

Group 2 – Final Project Report (Milestone 3)

Introduction and Background

Our project explores the global shift from fossil fuels to renewable energy sources like solar, wind, and hydroelectric power. As efforts to reduce carbon emissions intensify, innovation in green energy is essential for sustainability and environmental responsibility.

We aim to visualize the impacts of climate change on energy sources and explore the potential for economic growth through renewable energy development. By analyzing data from sources like IRENA and EIA, we compare carbon emissions before and after the rise of renewable energy to determine its tangible effects on the environment.

Key questions include: What is the **current state of carbon emissions in the U.S.**? How has **renewable energy's share of total energy evolved**? What are the **major sources of renewable energy**, and their **economic impacts**? Is there a **link between renewable energy adoption and decreasing carbon emissions**? Our visualizations in Tableau highlight the critical role renewable energy plays in combating climate change and improving lives.

Datasets

1. Data Source Description:

Dataset Name	Data Collector	Funding Source
Renewable Energy Statistics 2024	International Renewable Energy Agency (IRENA)	Funded by IRENA’s member countries and international partners
Renewable Energy and Jobs Annual Review 2023	International Renewable Energy Agency (IRENA)	Supported by IRENA to provide insights into job creation associated with renewable energy
CO2 Emission Data Tables	U.S. Energy Information Administration (EIA)	Funded by the U.S. government to monitor energy use and its environmental impact

2. Data Timeline:

Dataset Name	Time Period Covered	Data Updates/ Frequency
Renewable Energy Statistics 2024	Historical data up to the year 2024 (1970 – 2024)	Updated annually to track the growth of renewable energy technologies
Renewable Energy and Jobs Annual Review 2023	Employment data specifically for the year 2022 (2012-2022)	Continues IRENA’s historical series on jobs in renewable energy
CO2 Emission Data Tables	Annual data from (1960 to 2022)	Updated annually to monitor changes in carbon emissions globally

3. Variables by Data Source:

Dataset Name	Variables Included	Description
Renewable Energy Statistics 2024 (Electricity & Heat generation.xls)	- Year - Region - Technology (Source) - Electricity Generation	Tracks the amount of electricity generated by different renewable energy technologies (e.g., solar, wind, hydro) across various regions and years.

	<ul style="list-style-type: none">- RE or non-RE- Renewable Energy Adoption Growth Rate (calculated field)	
Renewable Energy and Jobs Annual Review 2023 (Jobs Growth.xls)	<ul style="list-style-type: none">- Year- Jobs (in Millions) for:<ol style="list-style-type: none">1. Bioenergy2. Hydropower3. Solar Total (calculated field)4. Wind Energy	Provides information on the number of jobs created by various renewable energy sources (e.g., solar, wind, biomass) in different years.
CO2 Emission Data Tables (Carbon emissions.xls, Carbon intensity.xls)	<ul style="list-style-type: none">- Year- Country- State- CO2 Emission YoY (calculated field)- Avg Carbon Intensity by State (calculated field)- Difference from National Average (calculated field)- Carbon Intensity	Contains data on carbon emissions and intensity by country over time, indicating the environmental impact of energy consumption in those regions.

4. Data Source Size:

Dataset Name	File Size	Number of Cases (Approximate)	Number of Variables
Renewable Energy Statistics 2024	11.2 MB	10,000+ rows	4 variables (Year, Region, Technology, Electricity Generation)
Renewable Energy and Jobs Annual Review 2023	20 KB		3 variables (Year, Jobs, Energy Source)
CO2 Emission Data Tables	52 KB	5,000+ rows	4 variables (Year, Country, Carbon Emission, Carbon Intensity)

5. Locations included in Data Sources:

The datasets used in this project contain data with a broad global scope, covering numerous countries and regions worldwide. However, for our analysis and visualizations, we specifically focused on data from the United States to provide more detailed insights. Here's a summary of the geographical coverage and how we tailored it for the project's objectives:

Dataset Name	Geographical Scope	Data Focus for Analysis
Renewable Energy Statistics 2024	Global and Regional	Analysis focused on renewable energy trends in the USA
Renewable Energy and Jobs Annual Review 2023	Global and Regional	Employment data in renewable energy sectors specifically for the USA
CO2 Emission Data Tables	Global and National	Detailed analysis conducted at the state level within the USA

Visualization Potential

Although the data has global aspects, we customized our visualizations to emphasize trends and patterns specifically within the United States. This approach allows us to:

- Highlight regional differences in renewable energy adoption and job creation in the USA.
- Create state-level maps showing carbon emissions and intensity, offering a detailed view of the country's environmental footprint.
- Provide targeted insights relevant to stakeholders interested in the USA's transition to renewable energy.

