Green Energy Feasibility Investment

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***Abstract*—Electricity is a critical component of modern society and is one of the foundations for essential services and economic development. In the United States, electricity generation is predominantly fueled by natural gas and an increasing share of renewable energy sources such as solar power. The selection of generation sources has significant economic and environmental implications, particularly in the context of climate change and energy policy. This project presents a comprehensive analysis that compares electricity generation from natural gas and solar energy in terms of cost, production efficiency, and carbon dioxide emissions. Using data from the U.S. Energy Information Administration (EIA) and an interactive web dashboard, we evaluate the long-term economic and environmental viability of these energy sources. The findings aim to inform energy investment strategies that support sustainable development and a low-carbon future.**

***Index Terms*—Natural Gas; Solar Power; Production Cost; Carbon Dioxide Emissions**

I. Introduction

Electricity generation is a foundational pillar of modern society, powering residential homes, commercial enterprises, public infrastructure, and digital technologies. This energy supports economic productivity and operational efficiency. In the United States, the electric power sector plays a central economic role and is also one of the largest contributors to greenhouse gas (GHG) emissions, accounting for approximately 25% of total emissions in 2022 [12]. The types of fuels used in electricity production significantly influence both the carbon footprint and long-term sustainability of the national energy infrastructure.

Natural gas has become the leading source of electricity generation in the United States, contributing about 43% of utility-scale electricity production in 2022 [14]. Its popularity stems from widespread availability, relatively low cost, and flexible deployment across a range of demand conditions. Compared to coal, natural gas produces substantially fewer emissions of GHG namely sulfur dioxide, nitrogen oxides, and carbon dioxide per kilowatt-hour. However, it remains a fossil fuel, and its extraction, processing, and combustion still release significant amounts of /CO_2, along with methane leaks during upstream operations, which further amplify its climate impact [12].

Climate concerns and environmental imperatives have placed increased emphasis on transitioning to cleaner, low-emission energy sources. Renewable technologies, particularly solar photovoltaic (PV) systems, offer an alternative solution. Over the past decade, the cost of solar power has decreased dramatically, making it more competitive with conventional fossil fuels. Solar energy systems produce no direct GHG emissions during operation and eliminate the need for fuel inputs, significantly reducing long-term environmental risks and operational costs [14]. However, the integration of solar power into existing grids introduces challenges related to intermittency, storage needs, and regulatory coordination.

The energy environment is also changing due to distributed generation technologies like small-scale systems and rooftop solar panels. These systems can reduce transmission losses, enhance grid resilience, and provide localized energy solutions. According to the EPA, distributed generation generally results in net environmental benefits when displacing fossil-fuel-based electricity [13]. Nonetheless, it presents integration challenges, including voltage regulation and supply variability, and raises important questions regarding lifecycle emissions and infrastructure planning.

While natural gas continues to serve as a crucial bridge fuel in the energy transition, the growth of solar energy highlights the strategic trade-offs facing policymakers and utilities. Natural gas provides stable, dispatchable power with existing infrastructure, but its continued use entrenches GHG emissions and subjects markets to price volatility [12]. In contrast, solar energy offers a zero-emission alternative with declining costs, yet requires substantial grid modernization and supportive policies to achieve large-scale deployment [14].

This study seeks to provide a data-driven comparative analysis of natural gas and solar power within the U.S. electricity sector. By leveraging publicly accessible data from the U.S. Energy Information Administration (EIA) and U.S. Environmental Protection Agency (EPA), the project evaluates multi-year trends in cost, emissions, and production efficiency.

The findings aim to inform evidence-based decision-making on energy investments and environmental policy, contributing to a broader understanding of the trade-offs involved in America's energy transition.

The remainder of this paper is organized as follows: Section II provides background on energy generation technologies and cost evaluation methods. Section III outlines the methodology used to collect and process data. Section IV presents the results and analysis. Section VI concludes with recommendations and future work.

II. Background

This section gives a brief description of the chosen the primary sources used in electricity production within the US.

A. Overview of Energy Used in Electricity Production

Within the past two decades, the U.S. energy mix has undergone a marked transformation, driven by economic, environmental, and policy factors. Historically, coal was the dominant source of electricity generation in the U.S., but its role has sharply declined due to market competition from natural gas, increased environmental regulation, and the rising affordability of renewables. According to the U.S. Energy Information Administration (EIA), coal accounted for only about 16% of U.S. electricity generation in 2022, indicating a decrease from over 50% in the early 2000s [1]. In contrast, natural gas has emerged as the largest single source of electricity generation, contributing approximately 43% of total U.S. utility-scale electricity in 2022 [1]. Its lower carbon emissions compared to coal, combined with flexibility to quickly fluctuate in response to demand. This makes it a preferred partner to intermittent renewable sources.

