THE INFLATION REDUCTION ACT: SHORT-TERM MARKET EFFECTS FOR RENEWABLE ENERGY

By

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An Undergraduate Thesis submitted in partial fulfillment of the requirements for the JOSEPH WHARTON SCHOLARS

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APRIL 2023

Abstract

The Inflation Reduction Act [IRA] is the largest climate legislation in US history. It includes billions of dollars in subsidies and incentives geared towards accelerating the energy transition in the United States and increasing domestic manufacturing of clean technology. This thesis conducts studies to gauge the impact of this monumental policy on US renewable energy investment markets, especially in the short-term time window designed around the dates when the IRA passed in US Congress. The results show that there are abnormally positive renewable energy stock returns and a significantly large proportion of clean energy M&A deals in the United States during the proposed time frames. These outcomes mean to show the impact of large-scale government subsidy policies on the financial markets of the industry it targets, as well as on the corporate decision-making that the legislation incentivizes. The thesis concludes that policies should heavily consider financial markets in order to achieve longer-lasting impact.

Keywords

Renewable energy, Inflation Reduction Act, abnormal return, Congress, M&A

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1. Introduction:

The renewable energy sector has been in the spotlight for the last few years as governments around the world pick up the pace and scope of climate regulation. In the United States, federal tax incentives have been at the forefront of policy developments to reduce the cost of renewable energy production, mostly by decreasing the tax liabilities for clean energy companies or allowing them to accelerate the depreciation of their assets. The 2022 Inflation Reduction Act is the largest climate law to have passed in US Congress, including record extensions and improvements for tax incentives such as the Investment Tax Credit and the Renewable Electricity Production Tax Credit, among other policy innovations that will be discussed in this paper. In total, US-based corporations in the clean energy and technology industries stand to gain $216 billion worth of tax credits. The federal investments brought forth by the IRA aim to strongly increase the value of renewable energy companies for the next ten years. They are likely to catalyze waves of investment in the renewable energy space, especially in electricity production and technology manufacturing. Given the importance of the IRA as an unprecedented piece of climate legislation, this thesis explores the impact of its policies by assessing (1) abnormal stock returns for renewable energy companies, including wind, solar, geothermal, hydropower, biomass energy producers and clean technology manufacturers, and (2) a significantly large dollar amount of clean energy M&A deals relative to long-term investment trends in the US economy. While the former gauges short-term market reactions, the latter signifies large-scale, longer-term investments in the clean energy space that are relevant to the time window of the Inflation Reduction Act's passing. Observing these reactions will gauge the weight that climate legislation has on the markets that it targets, as well as the rapidity of its effects. Details in the findings will point out the effects of specific Congress events on stock

price movements and abnormal returns and will evaluate clean energy stocks' dependency on policy developments.

2. The Inflation Reduction Act

2.1 A Close Look

The main goal of the Inflation Reduction Act is to "bring down consumer energy costs and increase American energy security while substantially reducing greenhouse gas emissions," as noted in the Summary of the Energy Security and Climate Change Investments section of the IRA. Out of the rough total of $433 billion budgeted in the legislation, $369 billion are invested in tax credits, subsidies, and grants that favor the transition to clean energy, while the rest is invested to target a reduction in US healthcare costs. In total, the IRA's climate investments include $216 billion in corporate tax incentives, $43 billion in consumer tax incentives, $82 billion in grants, $40 billion in loans and $13 billion in federal operations. These subsidies and investments target four distinct aims: make clean energy technologies affordable for consumers, increase American production of clean energy manufacturing, increase access to clean energy in small and rural communities in the country, and decarbonize the American economy.

According to the Senate policy summary, this sizable green investment will allow the US to reduce its greenhouse gas emissions below 2005 levels by 40 percent by 2030, setting the country on a path to net zero emissions by 2050. Among its most important breakthroughs is that it is the first US legislation to explicitly refer to greenhouse gases [GHG] as air pollutants, strengthening the Clean Air Act Section 111 and supporting the Environmental Protection Agency [EPA]'s legislative authority to regulate emissions for power generation. Notably, the incentives included in the policy would significantly reduce the cost for power plants to comply with EPA emissions standards through carbon capture tax credits and other investments outlined

in this section. Moreover, it introduces the first federal carbon tax on a greenhouse gas through a backstop methane charge of $900 per ton in 2024, reaching $1,500 per ton after 2026 inclusive. This regulation applies to any operation that emits the equivalent of over 25,000 metric tons of CO2 per year (HLS 2022). To target the decarbonization of the economy from a federal and state government standpoint, it includes roughly $30 billion in grants and loans for states and electric utilities to successfully transition to clean electricity; $6 billion in grants and tax subsidies for an "Advanced Industrial Facilities Deployment Program" to reduce emissions from chemical, steel and cement plans; over $9 billion for Federal purchases of US-manufactured clean technologies, including $3 billion for the Postal Service to acquire clean vehicles; a $27 billion investment in clean energy technology accelerator; and, lastly, a Methane Emissions Reduction Program to reduce leaks from natural gas production. Moreover, it includes over $20 billion to support climate-conscious agriculture, $5 billion in grants for forest conservation, tax credits and grants for American production of biofuels and $2.6 billion in grants for the conservation and restoration of coastal habitats.

The IRA is innovative in that it heavily involves everyday US consumers in the tax credits, grants, and subsidies, actively engaging individual Americans in the energy transition– a key factor to achieve the desired long-lasting effect of climate policy. To target consumer affordability, it includes $9 billion in consumer home energy rebate programs to electrify home appliances, ten years of consumer tax credits for rooftop solar panels, water heaters and heat pumps, $4,000 individual tax credits for used clean vehicles and up to $7,500 for new electric vehicles, and a $1 billion grant program to increase the energy efficiency of affordable housing. To target environmental justice and rural communities, it includes a $3 billion program for the Environmental and Climate Justice Block Grants for community-led projects, another $3 billion

in grants to reduce air pollution in ports, and $1 billion for clean school and transit transportation buses and garbage trucks.

Another key dimension of the IRA is the level of subsidization for large-scale, long-term renewable energy projects undertaken in the United States. The Investment Tax Credit in the bill subsidizes 30 percent of the development costs for solar, wind and related technologies that meet the IRA's labor requirements as a base rate through 2032. An additional 10 percent can be claimed if the materials of the project are sourced domestically or if it is implemented in a fossil-fuel dominated location. This means that a US renewable energy development has the potential to be subsidized by over half. The studies conducted in this thesis will evaluate this as an important factor for new investments to flourish. To specifically target domestic manufacturing, it includes $60 billion for onshore clean energy manufacturing across the energy and transportation supply chain. Within that quantity, $30 billion is to be invested in US manufacturing of solar panels, wind turbines, batteries, and "critical minerals processing," as well as $500 million for heat pumps and critical minerals processing. It includes a $10 billion investment in tax credits to build facilities that manufacture wind turbines, electric vehicles and solar panels, $2 billion in grants to transform car manufacturing facilities to produce electric vehicles and another $20 billion in loans to build new clean vehicle manufacturing plants. Lastly, it provides a $2 billion investment for energy research through National Labs.

