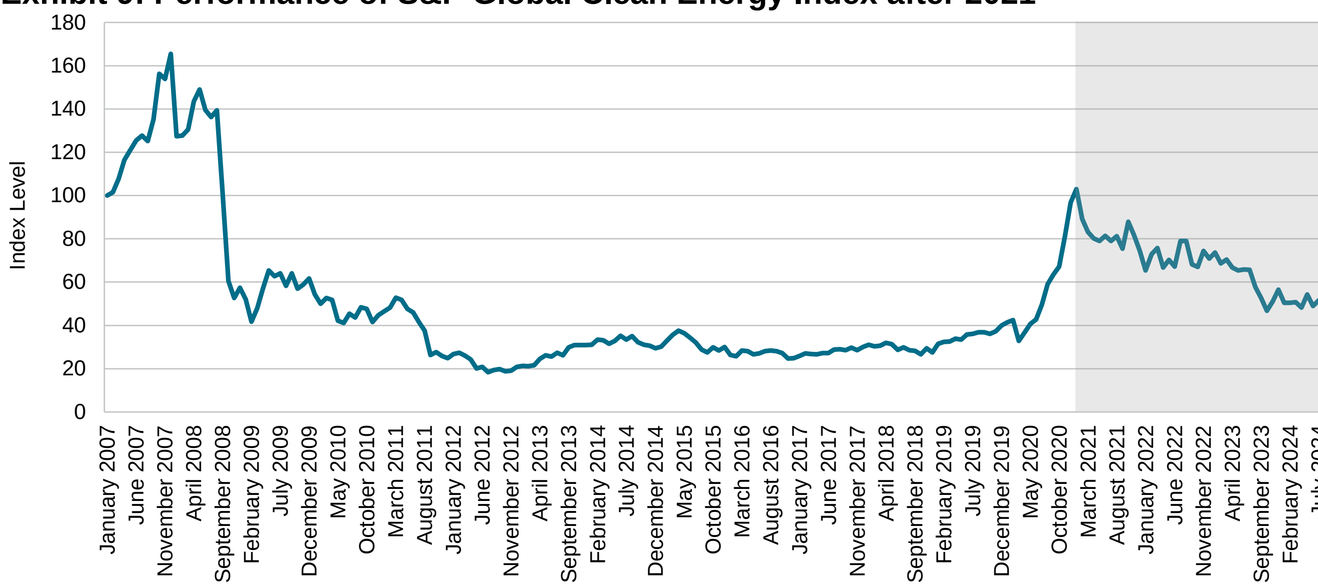
These incentives helped reduce the cost of clean energy projects and encouraged investment in the sector.

In Europe, the first revision of the Renewable Energy Directive came into effect as part of the Clean Energy for All Europeans Package in 2018. This directive required EU member states to incorporate it into their national laws by June 2021. It set a new binding renewable energy target of at least 32% of gross final energy consumption by 2030 for the EU.[20] In 2019, in alignment with the European Green Deal, the EU pledged to tackle energy, climate and environmental challenges while aiming for climate neutrality by 2050, in accordance with the Paris Agreement.[21]

Performance after 2021

The clean energy market faced a number of challenges during the post-COVID-19 global economic rebound, which led to another drawdown after index performance peaked for a second time in 2021 (see Exhibit 9). Inflation and rising interest rates posed challenges for financing new clean energy initiatives. The supply chain disruption, coupled with inconsistent policies and regulatory frameworks across different regions, created uncertainty for market participants and developers.

Exhibit 9: Performance of S&P Global Clean Energy Index after 2021



Source: S&P Dow Jones Indices LLC. Data from Jan. 31, 2007, to July 31, 2024. Index rebased to 100 on Jan. 31, 2007. Gray shaded section represents the drawdown period after the second peak of index performance. The S&P Global Clean Energy Index was launched Feb. 22, 2007. All data prior to such date is back-tested data. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of the document for the inherent limitations associated with back-tested performance.

[20] Zygierewicz, Anna, and Lucia Salvador Sanz, "Renewable Energy Directive: Revision of Revision of Directive (EU) 2018/2001," European Parliament, March 2021.

[21] European Parliament, "Renewable energy | Fact Sheets on the European Union," 2024.