Simultaneously, renewable energy, namely solar and wind, has experienced rapid growth. These technologies that produce these energies are being increasingly integrated into the national energy mix due to declining costs, federal tax credits, and state-level renewable portfolio standards. Solar energy, in particular, has become one of the fastest-growing electricity sources in the country. Data from USAFacts shows that solar energy grew more than 24-fold from 2010 to 2022, rising from a negligible share to roughly 4% of total electricity generation [2]. Combined with wind, hydro, and other renewables, these sources now account for more than 20% of electricity generation. This reflects a structural shift toward a cleaner and more diversified grid [1]. Despite challenges with intermittency and infrastructure, the continued expansion of renewables suggests a long-term trend toward decarbonization and energy independence.

B. Natural Gas in the U.S.

Natural gas remains one of the main sources of the U.S. energy infrastructure due to its domestic abundance, flexible use, and relatively cleaner combustion compared to coal. Most of the nation's supply is produced domestically through hydraulic fracturing and is distributed via a vast network of over 300,000 miles of interstate and intrastate pipelines [14] [15]. The fuel supports both baseload and peaking power generation and is integral to balancing intermittent renewable energy. While natural gas power plants have relatively low capital costs, they incur ongoing expenses related to fuel procurement, operations, and emissions compliance. Although it emits less carbon dioxide per unit of energy than coal, natural gas is a significant source of GHG emissions, especially due to methane leaks during extraction, transport, and storage [12] [13]. Furthermore, seasonal variations in demand, export activity, and international instability are some of the variables that might cause market volatility to impact fuel prices. [14] [15]. Despite the U.S. being a net exporter of natural gas, it still imports gas to meet regional supply demands, especially in the Northeast. Most imports come from Canada via pipelines, with smaller quantities received as liquefied natural gas (LNG) from countries like Trinidad and Tobago. Imports can fluctuate based on domestic production levels, weather-related demand, and international market prices [15].

C. Solar Power in the U.S.

Over the past ten years, solar power has grown significantly in the US, mostly as a result of advancements in technology and declining installation costs. One of the more outstanding forms of solar technology, called photovoltaic (PV) systems, have become prevalent, comprising both utility-scale and installation distributions. However, the efficiency of these systems varies depending on the climate and location as they use sunlight into electricity. While these solar projects require an upfront capital investment, to implement components such as panels, inverter, labor, and permitting the use of these technologies, they eventually benefit from minimal operational cost and zero fuel expenses over their lifetime (typically 25-30 years). Moreover, solar PV systems produce no GHG emissions during its operation, making them a key element of national and international decarbonization initiatives. Through economic shifts such as tax credits, state-level incentives, and renewable energy mandates, this made the expansion of solar energy much more economically attractive and accessible [**?**].

D. Cost Comparison Metrics

Standardized economic metrics must be used while evaluating energy producing technology in order to allow for equitable comparisons amongst sources. The Levelized Cost of Electricity (LCOE), which shows the average cost per megawatt-hour (MWh) of electricity produced over a power plant's lifetime, is one of the most commonly used measures. Important financial factors like initial capital investment, continuing fuel expenses, operations and maintenance costs, and financing are all included in LCOE. Natural gas plants have historically reported comparatively low LCOE rates because of their established infrastructure and affordable fuel. However, because of economies of scale and technological developments, the LCOE of solar photovoltaic systems has decreased dramatically over the last ten years. In the present, solar energy is as affordable as or less expensive than fossil fuel-based generating in many areas. Even though there are its benefits, LCOE has drawbacks. It ignores externalities like environmental deterioration and health effects from emissions, as well as the unpredictability of renewable energy sources and the cost of grid integration [15].

E. Environmental and Regulatory Considerations

Environmental regulations have become increasingly influential in shaping the U.S. energy landscape. The Clean Air Act, which regulates pollution from stationary sources, such as power plants, is enforced in large part by the Environmental Protection Agency (EPA). The economic feasibility of fossil fuel-based generating is directly impacted by these rules, which promote a move toward cleaner alternatives [17]. There has been an act where Renewable Portfolio Standards (RPS), in which this requires utilities to produce a certain percentage of their electricity from renewable sources like solar and wind, have further hastened the shift at the state level. As of 2024, over 30 U.S. states and territories have adopted RPS or similar goals, fostering regional clean energy markets and thereby driving up the demand for more renewable (including solar) technologies.