All these investments will be financed through an increase in the minimum tax on large corporations to 15 percent, a 1 percent tax on stock buybacks and $80 billion in new investments for IRS tax enforcement that will collect $203 billion over the next ten years. In total, the Congressional Budget Office estimates that the tax reform in this legislation will reduce budget deficits by $237 billion over the next decade. The climate policies included in this legislation

emphasize the importance of subsidies and incentives to catalyze action from consumers and private actors such as producers and investors. They rely on the fact that markets and consumers will respond to the economic benefits brought forward and hence push the energy and transportation sectors to transition into clean alternatives. This thesis, therefore, proposes that a key measure to observe the IRA's effectiveness is its short-term capacity to move private markets.

2.2 Projected Future Impacts of the IRA

To first gather information about the Inflation Reduction Act's overall impacts, this thesis looks at multiple independent research studies that analyze its effects in facilitating the energy transition in the long-run and predict increases in long-run corporate investment. Firstly, the Bill is projected to reduce greenhouse gas emissions by 37-41 percent below 2005 levels globally (Mahajan, Ashmoore, Rissman, Orvis and Gopal 2022), up to 10 percentage points more than without the legislation[1] (Larsen et al. 2022), underscoring the significance of the bill not only in the US but globally and providing a path for the country to achieve its Nationally Determined Commitments in the Paris Agreement. This percentage translates to a projected reduction of 2,500 to 2,800 metric tons of GHG below 2005 levels. Consequently, this reduction in emissions appears to result in positive health outcomes. The reduced air pollution from the emissions reduction could avoid between 2,900 and 4,500 premature deaths in 2030, primarily from asthma attacks, according to the Energy Innovation Policy & Technology LLC.

Second, different models have predicted that investment in clean energy and clean transportation will increase dramatically in the next ten years. Princeton University's Zero-carbon Energy Systems Research and Optimization Laboratory found that the IRA would

[1] RHG-NEMS, a version of the Energy Information Administration's (EIA) National Energy Modeling System modified by Rhodium Group.

incentivize a nearly $3.5 trillion investment in “new American energy supply infrastructure” from 2023 to 2032 (Jenkins et al. 2022). The model finds that the greatest impact will lie in wind power and solar energy production, which the policy will nearly double to $321 billion by 2030. It will also pool more than $20 billion in yearly investments for fossil power generation that is paired with carbon capture. Other models find that the rise in production and construction catalyzed by the IRA will lead to a GDP increase of 0.65 to 0.77 percent in 2030, with a capital equipment investment increase of $180 billion through 2030 (Mahajan et al. 2022).

Increase in investment in these areas is in many ways related to consumer demand for the same goods. The demand-side incentives and subsidies included in the legislation will decrease renewable energy costs for every-day Americans. According to the ZERO Lab model, the Inflation Reduction Act will total a savings of $50 billion per year for households, businesses and industries, with hundreds of dollars in yearly savings in energy bills for households (Jenkins et al. 2022), also partially due to the downward pressure these policies will place on oil and gas prices as a consequence of lower demand levels. Household investments are also expected to rise, including purchases of heating systems, solar panels, energy appliances and electric vehicles. In these aspects, the demand side of the energy system will be partially responsible for the overall projected increase in private investment.

Some of these studies’ results utilize predictions for economic decisions of businesses and households given the legislation’s incentives. However, whether actors ultimately make those decisions vary on unobservable factors that the models cannot account for. Even though these studies include detailed breakdowns of investment predictions, most literature doesn’t assess direct short-term impacts of the IRA. This paper will attempt to model how the legislation affected short-term stock market reactions in the clean energy sector and larger dollar-value

corporate projects that will show how the legislation has affected private action up until the current moment, highlighting how quickly climate policies can affect private markets.

Lastly, it is useful to observe examples of large-scale investments aligned to the incentives in the IRA from automakers and renewable energy manufacturers. Toyota announced that it would invest $2.5 billion in a North Carolina production facility for electric and hybrid vehicle batteries, while Honda and LG Energy Solution announced a project to collectively build a $4.4 billion electric vehicle battery factory (Ewing and Penn 2022). First Solar also announced a $1.2 billion investment to build its fourth production factory in the US. These are examples of announcements that were made within less than a month after President Joe Biden signed the legislation. Though these investments will take time to materialize and become economically productive, it is possible that they took place as a consequence of the market-moving magnitude of the IRA. This significance will be evaluated in the studies conducted.

3. Literature Review

3.1 Incentive Policies and Private Markets

This literature review looks at evidence of other Washington DC incentive policies that successfully catalyzed action from consumers, financial markets and private companies, and looks at the factors that triggered this reaction. As was argued above, the legislation under observation is yet another example of government activity attempting to provoke investment in a specific economic area. Similarly, the American Rescue Plan and the CHIPS & Science Act that preceded the Inflation Reduction Act attempted to incentivize increased consumer spending and investment in domestic technology manufacturing, respectively.

The American Rescue Plan is a bill that passed in March 2021 which includes incentives to help economic recovery from the COVID-19 pandemic in the US. The entire legislation

included $1.9 trillion in public funding, mostly aimed at direct payments to citizens, unemployment benefits and federal transfers to state and local governments in the context of the pandemic. A large factor in this legislation were individual payments of $1,400 for single people making less than $75,000 per year, heads of household making less than $112,500 and married couples jointly making less than $150,000 per year. These stimulus checks were aimed at inducing individual consumption to lift the economy from GDP declines and low national spending data, as outlined in The White House report of the American Rescue Plan. As Americans spent the checks that the government distributed, the bill proved to have affected an increase in 4 million jobs and doubled GDP growth through the end of 2021 (Yaros, Rogers, Cioffi, and Zandi 2022). This exemplifies how clear incentives –in this case, direct transfers– effectively improved a desired outcome through the action of the recipient of the incentives– citizens increasing individual consumption.

The next example is the CHIPS Act [Creating Helpful Incentives to Produce Semiconductors], a measure that was signed into law in August of 2022 and that provided incentives for US domestic semiconductor manufacturers to increase production. This Act provides funding for research and development and gives monetary incentives for companies to build new semiconductor facilities in the United States, totaling an average of $50 billion in subsidies and over $24 billion in tax credits (NGA 2022). This legislation is similar to the Inflation Reduction Act in that it provides supply-side incentives for corporations to increase exposure to a specific sector. Moreover, the CHIPS Act similarly highlights the importance of domestic manufacturing, incentivizing production of semiconductors within the country to reduce reliance on foreign manufacturers and increase its competitiveness in the global market (NGA 2022).