This focus on the USA ensures that our analysis remains relevant to national energy policies, economic growth, and environmental strategies, even though the datasets have a broader global perspective.

6. Views Created using Data Sources:

Visualization	Purpose	Data Source Limitations
Bar Graph of Renewable vs. Non-Renewable Energy Adoption	Showed the adoption of renewable energy sources compared to fossil fuels over time by region	Limited regional granularity; data was not uniformly available for all countries, affecting the accuracy of comparisons
Stacked Line Chart of Job Creation in Renewable Energy	Illustrated the number of jobs created in renewable energy sectors from 2012 to 2022	Employment data was limited to annual updates, lacking more granular monthly or quarterly details
Filled Map of Carbon Intensity and Emissions by State (USA)	Displayed state-level variations in carbon emissions and carbon intensity	Focused only on the USA despite having global data, missing out on comparative analysis between countries
Crosstab of Global Energy Consumption and CO2 Emissions	Compared energy consumption, job creation, and CO2 emissions by energy source	Inconsistent data for some countries and years, making it difficult to establish clear relationships across all regions
Line Chart of Decline in CO2 Emissions vs. Renewable Growth	Analyzed the correlation between CO2 emission reduction and renewable energy growth	Forecasting limitations due to incomplete data for certain regions and the absence of long-term projections
Line Chart of Global Oil/Gas Investments vs. Renewable Energy	Highlighted potential manipulation of energy markets by comparing oil/gas and renewables	Limited transparency in global investment data for oil and gas sectors, leading to assumptions in analysis

Data Story:

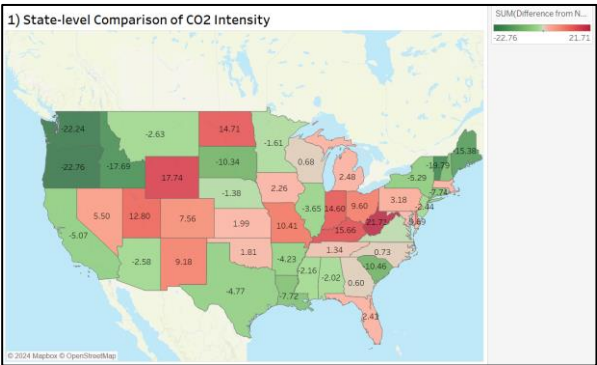


Fig 1.1: State-level Comparison of CO2 Intensity

Visual 1: This chart compares each state's carbon intensity to the national average using data from the U.S. Energy Information Administration (EIA). LOD calculations determine state and national averages. States with higher emissions intensity than the national average are highlighted in red, offering insights into the U.S. emissions landscape. **Limitations:** Certain regions or countries may have incomplete or missing data for specific years