III. Methodology

This paper outlines the methodology for analyzing the economic and environmental impacts of natural gas imports and the feasibility of transitioning to solar energy in the United States. It highlights the data-driven approach and the analytic processes implemented to determine at what point solar energy becomes economically advantageous compared to natural gas.

A. Methodology Overview

The primary aim of this project is to analyze and visualize data regarding the economic and environmental impacts of natural gas imports and evaluate the feasibility of transitioning towards solar energy generation in the United States. The analysis investigates trends, correlations, and comparative costs to pinpoint when solar energy becomes more economically viable compared to natural gas.

B. Data Collection and Preprocessing

Data utilized in this study were gathered from several authoritative sources, primarily the U.S. Energy Information Administration (EIA). Specific datasets analyzed include:

- Natural Gas Import Prices (1999–2024)
- Natural Gas Import Quantities (1999–2024)
- Natural Gas Production (1999–2024)
- Temperature data (1999–2025)
- Solar Energy Generation data (2001–2025)
- Solar Irradiance data (GHI & Clearsky GHI)

Pre-processing included:

Data Cleaning

- Identification and handling of missing values through dropping or interpolation, depending on contextual needs.
- Standardization of date formats by converting to datetime objects.

Data Integration

Datasets were merged based on common date attributes, resulting in a unified dataset (`cleaned_merged_dataset.csv`).

C. Exploratory Data Analysis (EDA)

EDA was conducted to uncover underlying patterns, trends, and foundational relationships:

Trend Analysis

- Seasonal variations and global event responses observed in natural gas import prices and quantities.
- Consistent upward trends identified in solar energy generation over recent decades.

Correlation Analysis

- Negative correlation identified between temperature and natural gas import prices (overall: -0.306, winter: -0.412).
- Negative correlation (-0.65) between domestic natural gas production and import quantities, indicating a substitution effect.

D. Visualization and Interactive Dashboard Development

Visualizations were developed using Python-based tools (Streamlit and Plotly) to deliver dynamic and interactive experiences. The main visualizations include:

- **Natural Gas Import Price Trends:** Bar charts illustrating price fluctuations.
- **Temperature Trends and Impact:** Line plots demonstrating temperature variability and economic implications.
- **Correlation Heatmaps:** Visualizing relationships between temperature and prices, and imports versus production.
- **Solar vs. Natural Gas Generation:** Comparative line charts and grouped bar plots illustrating generation trends.

E. Solar Energy Generation Analysis

Detailed assessments of solar feasibility included:

- **Historical Solar Generation Trends:** Line chart illustrating solar capacity growth from 2001 to 2025.
- **Solar Irradiance Analysis (GHI vs. Clearsky GHI):** Comparative analysis identifying efficiency gaps between ideal and actual irradiance conditions.
- **Annual Solar Growth Rate Analysis:** Bar charts demonstrating year-over-year growth, highlighting significant technological advancements and policy impacts.

F. Comparative Cost Analysis (Solar vs. Natural Gas)

An extensive cost comparison was conducted to evaluate economic feasibility:

- **Annualized Cost Comparison:** Yearly comparisons between solar (estimated costs) and actual natural gas generation costs illustrated using grouped bar charts.
- **Economic Interpretation:** Emphasized volatility in natural gas prices compared to stable or declining solar costs, supporting strategic policy recommendations and investment planning.

G. Methodological Improvements and Recommendations

Suggestions for enhancing future methodologies include:

- **Forecasting Integration:** Employing predictive modeling (ARIMA or Prophet) to forecast future energy prices and solar generation capacity.
- **Geographical Analysis:** Incorporating geographic granularity for targeted regional feasibility assessments and optimization of solar investments.
- **Break-even Analysis:** Determining the precise year in which solar becomes economically preferable to natural gas based on projected trends.

H. Tools and Technologies Utilized

The primary technical resources used included:

- **Programming Language:** Python
- **Libraries & Frameworks:** Pandas, NumPy, Matplotlib, Seaborn, Plotly Express, Streamlit
- **Environment:** Jupyter Notebook, Streamlit Web App

I. Workflow and Project Execution

The project's workflow encompassed three key phases:

- **Phase 1 (Data Collection & Cleaning):** Acquisition and cleaning of data, and dataset integration.
- **Phase 2 (Analysis & Visualization):** Conducting EDA, creating interactive visualizations, and dashboard development for comparative insights.
- **Phase 3 (Insights & Recommendations):** Formulating actionable insights for stakeholders concerning renewable energy feasibility.