So far, the Semiconductor Industry Association calculates that the CHIPS Act has sparked $200 billion in private investments for US Semiconductor Production in 16 states to increase manufacturing capacity, created 40,000 new jobs in the semiconductor area, and caused the announcement of over 40 new corporate projects around the country, including new manufacturing facilities and site expansions across the semiconductor supply chain (Casanova 2022). Most projects are expected to begin by the end of 2024. As the research study conducted by the Association indicates, "while the $50 billion federal incentive program would be a one-time investment, the result of building up this domestic semiconductor industrial infrastructure will have an enduring positive impact on the U.S. economy and jobs. An investment of this magnitude would help create an estimated 10 additional fabs [manufacturing facilities] in the U.S. that would otherwise not be built and add 42,000 new semiconductor jobs to the U.S. economy" (Reid 2021). This impact highlights the fact that an observable aspect of incentive policies is their ability to catalyze private action and thus create a long-lasting indirect impact in the economy.

Lastly, the Infrastructure Investment and Jobs Act, also known as the Bipartisan Infrastructure Bill, was a piece of legislation that passed in US Congress in November of 2021, totaling a $1.2 trillion investment in US infrastructure such as roads, public transit, bridges and internet access. The legislation allocates the overall investment over ten years, including $550 billion spent during the next five focusing on surface transportation and adding to core society infrastructure (Badlam, D'Emidio, Dunn, Kumar, and O'Rourke 2021). The passing of this legislation caused an increase in private investment on infrastructure company stocks following its passing in Congress. Shortly after the bill passed in the House of Representatives, analysts at Jefferies, Baird, Stifel and Evercore ISI observed relatively small stock price increases in

construction equipment and material manufacturers such as Caterpillar, Deere, Astec Industries, Nucor, and US Steel, as well as stock-market gains for electric-vehicle manufacturers (Klebnikov 2021). Moreover, a research report released by Blackrock states that "the Act provides funding for projects that can drive economic growth as well as prepare the U.S. economy for the transition to net-zero, but with the aim of tapping both private equity and private debt," honing in on the fact that greater public funding would make infrastructure sectors in the US more "investable" in the US market.

3.2 Climate Regulation and Private Investment

Climate regulation can be divided into groups of policies that "penalize" GHG emissions and groups of policies that "incentivize" investment in the energy transition. While the United States is notable for their use of tax incentives, international governments utilize carbon pricing as a mainstream tool for climate regulation. According to the World Bank's International Finance Corporation, "carbon pricing has proven to be one of the most effective tools to unlock potential from the private sector, companies, as well as investors" (IFC 2019). For this reason, this thesis considers it important to look at the interaction between these policies and private investment, in addition to the incentive policies and the projected impacts of the IRA's subsidies stated above, to provide a full picture of global climate regulation and its expected impacts. Carbon pricing policies, which include distributions of emissions allowances to firms and carbon taxes, according to the IMF, are usually more politically contentious and difficult to achieve than tax incentives and federal climate investments (Parry 2021). These policies mainly target corporations and high emitters to reduce their CO2 pollution levels. The California Cap-and-Trade system and the European Emissions Trading Scheme [ETS] are two examples of carbon

pricing policies. Research papers included in this section explore the impact these policies have on increasing private investment in renewable energy.

Work on the impact of cap-and-trade mechanisms on investments in renewable energy was conducted by Wei, Li-Feng and Hong-Yan in 2021. Their study sets up a statistical model that considers how an electricity generator will invest further in renewable energy after the government restricts its emissions through a cap-and-trade system. The model assumes that the electricity generator will utilize a benchmarking approach to invest in renewable energy and increase its electricity demand, thus pushing up its total investment in renewable energy. It finds that in the electricity supply chain, a cap-and-trade system will reduce the cost coefficient for renewable energy and thus increase its investment and the profit of the enterprises in its supply chain. This becomes relevant in our study because it highlights the possibility of other government policies that don't involve incentives to increase reactions from private actors. Another paper explores the impact of carbon taxes and carbon trading on wind power investments in China. The study finds that coordination between carbon trading [cap-and-trade system] and subsidy policies [such as the Inflation Reduction Act] yields higher voting rates from investors to implement wind farm projects than coordination between carbon taxing and subsidy policies, in which case investors will pay the funds of coal power generation (Sun, Wei, Zhao and Yang 2022). This is an important consideration for the study of this thesis as it allows for further perspective on what combination of global government policies might be more useful in encouraging private sector support for renewable energy investments.

4. Data & Methods

4.1 Financial Markets Reaction

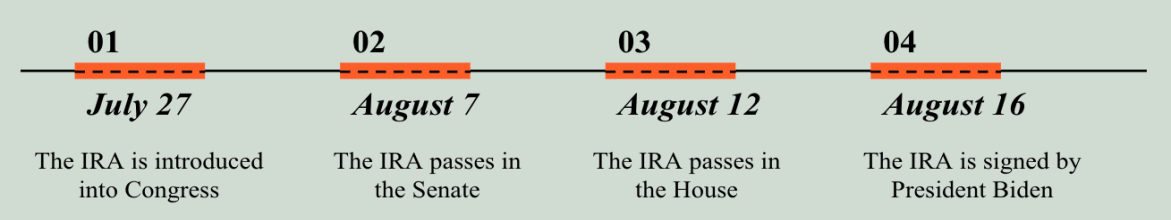
As stated above, there is already anecdotal evidence to suggest that the IRA is achieving its intended long-term goals. This thesis seeks to find significant short-term market reactions to the observed legislation to further gauge its impact. To that end, this paper looks at two sets of data: an event study to find the statistical significance of abnormal returns in major renewable energy stocks in US exchanges, and stock price charts to observe the reaction of major funds in the clean energy space throughout the 60-day period of Congress decision-making. The event study is set up to find Cumulative Abnormal Returns [CAR] relative to the overall market within the designated time period for a certain list of clean energy stocks. It evaluates whether there was a significant change in stock returns in excess of an entire market-wide movement due to an event that took place within the chosen time frame. The test rests on the fact that there exists a return for a certain firm's stock *i* on day *t*, and then regresses the individual stock returns on the market returns, modeled as follows:

$$Ri, t = a + bRm, t + ei, t$$

where a = alpha, b = beta, R = Return, and e = error term, and where the error term reflects the abnormal return to ensure that the individual firm's return is independent from market-wide movements. Wharton Research Data Services [WRDS] allows to plot this relationship through Cowan Research L.C.'s *Eventus* tool for a list of stocks included in the Center for Research in Security Prices [CRSP] –which includes all stocks traded in the New York Stock Exchange, NASDAQ, and American Stock Exchange– using parameter estimates and specific time windows.