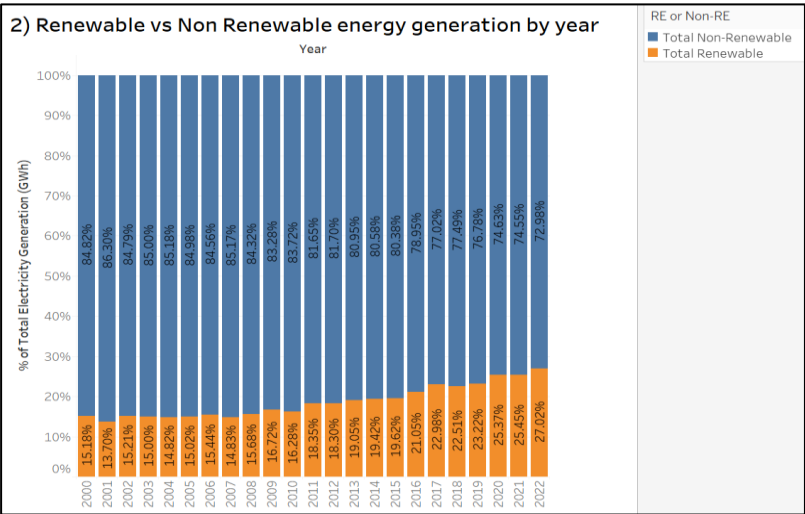


Fig 1.2: Renewable and Non Renewable energy generation by year

Visual 2: This 100% stacked bar chart shows the renewable vs. non-renewable energy generation in the USA from 2000 to 2022, using IRENA's 2024 data. The chart reveals a steady rise in renewable energy, with a sharp increase from 2015, driven by the replacement of the PTC with new technology credits and the U.S. commitments under the Paris Agreement. This highlights the growing shift toward renewable energy in recent years. **Limitations:** The most recent data may not always reflect current market trends due to delays in data collection and reporting.

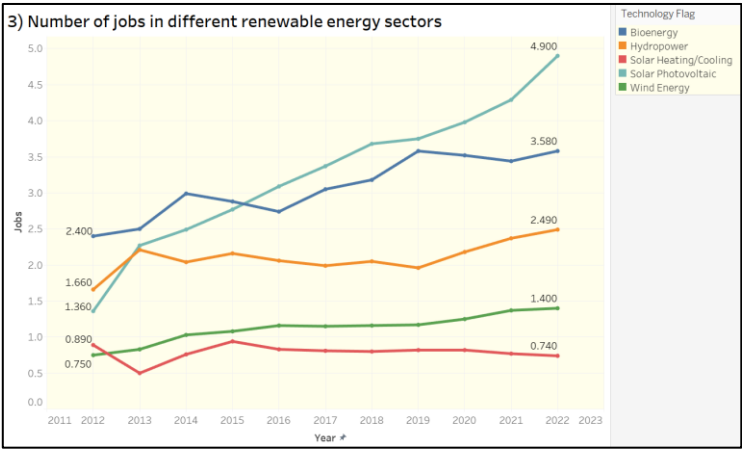


Fig 1.3: Number of jobs in different renewable energy sectors

Visual 3: This line chart illustrates the number of jobs in various renewable energy sectors from 2012 to 2022, using data from the *Renewable Energy and Jobs Annual Review 2023* by the International Renewable Energy Agency (IRENA). The chart utilizes the "number of jobs" and "year" columns, highlighting a consistent rise in employment across renewable energy sectors. Notably, the solar energy sector has been a leading driver of job creation during this period.

4) Percentage share of renewable energy (in USA)