J. Expected Outcomes and Impact

Anticipated outcomes and impacts include:

- Provision of a data-driven understanding regarding timing and viability of transitioning from natural gas to solar.
- Identification of critical economic and environmental factors influencing renewable energy adoption.
- Development of an interactive tool for stakeholders to explore and strategize energy solutions dynamically.

IV. Results and Discussion

Fig. 1 shows a bar graph of the import prices of natural gas over the years shows several fluctuations with notable peaks and troughs. In October 2005, the price of natural gas imports was at an all-time high of 11.99 United States Dollars per thousand cubic feet (USD/Mcf) according to [12]. This was a significant increase from the previous year, when the price was around 5.38 USD/Mcf. Reference [13] states the increase in price was attributed to several factors, including production disruption and increased demand for natural gas due to Hurricane Katrina, Hurricane Rita and other weather-related events that disrupted supply and production chains. Prices also spiked to 9.11 USD/Mcf in February 2014 when compared to previous months and years where prices were around 3 to 4 USD/Mcf due to extremely cold weather as seen in [14] and [15]. Another sudden rise in price occurred in December 2022. Reference [16] states this was likely due to several reasons such as the Russian invasion of Ukraine, increased global demand for LNG and supply chain disruptions caused by the Covid-19 pandemic.

Fig. 2 is a line graph of the average temperature in the United States of America (U.S.A) reveals a steady increase in temperature over the years which is consistent with the global trend of rising temperatures due to climate change according to [17].

The relationship between temperature and natural gas import prices was investigated using a correlation heatmap as seen in Fig. 3. The coefficient found was -0.31 indicating an inverse relationship. This is very apparent in July 2012 where the average temperature spiked to 55.39 Degrees Fahrenheit (F) and the import price of natural gas dropped to 2.78 USD/Mcf and in February 2014 where the average temperature dropped to 52.05 F and natural gas import prices rose to 9.11 USD/Mcf. It can be said that as temperatures decrease, the import price of natural gas increases.

It is also seen that temperatures usually fall during the winter months and rise during the summer months. Fig. 4 shows a seasonal correlation between import prices and temperature

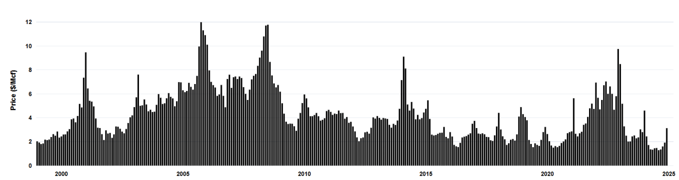

Fig. 1. Natural Gas Import Costs over time.

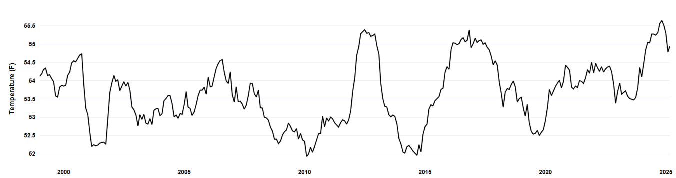

Fig. 2. Average Temperature over time.

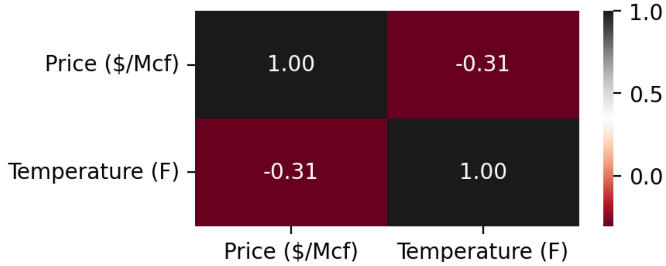

Fig. 3. Correlation between temperature and natural gas import cost.