In order to find the time window for the event the study keeps in mind the timeline of Congress decisions: the Inflation Reduction Act was introduced into Senate discussion on July 27, 2022, by Senators Joe Machin and Chuck Schumer. It passed in the Senate on August 7, 2022, after Vice President Harris broke a 50-50 voting tie, and subsequently passed in the House of Representatives on August 12. It was signed into federal law on August 16 by President Biden. For this event study, the time window is focused around the date that the legislation was approved in the House on August 12– the first instance where it becomes clear to the markets that it will be signed into law. Figure 1 reflects the timeline of relevant Congress events.

Figure 1: IRA timeline



Following this timeline for the legislation, the study compiles data for four different time windows: [0,1], [-1,1], [-15,15], [-30,30], where 0 is the designated event date, August 12. The study results consider the assumption that markets react preemptively to Congress decisions and stock returns will be priced in early. The study looks at stocks considered to be representative of the clean energy industry. It observes the 75 stock holdings in the WilderHill Clean Energy Index [ECO], which Bloomberg L.P describes as a modified equal dollar weighted index composed of publicly traded companies whose businesses stand to benefit substantially from the societal transition toward the use of clean energy and conservation. It includes holdings such as Enphase Energy Inc., Sunrun Inc., Plug Power Inc., and First Solar Inc. The full list of holdings is included in Appendix B.

In order to conduct the study, the names and tickers of each holding were exported into a .txt file to read it into the WRDS tool, which then provides the permanent identification number for each company as given by the Center for Research in Security Prices for August 12. Henceforth, this data is exported into a new file to upload to the Eventus R software tool. The software selects a market index as a benchmark to calculate the returns in excess of the market [CAR]. This study chooses to use both the CRSP Equally Weighted Index and the CRSP Value Weighted Index. The former adds the cumulative stock returns together and accounts for the number of stocks in the study, while the latter takes the weighted average of all the stocks as it relates to their market capitalization.

In order to estimate normal market returns, this study compares the four different time windows against a separate estimation period, which is programmed to have an estimation length of 255 trading days, running until 46 trading days before the event window begins [there are 252 trading days in one year]. The estimation is conducted using an Ordinary Least Squares regression to report the alpha and beta values in the study. The software runs a series of tests to find statistical significance in the cumulative abnormal returns. First, this thesis runs a cross-sectional t-test, which calculates the t-statistic by dividing the average event-period abnormal return by its contemporaneous cross-sectional standard deviation. In addition, it runs a Patell z-test, which standardizes each abnormal return by the forecast-error-corrected standard deviation before calculating the test statistic– this test helps standardize variance given the large sample size. Lastly, the study runs a series of non-parametric tests such as the Rank test and the Jackknife test to account for strong outliers and test for the difference in median, rather than mean. The variety of the tests ensures statistical significance across different statistical methodologies.

To add granularity to the results, this thesis also looks at time charts of stock price movements from July 1 to August 31 of 2022 from the largest clean energy Exchange-Traded Funds [ETFs] by assets under management. This will allow the study to point out which specific Congress event dates are likely to have influenced steeper spikes in market activity in the clean energy sector. The observed ETFs are the following: the Invesco WilderHill Clean Energy ETF [PBW US Equity, which mirrors the ECO index mentioned above] with 702.29M in AUM, the iShares Global Clean Energy ETF [ICLN US Equity] with 4.68B in AUM, the First Trust NASDAQ Clean Edge Green Energy Index [QCLN US Equity] with 1.58B in AUM, and the Invesco Solar ETF [TAN US Equity] with 2.24B in AUM. All these funds include important stocks in alternative energy sources and include a proportion of holdings in electric, semiconductors, auto manufacturers and chemicals. This thesis considers the holdings in these funds to accurately represent the renewable energy sector in the United States. The plot will show the price and inflow increases in these funds against the SPDR S&P 500 ETF Trust [SPY US Equity] to observe to what extent price and flows outpaced the market while controlling for overall market reactions on the observed dates. The observations relate to which specific Congress events [announcement, Senate, House, Presidential signature] are likely to have caused a larger uproar in the market.

4.2 Mergers and Acquisitions

The incentives in the Inflation Reduction Act are largely designed to benefit long-term corporate industrial developments in the American clean energy industry through its expansions of the Investment Tax Credit for domestic manufacturing investments, advanced clean energy projects, and technologies such as energy storage and microgrid controllers. As such, this thesis also studies the possible impact the Inflation Reduction Act had in increasing the total dollar-

value size of M&A deals, large-scale corporate investments and joint ventures in the clean energy space in the corresponding period as it compares to other periods of the same length.

As opposed to market returns, which are likely to take place shortly after an announcement is made due to markets preemptive decision-making, long-term corporate deals require several rounds of due diligence interactions, applications for debt from outside capital sources, budgeting plans, and strategy coordination to find the most cost-efficient long-term path to implementation. Consequently, this study takes a five-month window[2] to be sufficient to recognize deals potentially caused by the Inflation Reduction Act's approval [limitations to this method are listed in Conclusions].

This study starts by taking into consideration the dollar amount of clean energy deals that took place in the five-month period between the day the Inflation Reduction Act was proposed in the Senate on July 27, and the near end of the calendar year on December 27, 2022. The study considers deals that are (1) completed, (2) pending and (3) proposed throughout the respective time window. Given the length of time to complete an M&A deal, as just mentioned, taking into consideration pending and proposed deals is important in ensuring that this study's time frame does not prejudice the results by excluding deals that may still be in process during that period. Data collected includes both the number of deals and the total dollar amount of deals in the clean energy industry in the United States– this geographic constraint includes the target, seller, and acquirer of the deals observed in the dataset. It also shows the same data for the entire US economy. The purpose of this data collection is to explain what percentage of the dollar value of

[2] General research indicates the average time for an M&A deal to be successfully executed ranges from six months to one year, with outliers that can last multiple years for the buy-side. Given that this dataset includes deals that have been announced and proposed, not only those fully completed, a smaller time span of five months is considered appropriate.

deals in US markets corresponds to the clean energy space in the post-IRA time frame and evaluate the significance of this proportion relative to the other periods.

5. Results

There are two sets of results, one for the stock market returns and stock price movements, discussed in Section 3.1, and another for the M&A data, discussed in section 3.2. Both are included in this section.

5.1 Results: Financial Markets Reaction

The financial markets results summarize the mean abnormal returns of all considered stocks for each day of the [-30,30] time window, which are 61 days in total. In addition, the results show the different test statistics for each day's abnormal returns before turning the results into cumulative values for each specific time window, assigning significance values to each.

Observing the day-by-day list given by the output, there are a few notable characteristics in the data: eleven trading days before the observed day of August 12 carries abnormal returns of 6.08 percent above market. This day corresponds with the day after Congress proposed the Inflation Reduction Act [i.e., the first time that markets opened after the proposal became public]. The test statistics are significant, showing a t-value of 5.603 for the cross-sectional error t-test and a z-value of 6.213 for the Patell z-test in the [-30, 30] time window. Moreover, the mean abnormal returns start to show an important degree of statistical significance for the days directly after the study's chosen event date.