Many countries have experienced a period of rising interest rates since 2021. Higher interest rates increase borrowing costs. Clean energy projects, such as wind and solar farms, typically demand significant upfront investment, so the rising cost of capital can substantially elevate the overall expenses of these projects. This may hinder the development of new initiatives and render existing ones less financially viable. In addition, increasing interest rates can diminish the competitiveness of clean energy relative to traditional fossil fuels. For instance, a 2% hike in interest rates can raise the levelized cost of electricity (LCOE)[22] for renewables by as much as 20%, whereas the effect on natural gas plants is considerably less significant.[23]

Also, in late 2020, prices for key inputs like steel, copper, aluminum and polysilicon surged sharply due to supply chain disruptions and rising demand. By 2022, the average monthly price of polysilicon—essential for crystalline silicon solar PV cell production—was four times higher than at the start of 2020. Steel prices increased by 75% in China, 160% in the U.S. and 270% in Europe, while copper and aluminum saw price hikes of 60-80%. Freight rates experienced the highest growth—nearly sixfold. In 2022, the share of key commodities and transportation costs accounted for an estimated 30-35% of overall capital expenditure for utility-scale solar and wind projects, double the proportion in 2020.[24] The rising costs associated with the supply chain also posed challenges for the clean energy market.

From a regulation perspective, delays in obtaining necessary permits and regulatory approvals slowed the deployment of clean energy projects. This was a common issue across many regions, affecting project timelines and increasing costs. Many European countries have implemented policies to tackle the challenges associated with slow and complex permitting processes for clean energy projects. The time required to secure permits varies widely across EU countries, taking from one to five years for ground-mounted solar projects and three to nine years for onshore wind projects.[25] Delays caused by these authorization procedures limited participation in clean energy auctions, escalated project risks and costs, and ultimately undermined the economics and bankability of power plants.

In addition, the global energy crisis and geopolitical tensions, including the war in Ukraine starting in 2022, have significantly impacted energy markets. The conflict between Ukraine and Russia heightened concerns about energy security. Countries reliant on Russian energy had to seek alternative sources, driving up the demand and price for oil and gas from other regions. Rising energy prices contributed to higher inflation rates globally.[26] Energy costs are a significant component of overall inflation, affecting everything from transportation to

[22] The LCOE is the net present value of the cost of electricity over electricity generation during the lifetime of the generating system.

[23] Penrod, Emma, "High interest rates hit renewable energy harder than natural gas: Wood Mackenzie," Utility Dive, May 7, 2024.

[24] International Energy Agency, "Renewable Energy Market Update: Outlook for 2023 and 2024," June 2023.

[25] European Commission: Directorate-General for Energy, Tallat-Kelpšaitė, J., Brückmann, R., Banasiak, J., Kokkonen, S. et al., "Technical support for RES policy development and implementation – Simplification of permission and administrative procedures for RES installations (RES simplify) – Interim report," Publications Office of the European Union, 2022.

[26] Kilian, Lutz, and Xiaoqing Zhou, "The inflationary impact of energy prices," Centre for Economic Policy Research, Feb. 10, 2023.

manufacturing. It was difficult to qualitatively segment the joint impact from rising traditional energy costs and inflation on clean energy companies during this period.

Energy Transition Policy Support Continues

Despite the performance headwinds in the past few years, we continue to see encouraging commitment and policy support from governments worldwide.

According to the International Energy Agency (IEA), governments are increasingly directing long-term investments toward clean energy, with over USD 2 trillion allocated since 2020.[27] As countries prioritize clean energy in their economic strategies, we may expect enhanced collaboration between governments, businesses and communities. This collaborative approach not only fosters innovation but also accelerates the deployment of clean energy solutions.

In 2021 and 2022, President Biden signed into law a series of strategic public investments, which included the largest investment in carbon emissions reduction in U.S. history. The clean energy initiatives—primarily through the Bipartisan Infrastructure Law and the Inflation Reduction Act—represent the largest investment in clean energy transition to date. These two laws have introduced grants, loans and tax incentives aimed at accelerating the deployment of clean energy and fostering innovative technologies.[28] This comprehensive array of public sector tools provides unprecedented certainty to the private sector, as many provisions of the Inflation Reduction Act will extend over a decade.[29]

In the EU, it is projected that energy investments will reach EUR 396 billion per year from 2021 to 2030 and EUR 520-575 billion per year in the subsequent decades until 2050. The EU budget aims for 30% of its spending to be dedicated to climate initiatives, which encompass energy efficiency, clean energy deployment, energy infrastructure and smart energy systems.[30]

China has declared its intention to peak carbon dioxide emissions by 2030 and attain carbon neutrality by 2060. In addition to advancing its own new energy initiatives, China is exporting high quality and affordable clean energy products to other nations, contributing to a global energy transformation. For example, China's exports of wind power and photovoltaic products

[27] International Energy Agency, "State of Energy Policy 2024 – Key Findings," September 2024.