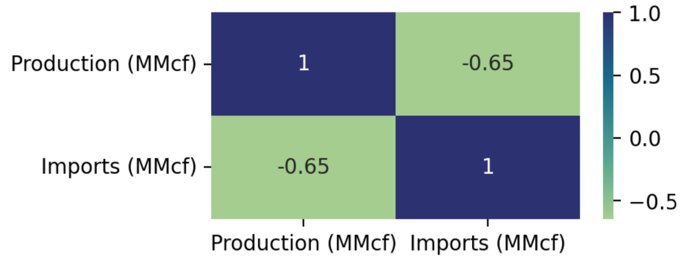

Fig. 6. Correlation between Natural Gas Imports and Production.

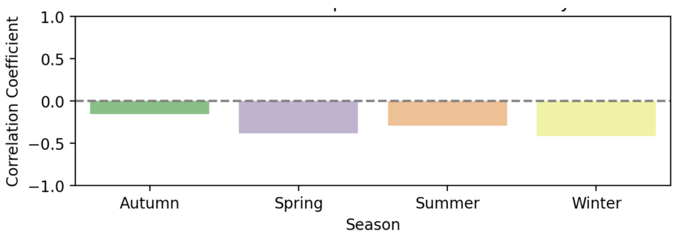

Fig. 4. Seasonal Correlation between temperature and natural gas import cost.

that resulted in coefficients for Autumn, Spring, Summer and Winter being -0.16, -0.38, -0.29 and -0.41 respectively. Reference [20] states the reason for Summer and Winter having the strongest coefficients is because more energy is consumed for air conditioning and heating since temperatures are typically at their highest and lowest during these seasons.

Fig. 5 represents a line graph of the quantity of natural gas imported into the U.S.A reveals and multiple fluctuations throughout the years with higher imports during colder months and lower imports during warmer months. Natural Gas import quantities gradually increased until 2008 when they began to gradually decrease. Reference [19] states this is due to financial crisis and the creation of three new Natural Gas facilities in the U.S.A. It was also seen that Natural Gas production gradually increased over the years and hit an all-time high in 2024. The reason for this may be due to the addition of new natural gas facilities and improved processing techniques as mentioned in [20]. A correlation coefficient of -0.65 was found between natural gas imports and production as seen in Fig. 6. This indicates the existence of a strong inverse relationship meaning as the quantity of natural gas produced increases, the import quantity decreases and vice versa.

The total amount of money spent on natural gas imports was calculated by multiplying the quantities imported and the cost of importing over the years. As seen in Fig. 7 the total cost rose till 2008 and then began to gradually fall. Reference [20] backs this by claiming that most of the natural gas consumed by the U.S.A is self-produced. In April 2020 the total cost dropped to around 285 million USD due the covid-19 pandemic and in December 2022 the total cost rose to around 2.86 billion USD due to the Russian invasion of Ukraine creating disruptions and shortages according to [21]. This also conforms to the inverse relationship between natural gas imports and production stated earlier.

Fig. 8 represents a bar chart of the prices of Solar Photovoltaic (PV) panels that showed prices have gradually decreased over the years and hit an all-time low of 0.31 USD per Watt ($/W) in 2023. Reference [22] states this trend is likely due to increased production, popularity and technological advancements. It is also seen that Solar PV panel prices abide by 'Wrights Law' which states that the cost of technology falls consistently as the cumulative production of that technology increases according to [23].

When comparing the amount of energy generated using natural gas versus using solar in Fig. 9, both are seen to have gradually increased over the years however, natural gas consistently generated significantly more energy than solar power. Reference [24] backs this by claiming that Natural Gas is the largest source of energy generation in the United States followed by renewables. For further insight into environmental effects, the correlation between carbon dioxide emissions,

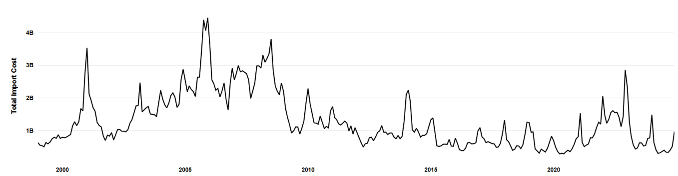

Fig. 7. Total Cost to Import Natural Gas over the years.

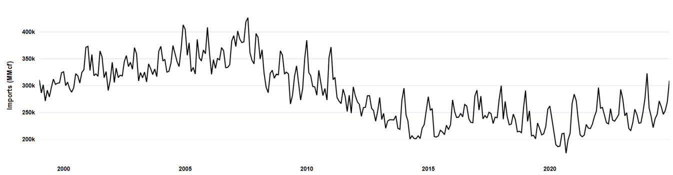

Fig. 5. Natural Gas Import Quantities over time.