Table 1: Mean Cumulative Abnormal Returns, Value Weighted Index

Days	N	Mean Cumulative Abnormal Return	Precision Weighted CAAR	Positive: Negative	CSectErr [t]	Portfolio Time-Series (CDA) [t]	Uncorrected Patell [z]	Rank Test [z]	Jackknife [z]
[-30,+30]	74	23.26%	21.47%	57:17>>>	5.603***	1.461$	6.213***	1.385$	6.160***
[-15,+15]	74	11.97%	12.07%	53:21>>>	3.833***	1.055	4.912***	0.985	4.795***
[-1,+1]	74	0.95%	0.85%	35:39	0.966	0.270	1.109	-0.058	0.806
[0,+1]	74	0.67%	0.62%	37:37	0.891	0.231	0.997	0.039	0.534

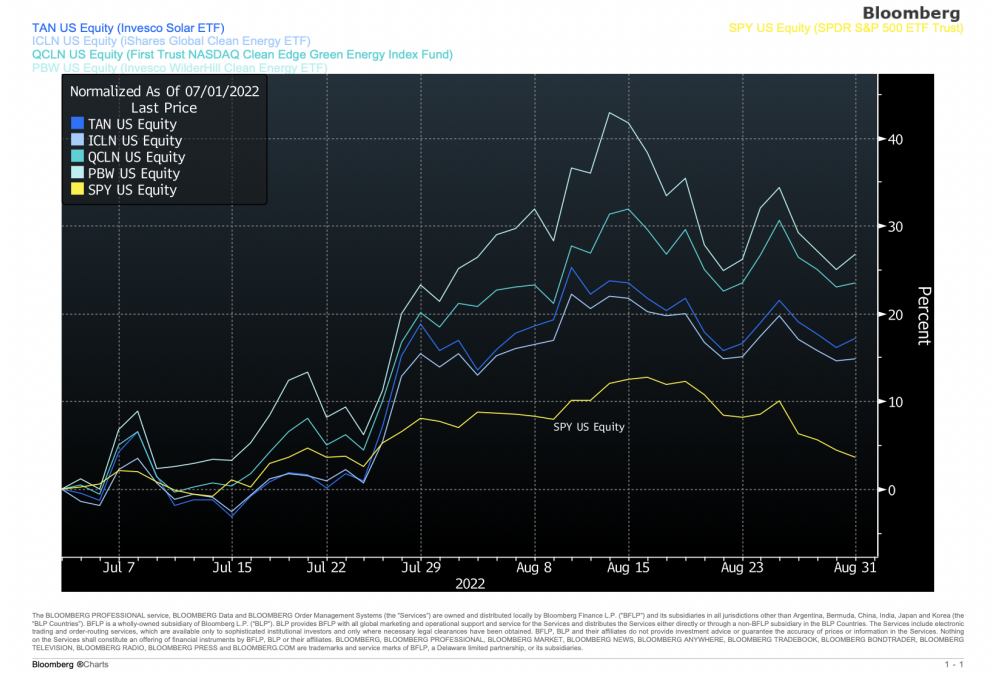
Data source: Wharton Research and Data Services

The symbols $,,**, and *** denote statistical significance at the 0.10, 0.05, 0.01 and 0.001 levels, respectively, using a generic one-tail test. The symbols (,< or),> etc. correspond to $,* and show the direction and significance of a generic one-tail generalized sign test.*

The mean cumulative abnormal return is positive for all time windows and statistically significant for the [-30,30] and [-15,15] time periods. Those periods include the date when the legislation proposal first became public. The study results show that the abnormal returns for clean energy companies are correlated with an event in the window under observation. In other words, it shows a statistically significant linear relationship between the time when the Inflation Reduction Act passed in Congress and increased short-term returns of renewable energy stocks. All clean energy funds under this study increasingly outperformed the SPDR S&P 500 ETF Trust from July 26 to August 16, 2022, as government decisions unfolded. Data analyzed under Bloomberg L.P.'s Comparative Returns function shows that the Invesco Solar ETF, the First Trust NASDAQ Clean Edge Green Energy Index, the iShares Global Clean Energy ETF, and the Invesco WilderHill Clean Energy ETF outperformed the S&P 500 by 10.75, 14.06, 9.52, and 20.37 percentage points, respectively. This serves as supporting evidence, showing strong clean energy returns comparative to the market, which the statistical study qualifies as significant.

For a more detailed observation, Figure 2 below displays the price appreciation for each of the Exchange-Traded Funds [listed under Data & Methods] for the significant Congress decision dates and shows the difference between these ETFs' stock price movements to the performance of the SPDR S&P 500 ETF Trust [SPY US Equity], which contains the stocks in the S&P 500 and mirrors its performance.

Figure 2: Price Percentage Appreciation, July-Aug 2022: Clean, SPX:



Source: Bloomberg

Figure 1 shows a price spike of almost 20 percentage points in all four major clean energy ETFs between July 27 and July 29, after the first proposal was voiced in the Senate. This could potentially provide additional insight as to how quickly financial markets are likely to react to policy news. Furthermore, we can see another spike for all four funds between August 8 and August 12, the days that the legislation passed in the Senate and the House of Representatives, respectively. It is notable that the price of the SPDR S&P 500 ETF Trust remained constant, with variations that did not surpass 4 percentage points. This provides further evidence that the increase in clean energy ETF prices is unlikely to have taken place as a consequence of an overall positive movement in the United States stock market.[3]

[3] There exist exogenous factors that can limit stating a causational relationship as it relates to the Inflation Reduction Act. This is further discussed under confounding variables and limitations.

Markets' preemptive reaction to external events allows stocks and funds to change in market value given expectations of future performance or overall future benefits for the industry that they're a part of. Figure 3 below shows price increases in the clean energy funds from the start of 2018 to contrast the 60-day period return and price increase with a long-term interval.

Figure 3: Price Percentage Appreciation, Jan 2018-Mar 2023

Source: Bloomberg

The peak price for the observed clean energy ETFs took place in January of 2021 when President Biden was sworn into office. Peak inflows also took place during this time [shown in Appendix A]. Given his campaign's focus on climate regulation, his election signaled increases in federal renewable energy investments for the following four years and commitments to global climate standards such as the Paris Agreement, making it likely for markets to have priced in an investment such as the Inflation Reduction Act at that time. The figure shows that the full market

effect of a policy such as the IRA can be attributed to different time spaces according to varying activity in the market and regulating entities.