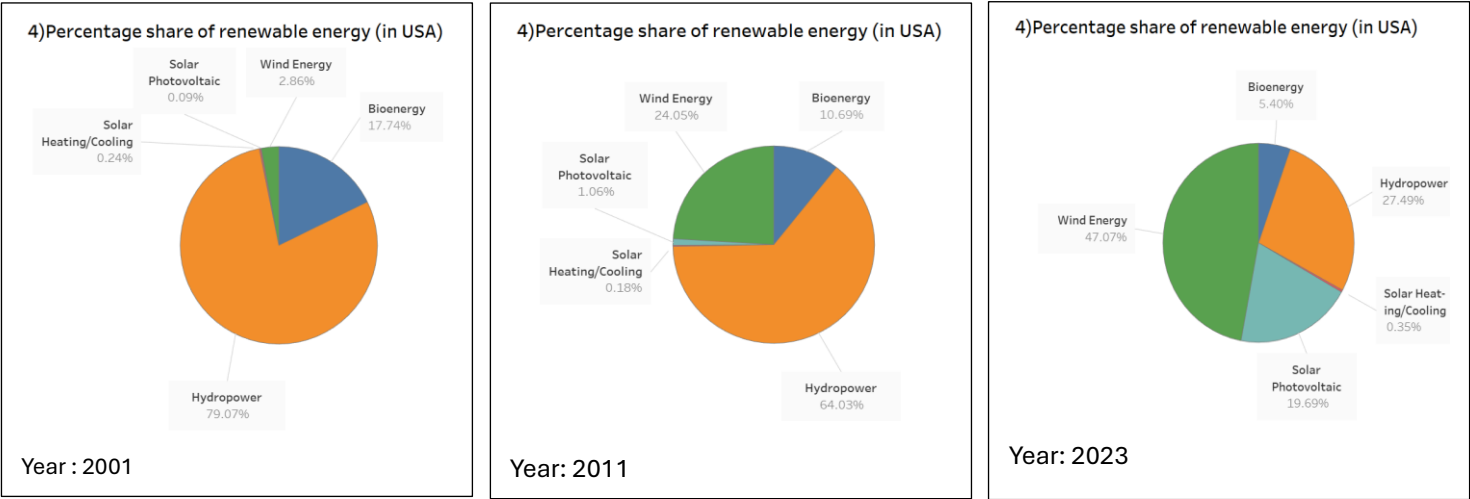


Fig 1.4: Percentage share of renewable energy (in USA)

Visual 4: This chart illustrates the changing share of renewable energy types over time using IRENA's 2024 data. Initially dominated by hydropower, the renewable energy market saw wind energy emerge as the leading source. The shift is linked to the reduction in taxation (PTC) on wind plant installations in 2012, promoting its rapid growth in electricity generation. Using the "Technology Flag" and "% of total electricity generation" fields, the chart highlights that the renewable energy market was initially dominated by hydropower. **Limitations:** The dataset provides a broad overview of energy generation but lacks more detailed metrics like capacity factors or efficiency for different technologies.

5) Global Electricity Generation vs Jobs created by Renewable Energy			YEAR(Year)
Technology Flag	Electricity Generation (GWh)	Jobs (in Mn)	2021
Bioenergy	52,437	34	
Hydropower	253,478	23	
Solar Heating/Co..	3,170	9	
Solar Photovolta..	148,153	36	
Wind Energy	382,814	12	

Fig 1.5: Global Electricity Generation vs Jobs created by Renewable Energy

Visual 5: This crosstab chart blends two data sources: *Renewable Energy and Jobs Annual Review 2023* by the International Renewable Energy Agency (IRENA) and the *Renewable Energy Statistics 2024* dataset, also from IRENA. The tables are blended on the fields "Technology Flag" and "Year," with the Renewable Energy and Jobs Annual Review 2023 serving as the primary table. The chart provides insights into electricity generation and the number of jobs within each renewable energy sector over specific years. **Limitations:** The data aggregates job creation by sector (e.g., solar, wind) but does not break down jobs by role or skill level, limiting a more nuanced understanding of employment impacts within the renewable energy industry.

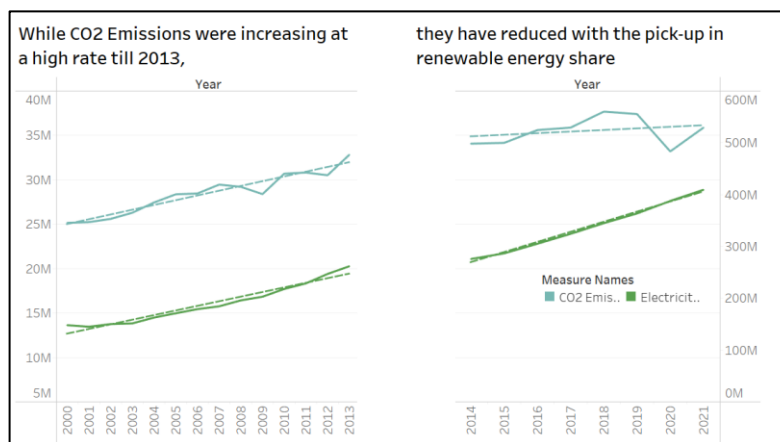


Fig 1.6: Comparison of trend lines of CO2 emissions and electricity generated by renewable sources

Visual 6: This visual combines data from IRENA's Renewable Energy Statistics 2024 and the EIA's CO2 Emission Data Tables, showing CO2 emissions and renewable energy generation trends. After 2013, CO2 emissions continued to rise but at a slower rate, coinciding with the rapid growth of renewable energy. The blue line represents CO2 emissions, while the green line shows renewable energy generation. This visual emphasizes the link between increased renewable energy adoption and the deceleration of CO2 emissions growth. **Limitations:** There could be variations in how data is collected across states in the US, which might affect the reliability and comparability of results.