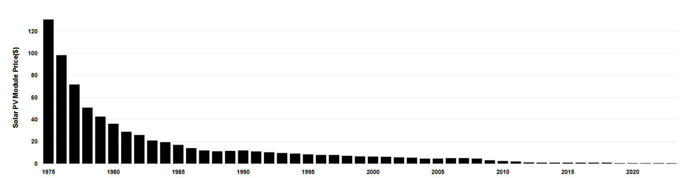

Fig. 8. Solar Photovoltaic Module Cost over the years.

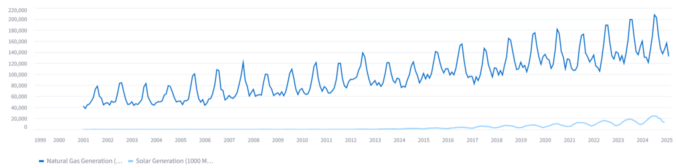

Fig. 9. Natural Gas vs Solar Energy Generation Quantities.

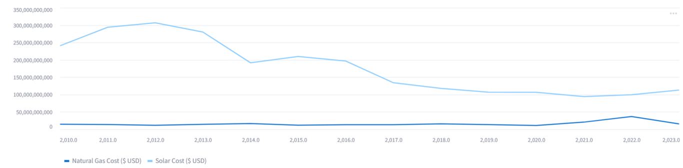

Fig. 12. Cost of using Solar vs Natural Gas for Energy Generation.

natural gas energy generation and solar energy generation was investigated as shown in Fig. 10. Natural Gas energy generation had a coefficient of 0.99 whereas solar energy generation had a coefficient of 0.76. This indicated a strong direct relationship meaning natural gas energy generation emits more carbon dioxide and as energy generation increases, so does carbon dioxide emissions. However, these coefficients are skewed since the carbon dioxide dataset used was caused by natural gas and not solar. The reason for this is because solar emits a very minute amount of carbon dioxide and a dataset for it could not be found.

Trends in the cost to generate the amount of electricity consumed were identified using a line graph as seen in Fig. 11. Between the years 2009 and 2020 costs fluctuated around 1.9 and 4.7 billion dollars, however, in February 2021 costs spiked to 13.9 billion dollars. Reference [25] states this was due to extremely low temperatures caused by a winter storm. Costs returned to around 2.5 billion after the storm passed but later spiked to 12.8 billion in August 2022. The Russian invasion of Ukraine causing natural gas supply disruptions seems to be the main contributor for the spike according to [21].

Invaluable information can be derived from the line graph in Fig. 12 comparing the cost of only using solar to generate the amount of energy consumed with the cost of only using natural gas to generate the same amount of energy. The cost of only using solar was seen to be much larger than only using natural gas, as solar requires a large amount of money for initial investment and maintenance can be costly. However, the solar costs gradually declined over the years due to increased production, demand and availability of modules. 2022 saw the lowest cost of only using solar for energy generation and had the smallest difference between natural gas prices thus making it the most optimal year to invest and/or transition to solar. Currently completely transitioning from natural gas to solar for energy generation may not be wise but if the declining trend continues, then in the near future solar can replace natural gas.

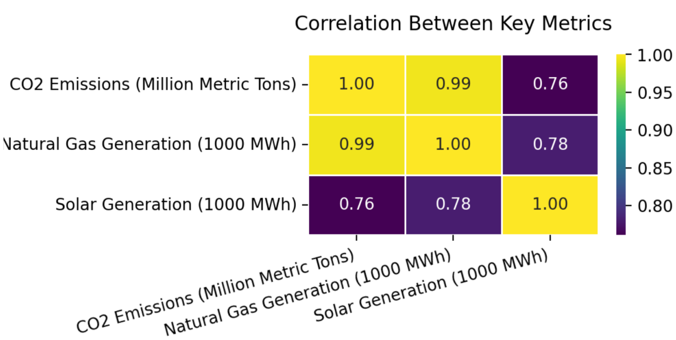

Fig. 10. Correlation between carbon dioxide emissions and different energy generations.

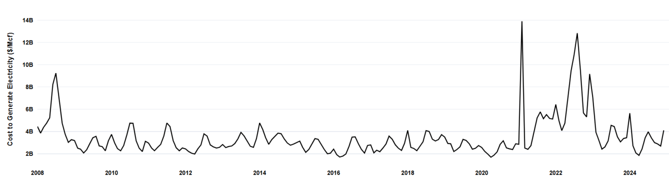

Fig. 11. Costs to generate amount of consumed energy.