5.2 Results: Mergers and Acquisitions

At first, the study compared the data collected for the post-IRA five-month timeframe to all data available for the ten preceding years, up until July 26, 2012. However, this showed a very significant difference, which merited a closer look. Both deal count and total dollar value decrease significantly as the window is set further back in time, which aligns with research previously reviewed given the exponential growth in the renewable energy industry and the larger amount of government subsidies given out in recent years. These qualitative differences made it hard for both timeframes to be comparable, so the study found a different method to perform a more accurate comparison. The data points were divided into eleven separate five-month timeframes up until 15/17/2018 [outlined below] to use as comparisons to the post-IRA window.

Table 2: M&A Data

Period	Date Range	US economy deals	Total size of US economy deals ($1000)	Clean energy deals	Total size of clean energy deals ($1000)	Clean ($) / Total ($)
1	07/27/2022 - 12/27/2022	9391	1,100,000,000	174	27,000,000	0.024545455
2	02/26/2022 - 07/26/2022	11,066	1,400,000,000	224	14,700,000	0.0105
3	09/25/2021 - 02/25/2022	13,963	1,900,000,000	208	23,600,000	0.012421053
4	04/24/2021 - 09/24/2021	12,340	1,900,000,000	184	17,600,000	0.009263158
5	11/23/2020 - 04/23/2021	10,498	1,700,000,000	163	16,000,000	0.009411765
6	06/22/2020 - 11/22/2020	8,084	1,300,000,000	125	10,600,000	0.008153846
7	01/21/2020 - 06/21/2020	6,970	1,200,000,000	74	14,300,000	0.011916667
8	08/20/2019 - 01/20/2020	8,698	1,400,000,000	100	12,200,000	0.008714286
9	03/19/2019 - 08/19/2019	8,672	1,700,000,000	129	14,000,000	0.008235294
10	10/18/2018 - 03/18/2019	8,424	1,700,000,000	115	19,800,000	0.011647059
11	05/17/2018 - 10/17/2018	8,522	1,900,000,000	106	21,700,000	0.011421053

Data source: Bloomberg

At first sight, we can see that the total dollar value of clean energy deals in the post-IRA time window [$27Bn] is larger than in any of the other observed timeframes. The last column in this table shows the proportion of the dollar value of clean energy deals relative to the total dollar value of all deals in the US economy. The table shows that the clean energy deals within the timeframe after the Inflation Reduction Act passed correspond to 2.45 percent of the total US

economy deals. This value is larger than in any of the additional time windows. In order to gauge the statistical significance of this proportional difference given this new data, this thesis conducts a one sample proportion t-test. This test will be used to determine whether the mean dollar value of clean energy deals over the total dollar value of US economy deals in the first observed period is significantly different from the population means of the different time periods.

The sample mean shown in Table 1 corresponding to the first time period is 0.0245, indicating that a 2.45 percent of the dollar value of the total M&A, joint-venture, and long-term investment deals in the United States corresponds to the alternative energy industry. This study performs an analysis with Python data analysis tools that extracts the proportion of the dollar value of clean energy deals in the US economy for the first time period, computes the mean and standard deviation of the observed datapoint with that of the entire dataset, and performs a one-sample t-test with a null hypothesis that the population mean is equal to the sample mean.

The study then provides the following results and conclusions: the sample mean of 0.0245 indicates that the first date range has a higher dollar amount of clean energy deals over the dollar amount of total US deals compared to the population mean of 0.0115. Moreover, the test yields a t-statistic of –9.4385, which indicates that there is a statistically significant difference between the sample mean and the population mean, and it is highly unlikely that this difference occurred by chance. Lastly, the p-value of 0.0000 given by the test confirms that the observed difference between the sample mean and the population mean is statistically significant. This allows this study to confidently conclude that the date range corresponding to the five-month period after the announcement of the Inflation Reduction Act in the US Senate has a significantly higher proportion of clean energy deals as a percentage of total deals in the United States Economy than in the other observed time periods. Given the fact that M&A deals

and long-term investments take a longer time to materialize than stock market returns and given the fact that there is a significantly higher proportion of clean energy deal value in the time window after the IRA than in the prior periods spanning up until 2018, this data is likely to be independent from short-term price moves in other types of energy sources. However, this thesis takes natural gas into consideration to account for endogeneity.

6. Confounding Factors: Natural Gas

This study questions whether the observed abnormal returns of renewable energy stocks could be attributed to a factor other than the IRA, which could happen to be synchronized with the IRA's timeline. If this was the case, the presented results would suffer from endogeneity. Energy prices play an important role in the performance of energy stocks by affecting demand and company profitability, which affects fluctuations in investment from one type of energy to another. About 21.5 percent of energy generated in the United States comes from renewable sources, compared to 60.2 percent from fossil fuels and almost 40 percent from natural gas, as shown by data from the US Energy Information Administration. Although the substitutability of fossil fuels and renewable sources of energy as electricity providers and investments is questionable, natural gas and renewable energy are both majorly directed towards US power generation. This potential functional overlap merits study about whether the market movements of tradable funds including stocks in each energy type are likely to move in a similar, opposite, or independent manner. A significant negative correlation between investment vehicles in each energy type would be necessary to infer that natural gas market performance influenced the increased returns, stock price, and investment in the clean energy companies observed under the study. Table 3 shows the correlation values between the First Trust Natural Gas ETF [FCG US

Equity], which holds US-listed companies in the exploration and production of natural gas, and the four clean energy ETFs studied above for the 60-day period from July 1 to August 31.

Table 3: Correlation Matrix Output, 60-day period

	FCG	TAN	ICLN	QCLN	PBW
FCG	1.000	0.413	0.386	0.387	0.329
TAN	0.413	1.000	0.972	0.910	0.839
ICLN	0.386	0.972	1.000	0.898	0.838
QCLN	0.387	0.910	0.898	1.000	0.961
PBW	0.329	0.839	0.838	0.961	1.000

Source: Bloomberg

The highlighted values show each clean energy ETF's correlation to the First Trust Natural Gas ETF. These values show a positive and weak linear relationship between [FCG] and [TAN, ICLN, QCLN and PBW]. This indicates that natural gas and clean energy holdings included in the mentioned ETFs are more likely to move independently within the observed time window. It is possible that an event occurred during this time frame that influenced natural gas prices in an abnormal manner, which could affect the relationship between both types of stocks. On July 25, 2022, Russian energy supplier Gazprom announced that it would reduce natural gas supply from the Nord Stream 1 pipeline for maintenance.[4] It reported that, due to turbine stoppage, daily gas production capacity would be cut to 33 million cubic meters down from its full capacity of over 160 million cubic meters on July 27. This event, in addition to the grip that Russia's war in Ukraine already had on European gas supply, and record-hot temperatures in many locations around the world, caused a significant increase in US natural gas prices around the same time that the Inflation Reduction Act was introduced into Congress. Although sharp increases in natural gas prices can make renewable sources of energy more economically

[4] Reuters, July 25, 2022.

competitive and more attractive investments due to demand-side responses to high prices, they can also increase investment in natural gas production, exploration, and infrastructure companies as they see rises in profitability. The movement in natural gas stocks shows the latter effect, as the First Trust Natural Gas ETF saw a positive price movement of 23.15 percent and a positive net change in inflows of 250.86 percent during the 60-day window.[5] These positive values are in line with the correlation results as both types of stocks increased in value during the observed time frame. To ensure that the 60-day correlation values are not an exclusive result of the unusual spike in natural gas prices, longer-term values are observed as follows.