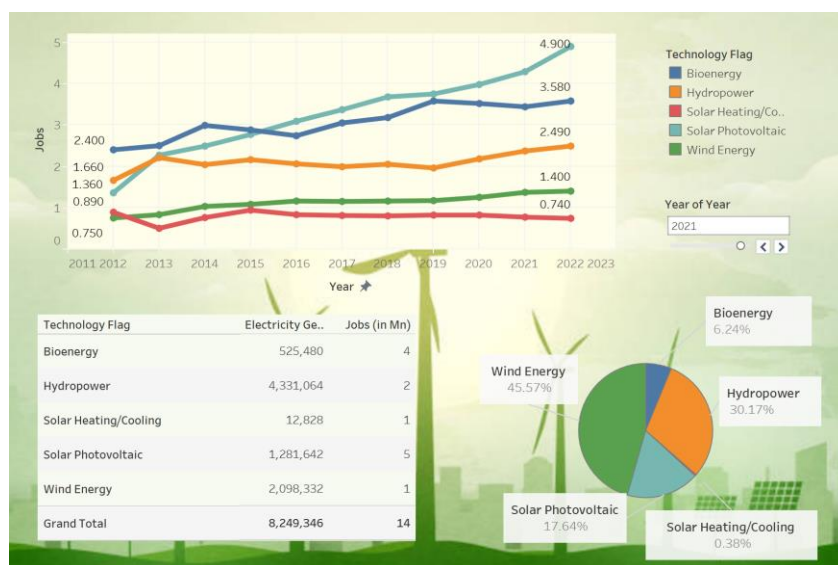


Fig 2.1: Integrated view of job growth, energy generation trends, and sectoral shifts in renewable energy

Dashboard: This interactive Tableau dashboard offers a detailed view of renewable energy trends from 2012 to 2022, displaying job growth, electricity generation, and technology shares across three linked charts. Hovering over technologies like solar or wind highlights their performance across all charts, while clicking a year in the line chart filters the entire dashboard, updating the pie chart for that year's energy share. Users can analyze specific time periods and energy shifts. The dashboard also includes menu options with direct links to Wikipedia pages for more information on each renewable energy technology.

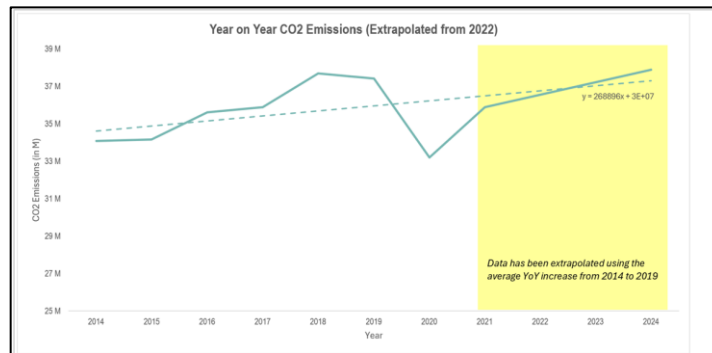


Fig 3.1: Extrapolation of CO2 emissions data for years from 2021(Post covid impact analysis)

Appendix Visual:

This visual predicts CO2 emissions from 2021 to 2024, confirming that the decline in emission growth is not solely due to COVID-19. By extrapolating data beyond 2021, it shows the continued slowdown in CO2 emission increases, driven by the rise of renewable energy, independent of the pandemic's impact.

References

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Contributions

1. **Data Source Generation:** Sourcing and analysis of the three data sets being used –
 - **Avanti Kailas Chandratre**
 - **Jayesh R Chaudhari**
2. **Tableau Chart Creation:** Building the charts shown in the tableau file –
 - **Darshan P Upadhyay** - Filled map showing carbon emissions and Intensity by US State
 - **Saqib Hussain** - Bar Chart showing split of renewable vs traditional energy
 - **Nikhil Ram Atluri** – Pie chart showing energy split in Renewable Energy technology
 - **Avanti Kailas Chandratre** - Line Chart visualizing jobs in different renewable energy sectors
 - **Himanshu Sharma, Jayesh R Chaudhari** – Line chart showing YoY trends of CO2 emissions and how they were affected by rise in Renewable Energy usage
3. **Documentation:** Creating documentation based on provided guidelines – **Nikhil Ram Atluri**
4. **Insights, Story and Final Presentation** – **Saqib Hussain, Himanshu Sharma**