[28] The White House, "FACT SHEET: Biden-Harris Administration Takes Action to Expand Access to Capital for Small- and Medium-Sized Climate Businesses," May 30, 2024.

[29] Stiglitz, Joseph, "Why the Inflation Reduction Act Is a Big Deal," Roosevelt Institute, Aug. 10, 2022.

[30] Widuto, Agnieszka, "Energy transition in the EU," European Parliament, 2023.

enabled other countries to cut carbon dioxide emissions by approximately 810 million metric tons in 2023.[31]

Understanding Performance from a Quantitative Lens

Now that we have analyzed the historical performance of the S&P Global Clean Energy Index from a qualitative angle, we will now build a quantitative framework to understand the performance drivers.

The historical performance of the S&P Global Clean Energy Index has been affected by various factors. Despite the fact that the S&P 500® kept hitting all-time highs over the past two decades, there have been several market drawdowns, such as the global financial crisis, the beginning of the COVID-19 pandemic in March 2020 and the market correction in 2022. The U.S. economy experienced its first real inflation spike in over 30 years. The clean energy industry keeps evolving, as we see new technologies and new businesses entering the space.

To understand the performance drivers, we constructed a regression model to break the performance into several factors:

$$R(t) - R(f) = Intercept + Beta * \left(Market - R(f)\right) + B_S * SMB + B_H * HML + B_{ST} * 2YrYield + B_{LT} * 10YrYield + B_I * Core\ CPI + B\_O * Oil$$

This model is an extension of the Fama-French three factor model that incorporates the change in short-term and long-term yield curves, the change in Core Consumer Price Index (Core CPI), and the change in oil price. We are using the Developed three factor model and the risk-free rate from Ken French's data library.[32] The 2-year yield,[33] 10-year yield,[34] Core CPI[35] and crude oil price[36] are all sourced from the Federal Reserve Economic Data (FRED) database. In addition, given the evolution of the clean energy landscape since the index launch, simply running the regression over the full sample period might not reveal the change of macroeconomic regimes and the dynamic relationship between the S&P Global Clean Energy Index performance and the factors that could impact it. Thus, we ran the regression

[31] The State Council, "China's energy transition contributes to global green development," The People's Republic of China, Aug. 29, 2024.

[32] French, Ken, "Ken French's Data Library," accessed November 2024.

[33] Board of Governors of the Federal Reserve System (US), "Market Yield on U.S. Treasury Securities at 2-Year Constant Maturity, Quoted on an Investment Basis [DGS2]," retrieved from FRED, Federal Reserve Bank of St. Louis, Oct. 29, 2024.

[34] Board of Governors of the Federal Reserve System (US), "Market Yield on U.S. Treasury Securities at 10-Year Constant Maturity, Quoted on an Investment Basis [DGS10]," retrieved from FRED, Federal Reserve Bank of St. Louis, Oct. 29, 2024.

[35] U.S. Bureau of Labor Statistics, "Consumer Price Index for All Urban Consumers: All Items Less Food and Energy in U.S. City Average," retrieved from FRED, Federal Reserve Bank of St. Louis, Oct. 29, 2024.

[36] U.S. Energy Information Administration, "Crude Oil Prices: Brent - Europe [DCOILBRENTEU]," retrieved from FRED, Federal Reserve Bank of St. Louis, Oct. 29, 2024.

using the rolling 60-month window since February 2007. Between February 2007 and September 2024, we have 212 return observations, so in total we can run 152 regressions on a rolling 60-month basis.

The chart of regression coefficients and their corresponding t-stats can be found in Exhibit 11 in the Appendix. From this regression output, we can observe some historical dynamic changes.

- For most periods, the market beta coefficient was well above 1 and statistically significant, which indicates that the S&P Global Clean Energy Index had higher volatility than the market. We also observe the downward trend of the beta since 2016, which is consistent with the decreasing volatility during that period. Since 2020, the beta has stayed in a relatively low regime. This is partly due to the expansion of the constituents in the S&P Global Clean Energy Index from 30 to 100, which improved the diversification of the index.