Table 4: Correlation Matrix Output, 2-year period

	FCG	TAN	ICLN	QCLN	PBW
FCG	1.000	0.218	0.263	0.328	0.347
TAN	0.218	1.000	0.935	0.903	0.873
ICLN	0.263	0.935	1.000	0.898	0.871
QCLN	0.328	0.903	0.898	1.000	0.956
PBW	0.347	0.873	0.871	0.956	1.000

Source: Bloomberg

These results show similar evidence that natural gas and clean energy stock price movements are unlikely to be dependent on each other throughout the 2-year period between August 31, 2020, and August 31, 2022. This allows this study to rule out natural gas price movements as a confounding variable to the abnormal returns or positive price movements for clean energy stocks.

[5] These values are not meant to show statistical significance [that fact is unknown], but rather simply show positive market movements for natural gas stocks. No scope significance is attributed to those values by this thesis.

7. Conclusions

7.1 Implications of Results

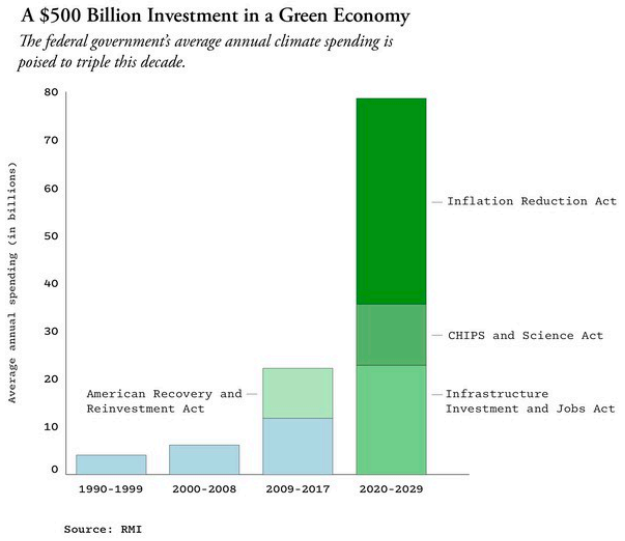
The results found in this thesis show two major effects in the United States renewable energy investment space during the observed time windows: abnormal short-term positive stock returns and larger-than-usual total dollar value of corporate clean energy deals. The tests run in this study show that there are statistically significant values for both clean energy stock returns and M&A, joint venture, and large-scale investment deals. Together, they provide significant insight as to how quickly markets moved during the respective time windows under study, organized around the Inflation Reduction Act. Moreover, the study finds that price movements in other energy types are unlikely to have affected the market value of clean energy stocks and exchange-traded funds by finding a weak and positive linear relationship between natural gas exchange-traded fund movements and clean energy exchange-traded fund price fluctuations. Overall, the results reflect an increase in market value and investment capacity for companies in the alternative energy industry.

7.2 Limitations and Additional Steps

The causational role of the Inflation Reduction Act is challenged by exogenous events that might have independently influenced these results. Limitations and additional possibilities for study include the following: (1) Further research would perform a cross-sectional analysis for the abnormal returns of clean energy stocks to account for the effect of company size, revenue reports, and other firm-specific factors on market returns. (2) Market reaction is limited by the extent of news coverage and social media interactions with the policy. Similarly, the overall reach of the legislation to everyday consumers is limited by public awareness. A study that finds a significant correlation between independent mentions of the Inflation Reduction Act in popular

stock-market news outlets and significant price movements in clean energy stocks would provide additional insight. Bloomberg Quant Research performed a study drawing a relationship between Bloomberg Automated Intelligence [BAI] news stories and sudden increases in stock prices and M&A deals. It sates the following: “The results reveal that automated stories have been ahead of major announcements by companies across a diverse set of industries. In particular, corporate actions such as M&A follow certain combinations of automated stories far more often than would be expected in a random sampling” (Fesanghary and Verma 2020). This would be interesting to explore for stronger causational insights. (3) It is possible that other government policies that passed during this time window had an additional effect on clean energy stock market returns, prices, and long-term deals by increasing the investment base for the transition to renewable energy sources. Figure 4 below reflects recent investments in the green economy in the United States.

Figure 4: Federal Climate Investment Breakdown, 1990-2029:



Source: Rocky Mountain Institute, EnergySage.

While the Infrastructure Investment and Jobs Act passed in November 2021 and is unlikely to have affected short-term investment in the summer months of 2022, the CHIPS and Science Act was signed into law on August 9, 2022, and included investments for climate research and zero-carbon technology. Although the significantly larger extent of the Inflation Reduction Act's incentives is likely to have had a larger proportional market effect, it is statistically possible that both policies played a combined role in the observed market reactions. This could be considered for further study.

7.3 Discussion

Using stock market and M&A data, this thesis has demonstrated a correlation between the timeline of the IRA in Congress and unusual returns, stock prices, and large-scale investment deals in the renewable energy industry. The information gathered in this thesis underscores how volatile and dependent clean energy stocks, funds, and investment projects can be to government subsidies and incentives. A large investment such as the Inflation Reduction Act can push the market value of renewable energy companies forward and attract abnormal returns for clean energy stock and exchange-traded funds as the market becomes aware of the consequences of the legislation. This paper finds it essential for government policies to take market reactions into account when designing climate incentive policies– such reactions will allow the legislation to affect the target industry by an exponential amount as retail and institutional investors become increasingly involved in the energy transition.