V. Conclusion

Throughout this project we performed several analyses to evaluate the environmental and economic impacts and feasibility of using natural gas and solar for energy generation in the United States (U.S). We acquired reliable datasets from credible sources and used sound methods to derive valuable insights from trends and relationships.

It was found that the U.S is slowly but gradually producing more natural gas and importing less. External factors such as temperature have an inverse relationship with the amount of energy generated and the amount of natural gas imported whereas factors such as carbon dioxide emissions and solar irradiance have strong and direct relationships with energy generation. It was also found that most of the electricity consumed is generated using natural gas as it is currently more affordable to generate energy using natural gas rather than using solar solely. However, the cost of solar for energy generation is on a steady decline and the closest it has been to the price of using natural gas was in 2022, making it the most optimal year to transition to solar. It is safe to infer that as solar costs follow the declining trend, it will soon be more efficient and financially sound to transition to it.

While the results of this project provide invaluable insights, there is still room for improvement. Due to solar panels emitting a minute amount of carbon dioxide there was no dataset for these emissions available. Therefore a natural gas carbon dioxide dataset was used for analysis and potentially skewed results. The implementation of a a predictive model displaying future costs of energy generation, production and imports would also supplement this project. Interactive features where users can input specific values and conditions to view potential economic and environmental effects on natural gas/solar generation would also improve the quality and value of the dashboard and should be implemented in the future.

VI. Supplementary Material

The deployed version of the dashboard can be found at: [https://greenenergyfeasibility.streamlit.app/].

The GitHub repository for this project can be found at: [https://github.com/thatguybk/Big-Data-Project].

In order to run the dashboard locally you must have VS Code and python(version 3.12 or prior) installed. VS Code extensions such as GitHub Codespaces, GitHub Repositories, GitHub Pull Requests and Remote Repositories should also be installed.

Follow these steps carefully to run the Dashboard locally:

1) **Clone the Repository:**
First, open VS Code on your device and press
```
CTL + SHIFT + P
```
This will bring up the command palette. Next Type "git clone" and click "Git: Clone". Enter the following link: [https://github.com/thatguybk/Big-Data-Project.git] and press ENTER. This will clone the repository locally on your device.
2) **Navigate to correct directory:**
Press CTL + ‘. This will open up the terminal. Then type the following:
```
cd WebDashboard
```
3) **Install Project Requirements:**
The project requires specific Python packages. Install these by executing:
```
pip install -r requirements.txt
```
4) **Launch the Dashboard via Streamlit:**
After installing the dependencies, run the following command to launch the Dashboard:
```
streamlit run app.py
```
After execution, the WebDashboard will automatically open in your default web browser.
5) **Close Dashboard:**
Simply click the x in the brower tab to close the dashboard. The port the dashboard is running on will automatically open back up.

References

[1] U.S. Environmental Protection Agency, “Electric Power Sector Emissions,” EPA, 2023. Online. Available: https://www.epa.gov/ghgemissions/electric-power-sector-emissions

[2] U.S. Environmental Protection Agency, “Distributed Generation of Electricity and Its Environmental Impacts,” EPA, 2023. Online. Available: https://www.epa.gov/energy/distributed-generation-electricity-and-its-environmental-impacts

[3] U.S. Energy Information Administration, “Electricity in the U.S.,” EIA, 2023. Online. Available: https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php

[4] Wikipedia, “Cost of electricity by source,”,2025. Available: https://en.wikipedia.org/wiki/Cost_of_electricity_by_source

[5] U.S. Environmental Protection Agency, “Clean Air Act Standards and Guidelines for the Power Sector,” Online. Available: https://www.epa.gov/stationary-sources-air-pollution/power-sector

[6] National Conference of State Legislatures, “State Renewable Portfolio Standards and Goals,” Online. Available: https://www.ncsl.org/energy/state-renewable-portfolio-standards-and-goals

[7] U.S. Department of Energy, “Inflation Reduction Act Clean Energy Investments,” Online. Available: https://www.energy.gov/policy/inflation-reduction-act-clean-energy-investments

[8] U.S. Energy Information Administration. (2024). U.S. Energy Facts Explained. [Online]. Available: https://www.eia.gov/energyexplained/us-energy-facts/

[9] U.S. Energy Information Administration. (2023). Electricity in the U.S. [Online]. Available: https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php