- Most of the time, the S&P Global Clean Energy Index had some tilt toward small-cap companies, as we can see that the small minus big (SMB) regression coefficient (B_S) has been above 0.5. The size exposure was statistically significant (i.e., absolute t-stats above 2) between 2010 and 2018, as well as since 2021. The value exposure of the S&P Global Clean Energy Index has been unclear. The high minus low (HML) regression coefficient (B_H) fluctuated between positive and negative, and the t-stats have been insignificant throughout the index history.

- Before 2020, the coefficient against the 2-year yield (B_ST) and the 10-year yield (B_LT) tended to fluctuate and was insignificant. After 2020, the S&P Global Clean Energy Index showed a positive relationship to the change in the 2-year yield and a negative relationship to the change in the 10-year yield. The negative relationship with the 10-year yield would make sense, as clean energy projects tend to have exposure to the long-term borrowing rate due to the length of those projects. The positive relationship with the 2-year yield is an interesting observation that's somewhat against the intuition. Despite the high correlation between the 2-year yield and the 10-year yield in recent years, when controlling the long-term yield factor, the short-term yield relationship with the S&P Global Clean Energy Index performance became positive.

- The coefficient against the month-to-month changes in the Core CPI (B_I) and crude oil price (B_O) was statistically insignificant. However, the coefficient against the Core CPI tended to be in the positive trajectory, and the coefficient against the crude oil price tended to be in the negative trajectory. The negative relationship against the crude oil price makes sense, as the rise in oil prices would benefit the traditional energy companies, which might generate a headwind for clean energy companies.

The R-squared of the regression model was above 0.5 but below 0.7 most of the time, indicating that, despite this being a strong model, it still can't explain a portion of the historical volatility behind the S&P Global Clean Energy Index. However, the model can still help us understand directionally how the index moved against some of the common equity factors and macroeconomic indicators, as well as the historical fluctuation behind those factor exposures.

Looking at the overall regression result, there seems to have been a regime shift since 2020. After 2020, the S&P Global Clean Energy Index had more significant tilt toward companies with higher valuations and smaller market capitalizations and tended to be negatively correlated with the rising 10-year yield and positively correlated with the 2-year yield. The relationship with the Core CPI tended to be positive and with oil prices tended to be negative, but neither were strong or clear.

Looking Forward

Energy transition efforts have gained momentum over the past decade despite facing macroeconomic and geopolitical challenges since 2022. There has been a significant increase in government pledges to achieve net-zero greenhouse gas emissions, but more action is needed to achieve the net-zero goal by 2050. According to the IEA, in order to achieve this goal, solar PV and wind would need to become the leading sources of electricity globally before 2030, and together they would need to provide nearly 70% of global generation by 2050.[37]

On Nov. 5, 2024, Donald Trump was re-elected as the next president of the United States, which created market concerns on the clean energy adoption prospects in the U.S., since Trump's energy policy during his campaign had been pro-fossil fuel.[38] This could be part of the reason why the S&P Global Clean Energy Index was down 6.08% on Nov. 6, 2024. However, as we have seen throughout this paper, the drivers of clean energy sector performance are multifaceted—market performance, clean energy technology advancement, inflation, oil prices and government policy globally may all have some impact on the sector's performance. During the first Trump administration, between Jan. 20, 2017, and Jan. 20, 2021, the S&P Global Clean Energy Index was up by 314%. In addition, U.S. companies only accounted for 23.8% of the weight of the S&P Global Clean Energy Index as of Oct. 31, 2024.

Overall, energy transition is a long-term strategy and a multi-decade trend that reflects a fundamental shift in how we produce and consume energy. This transition encompasses the move from fossil fuels to clean energy sources, the adoption of energy-efficient technologies, and the implementation of sustainable practices across various sectors. Some of the pioneers

[37] International Energy Agency, "Net Zero by 2050 - A Roadmap for the Global Energy Sector," October 2021.

[38] Reuters, "How do Trump and Harris differ on energy policy?" Oct. 29, 2024.

in this transition are in fact existing traditional energy players that have been investing actively in their clean energy business and technology capabilities. As countries and industries increasingly prioritize climate goals, this transformation could not only reshape energy markets but also drive innovation, create new job opportunities and foster economic resilience. The journey toward a sustainable future will likely require ongoing commitment, collaboration and investment from all stakeholders to ensure a successful transition.