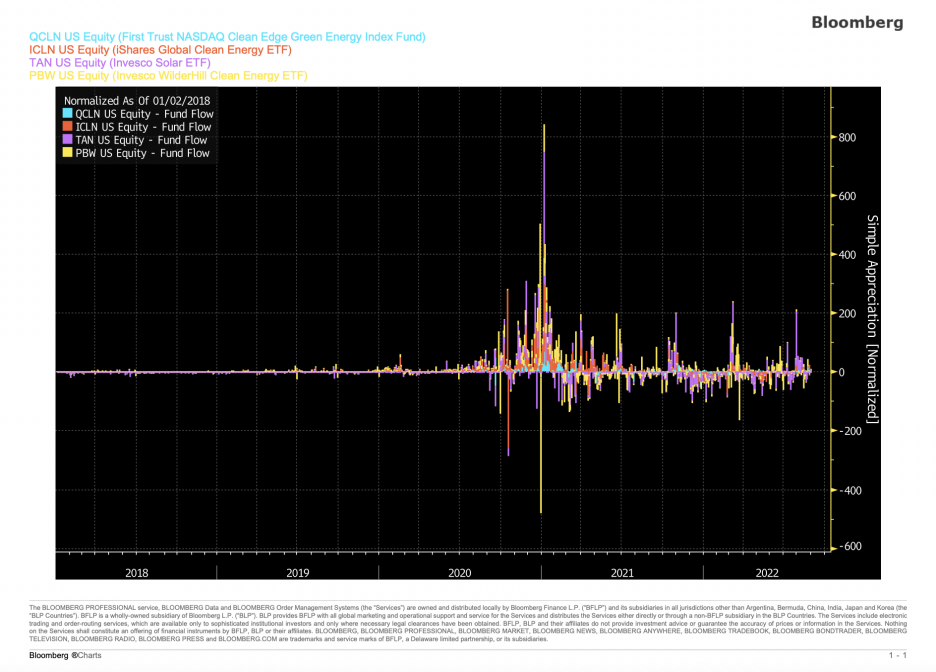
Subsidy policies have been criticized by fossil fuel supporters and climate groups alike, the former stating that the subsidies are abusive and the latter protesting that it does not encourage as rapid a decrease in emissions as a carbon tax or a carbon trading scheme would. However, the incentives in this policy are vital to the long-term commitment of the United States

to the energy transition– they significantly shorten renewable energy project payback periods and encourage long-lasting technological and energy generation developments[6]. Fossil fuels have received US government subsidies ranging from $10 to $50 billion per year since approximately 1916, according to NRDC research. The International Energy Agency estimates that global fossil fuel consumption subsidies in 2022 nearly doubled from the previous year at an all-time high of USD 1 trillion. In the relative scale of the amount of government aid that other industries receive, the IRA isn't but a first step in what is to be a national and global policy shift. Policies such as the Inflation Reduction Act will become essential in providing new tools that push renewable energy efficiency forward and facilitate an efficient global energy transition– and it will be imperative to observe how markets follow as renewable energy investments create more and more value in the American economy.

[6] IRA incentives shorten the payback period [amount of time taken to recoup the initial investment] from 15-20 years to approximately 8-10 years, according to Virginia Mercury.

Appendix A

Bloomberg L.P. Fund Flows, Jan 2018-Mar 2023:



Democrats Senate IRA Budget Estimates:

TOPLINE ESTIMATES:

TOTAL REVENUE RAISED	**$739 billion**
15% Corporate Minimum Tax	*313 billion**
Prescription Drug Pricing Reform	*288 billion***
IRS Tax Enforcement	*124 billion***
Carried Interest Loophole	*14 billion**
TOTAL INVESTMENTS	**$433 billion**
Energy Security and Climate Change	*369 billion****
Affordable Care Act Extension	*64 billion***
TOTAL DEFICIT REDUCTION	**$300+ billion**

* = Joint Committee on Taxation estimate
** = Congressional Budget Office estimate

Appendix B

WilderHill Clean Energy Index Holdings, Name and Ticker:

Navitas Semiconductor Corp	NVTS UQ Equity
MYR Group Inc	MYRG UW Equity
Universal Display Corp	OLED UW Equity
First Solar Inc	FSLR UW Equity
Tesla Inc	TSLA UW Equity
QuantumScape Corp	QS UN Equity
EVgo Inc	EVGO UW Equity
Maxeon Solar Technologies Ltd	MAXN UW Equity
TPI Composites Inc	TPIC UQ Equity
Archer Aviation Inc	ACHR UN Equity
Wallbox NV	WBX UN Equity
Sigma Lithium Corp	SGML UR Equity
Canadian Solar Inc	CSIQ UW Equity
Piedmont Lithium Inc	PLL UR Equity
Brookfield Renewable Corp	BEPC UN Equity
Quanta Services Inc	PWR UN Equity
Solid Power Inc	SLDP UW Equity
Advanced Energy Industries Inc	AEIS UW Equity
Gogoro Inc	GGR UW Equity
Joby Aviation Inc	JOBY UN Equity
FuelCell Energy Inc	FCEL UQ Equity
Itron Inc	ITRI UW Equity
ChargePoint Holdings Inc	CHPT UN Equity
Emeren Group Ltd	SOL UN Equity
Ormat Technologies Inc	ORA UN Equity
JinkoSolar Holding Co Ltd	JKS UN Equity
Standard Lithium Ltd	SLI UA Equity
Enovix Corp	ENVX UW Equity
Livent Corp	LTHM UN Equity

Li-Cycle Holdings Corp	LICY UN Equity
ESCO Technologies Inc	ESE UN Equity
Lithium Americas Corp	LAC UN Equity
Ballard Power Systems Inc	BLDP UQ Equity
MP Materials Corp	MP UN Equity
Sociedad Quimica y Minera de Chile SA	SQM UN Equity
Albemarle Corp	ALB UN Equity
Energy Vault Holdings Inc	NRGV UN Equity
Altus Power Inc	AMPS UN Equity
Lion Electric Co/The	LEV UN Equity
Gentherm Inc	THRM UW Equity
ReNew Energy Global PLC	RNW UW Equity
Array Technologies Inc	ARRY UQ Equity
Tritium DCFC Ltd	DCFC UQ Equity
FTC Solar Inc	FTCI UQ Equity
Wolfspeed Inc	WOLF UN Equity
Bloom Energy Corp	BE UN Equity
Shoals Technologies Group Inc	SHLS UQ Equity
SolarEdge Technologies Inc	SEDG UW Equity
Plug Power Inc	PLUG UR Equity
Fluence Energy Inc	FLNC UW Equity
Fisker Inc	FSR UN Equity
Workhorse Group Inc	WKHS UR Equity
XPeng Inc	XPEV UN Equity
5E Advanced Materials Inc	FEAM UW Equity
Polestar Automotive Holding UK PLC	PSNY UQ Equity
SES AI Corp	SES UN Equity
Ameresco Inc	AMRC UN Equity
NIO Inc	NIO UN Equity
Sunnova Energy International Inc	NOVA UN Equity
Gevo Inc	GEVO UR Equity
SunPower Corp	SPWR UW Equity
Sunrun Inc	RUN UW Equity

Stem Inc	STEM UN Equity
Blink Charging Co	BLNK UR Equity
Lilium NV	LILM UW Equity
Rivian Automotive Inc	RIVN UW Equity
Lordstown Motors Corp	RIDE UW Equity
Hyzon Motors Inc	HYZN UW Equity
Enphase Energy Inc	ENPH UQ Equity
ESS Tech Inc	GWH UN Equity
Vertical Aerospace Ltd	EVTL UN Equity
Azure Power Global Ltd	AZRE UN Equity
American Superconductor Corp	AMSC UW Equity
Beam Global	BEEM UR Equity

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