[10] Wikipedia Contributors. (2019). Cost of Electricity by Source. Wikipedia. [Online]. Available: https://en.wikipedia.org/wiki/Costofelectricitybysource

[11] National Centers for Environmental Information. (2025). Climate at a Glance. [Online]. Available: https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/national/time-series/110/tavg/12/0/1895-2025

[12] U.S Energy Information Administration, 2015, “Price of U.S. Natural Gas Imports (Dollars per Thousand Cubic Feet),” U.S Energy Information Administration, Natural Gas. [Online]. Available: https://www.eia.gov/dnav/ng/hist/n9100us3m.htm

[13] “Natural gas explained - Factors affecting natural gas prices,” U.S Energy Information Administration, Washington, DC, USA, Oct. 25, 2023. Accessed: May. 8, 2025. [Online]. Available: https://www.eia.gov/energyexplained/natural-gas/factors-affecting-natural-gas-prices.php

[14] “Cold weather brings near record-high natural gas spot prices - Today in Energy - U.S. Energy Information Administration (EIA) Today In Energy,” U.S Energy Information Administration, Washington, DC, USA, Mar. 5, 2021. Accessed: May. 8, 2025. [Online]. Available: https://www.eia.gov/todayinenergy/detail.php?id=47016

[15] “The Winter Weather Event of February 10-11, 2014,” Weather.gov National Weather Service, 2025. Accessed: May. 8, 2025. [Online]. Available: https://www.weather.gov/oun/events-20140211

[16] “U.S. natural gas prices calmed after a volatile 2022 - U.S. Energy Information Administration (EIA),” U.S Energy Information Administration, Washington, DC, USA, Jun. 4, 2024. Accessed: May. 8, 2025. [Online]. Available: https://www.eia.gov/todayinenergy/detail.php?id=62203

[17] “Global Climate Highlights 2024,” Copernicus, Jan. 17, 2025. Accessed: Apr. 8, 2025. [Online]. Avaiable: https://climate.copernicus.eu/global-climate-highlights-2024

[18] S. Wolfe, “The Latest in Power Generation News — Power Engineering,” Power Engineering, Dec. 18, 2024. Accessed: Apr. 8, 2025. [Online]. Available: https://www.power-eng.com/gas/eia-us-natural-gas-consumption-for-generation-continues-to-grow/

[19] “U.S. Natural Gas Imports & Exports: 2008,” U.S Energy Information Administration, Washington, DC, USA, Sep. 11, 2009. Accessed: May. 8, 2025. [Online]. Available: https://www.eia.gov/naturalgas/importsexports/annual/archives/2009/ngimpexp2008/ngi

[20] “Where our natural gas comes from - U.S. Energy Information Administration (EIA),” U.S Energy Information Administration, Washington, DC, USA, Dec. 21, 2023. Accessed: May. 8, 2025. [Online]. Available: https://www.eia.gov/energyexplained/natural-gas/where-our-natural-gas-comes-from.php

[21] M.Tertre, I. Martinez, M.Rabago, “Reasons behind the 2022 energy price increases and prospects for next year,” CEPR, Jul. 20, 2023. Accessed: May. 8, 2025. [Online]. Available: https://cepr.org/voxeu/columns/reasons-behind-2022-energy-price-increases-and-prospects-next-year

[22] “RENEWABLE POWER: SHARPLY FALLING GENERATION COSTS,” IRENA, Accessed: May. 8, 2025. [Online]. Available: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Nov/%20IRENA_Sharply_falling_costs_

[23] H. Ritchie, “Solar Panel Prices Have Fallen by around 20% Every Time Global Capacity Doubled,” Our World in Data, Jun. 13, 2024. Accessed: May. 8, 2025. [Online]. Available: https://ourworldindata.org/data-insights/solar-panel-prices-have-fallen-by-around-20-every-time-global-capacity-doubled

[24] “Sustainable Energy in America 2025 Factbook Tracking Market & Policy Trends, ” BloombergNEF, Accessed: May. 8, 2025.

[Online]. Available: https://bcse.org/wp-content/uploads/2025/02/2025-Sustainable-Energy-in-America-Factbook.pdf
[25] "Wholesale electricity prices trended higher in 2021 due to increasing natural gas prices - Today in Energy," U.S Energy Information Administration, Washington, DC, USA, Jan. 7, 2022. Accessed: May. 8, 2025. [Online]. Available: https://www.eia.gov/todayinenergy/detail.php?id=50798