As we navigate the complexities of the clean energy transition, the right index may be critical to gauge the industry's dynamic changes. The S&P Global Clean Energy Index could reflect emerging trends and innovations in the clean energy space by offering performance measures of clean energy-related companies. The index will continue to serve as a benchmark for the global clean energy sector.

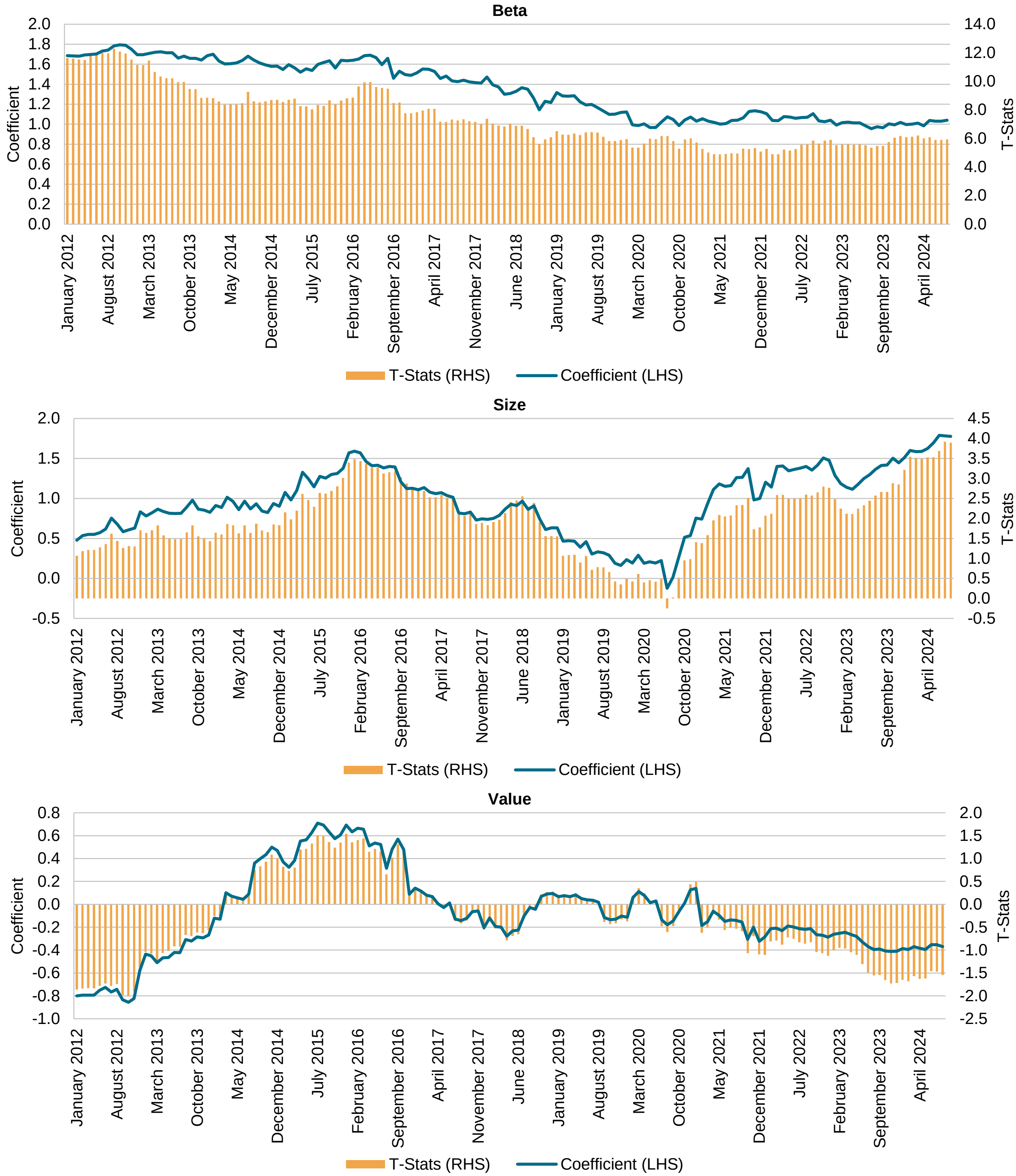
Appendix

Exhibit 10: Top 10 Constituents by Market Cap in the S&P Global Clean Energy Index

Company	Exchange Ticker	Country of Domicile
China Yangtze Power Co. A	600900	China
Iberdrola S.A.	IBE	Spain
PT Barito Renewables Energy	BREN	Indonesia
Consolidated Edison Inc.	ED	United States
Huaneng Lancang River Hydropower Inc. A	600025	China
Orsted	ORSTED	Denmark
Vestas Wind Systems AS	VWS	Denmark
First Solar Inc.	FSLR	United States
China Three Gorges Renewables (Group) Co. Ltd. A	600905	China
Energias de Portugal S.A.	EDP	Portugal

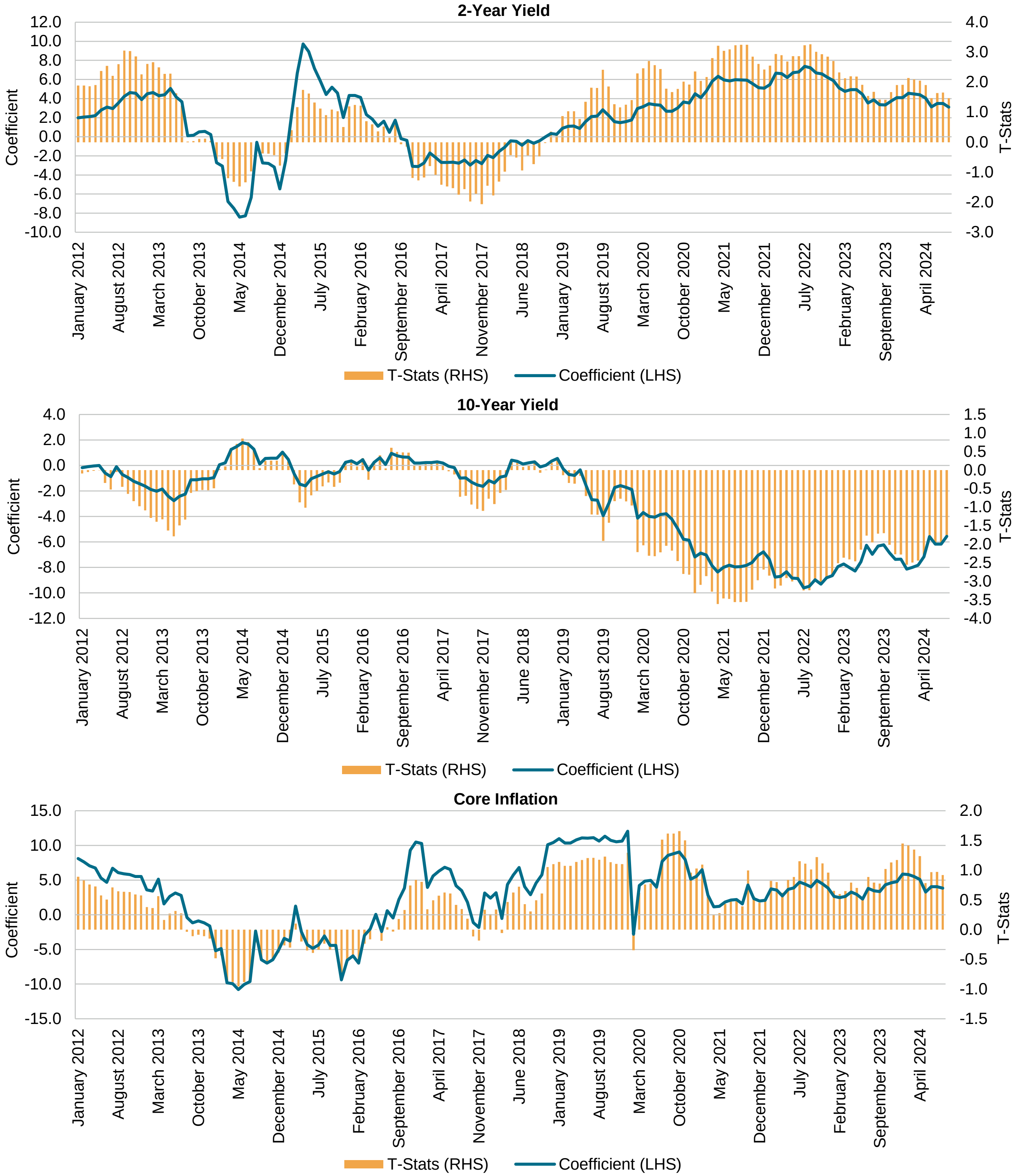
Source: S&P Dow Jones Indices LLC. Data as of July 31, 2024. Table is provided for illustrative purposes.

Exhibit 11: Regression Coefficient



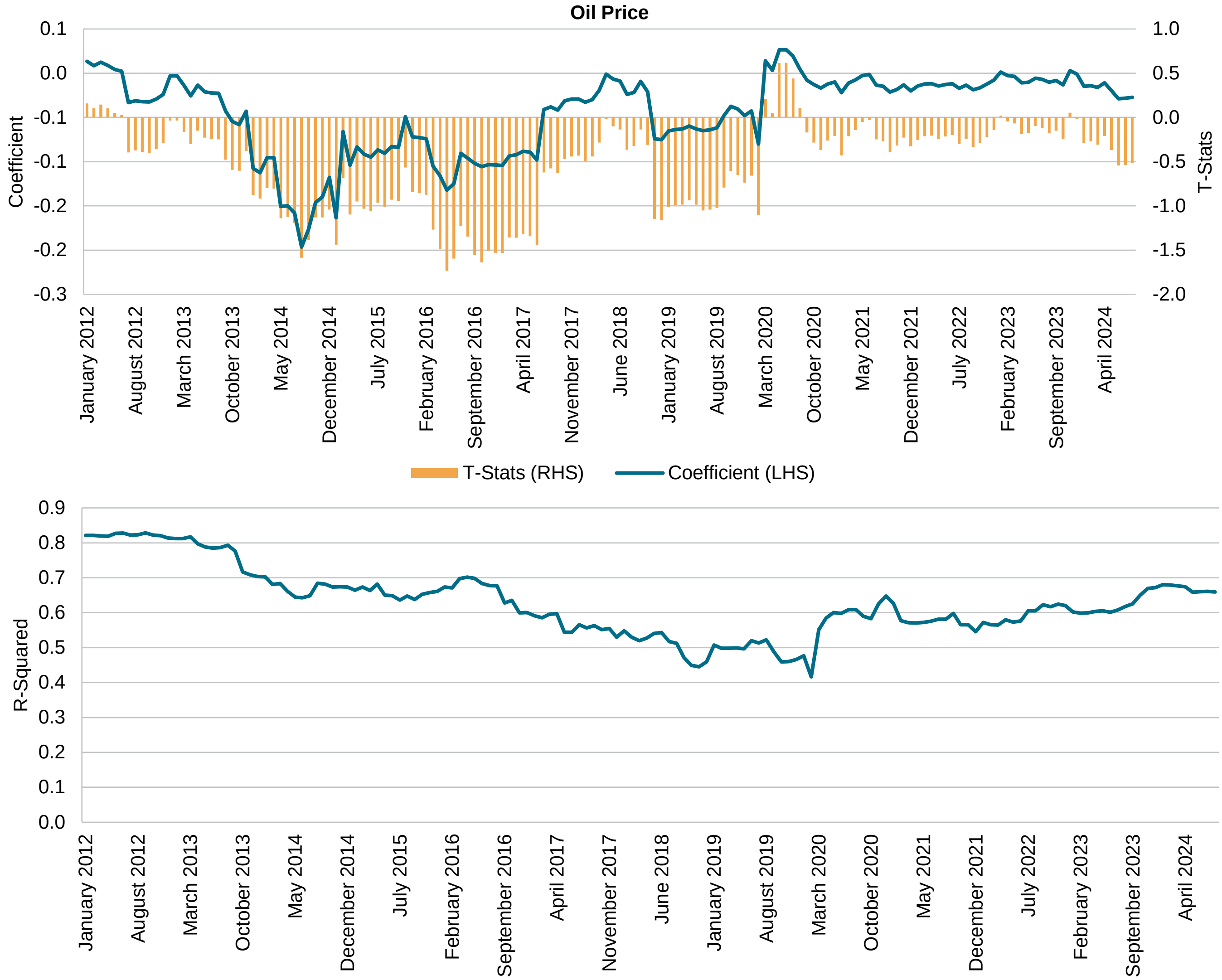
Source: S&P Dow Jones Indices LLC, Ken French Data Library, Federal Reserve Bank of St. Louis. Data from Jan. 31, 2007, to July 31, 2024. The S&P Global Clean Energy Index was launched Feb. 22, 2007. All data prior to such date is back-tested data. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Charts are provided for illustrative purposes and reflect hypothetical historical performance. Please see the Performance Disclosure at the end of the document for the inherent limitations associated with back-tested performance.

Exhibit 11: Regression Coefficient (Cont.)



Source: S&P Dow Jones Indices LLC, Ken French Data Library, Federal Reserve Bank of St. Louis. Data from Jan. 31, 2007, to July 31, 2024. The S&P Global Clean Energy Index was launched Feb. 22, 2007. All data prior to such date is back-tested data. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Charts are provided for illustrative purposes and reflect hypothetical historical performance. Please see the Performance Disclosure at the end of the document for the inherent limitations associated with back-tested performance.

Exhibit 11: Regression Coefficient (Cont.)



Source: S&P Dow Jones Indices LLC, Ken French Data Library, Federal Reserve Bank of St. Louis. Data from Jan. 31, 2007, to July 31, 2024. The S&P Global Clean Energy Index was launched Feb. 22, 2007. All data prior to such date is back-tested data. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Charts are provided for illustrative purposes and reflect hypothetical historical performance. Please see the Performance Disclosure at the end of the document for the inherent limitations associated with back-tested performance.

Performance Disclosure/Back-Tested Data

The S&P Global Clean Energy Index was launched Feb. 22, 2007. All information presented prior to an index's Launch Date is hypothetical (back-tested), not actual performance. The back-test calculations are based on the same methodology that was in effect on the index Launch Date. However, when creating back-tested history for periods of market anomalies or other periods that do not reflect the general current market environment, index methodology rules may be relaxed to capture a large enough universe of securities to simulate the target market the index is designed to measure or strategy the index is designed to capture. For example, market capitalization and liquidity thresholds may be reduced. Complete index methodology details are available at www.spglobal.com/spdji. Past performance of the Index is not an indication of future results. Back-tested performance reflects application of an index methodology and selection of index constituents with the benefit of hindsight and knowledge of factors that may have positively affected its performance, cannot account for all financial risk that may affect results and may be considered to reflect survivor/look ahead bias. Actual returns may differ significantly from, and be lower than, back-tested returns. Past performance is not an indication or guarantee of future results. Please refer to the methodology for the Index for more details about the index, including the manner in which it is rebalanced, the timing of such rebalancing, criteria for additions and deletions, as well as all index calculations. Back-tested performance is for use with institutions only; not for use with retail investors.

S&P Dow Jones Indices defines various dates to assist our clients in providing transparency. The First Value Date is the first day for which there is a calculated value (either live or back-tested) for a given index. The Base Date is the date at which the index is set to a fixed value for calculation purposes. The Launch Date designates the date when the values of an index are first considered live: index values provided for any date or time period prior to the index's Launch Date are considered back-tested. S&P Dow Jones Indices defines the Launch Date as the date by which the values of an index are known to have been released to the public, for example via the company's public website or its data feed to external parties. For Dow Jones-branded indices introduced prior to May 31, 2013, the Launch Date (which prior to May 31, 2013, was termed "Date of introduction") is set at a date upon which no further changes were permitted to be made to the index methodology, but that may have been prior to the Index's public release date.

Typically, when S&P DJI creates back-tested index data, S&P DJI uses actual historical constituent-level data (e.g., historical price, market capitalization, and corporate action data) in its calculations. As ESG investing is still in early stages of development, certain datapoints used to calculate S&P DJI's ESG indices may not be available for the entire desired period of back-tested history. The same data availability issue could be true for other indices as well. In cases when actual data is not available for all relevant historical periods, S&P DJI may employ a process of using "Backward Data Assumption" (or pulling back) of ESG data for the calculation of back-tested historical performance. "Backward Data Assumption" is a process that applies the earliest actual live data point available for an index constituent company to all prior historical instances in the index performance. For example, Backward Data Assumption inherently assumes that companies currently not involved in a specific business activity (also known as "product involvement") were never involved historically and similarly also assumes that companies currently involved in a specific business activity were involved historically too. The Backward Data Assumption allows the hypothetical back-test to be extended over more historical years than would be feasible using only actual data. For more information on "Backward Data Assumption" please refer to the FAQ. The methodology and factsheets of any index that employs backward assumption in the back-tested history will explicitly state so. The methodology will include an Appendix with a table setting forth the specific data points and relevant time period for which backward projected data was used.

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