

Impact of Federal Energy Policy on Uptake of Renewable Energy Technology Research in the United States of America

Introduction

Energy Security has always been an important policy objective for most nation states. However, over time the renewable energy transition has also become an important policy objective globally. This is in line with commitments by most nations of the world, to achieve a net zero economy by 2050. It is particularly important for countries like the USA - one of the biggest oil exporting countries, to lead the clean energy transition, implement ambitious policies and lead the efforts to shift from coal and gas towards more renewable energy sources and eventually a net zero economy.

However, a clean energy transition requires intensive capital investment and systems shifts within the energy sector to shift from traditional energy sources to renewable energy production. To ensure the production and supply chain is efficient and clean (low on emissions) and to ensure it is around for a long time requires a lot of research, development and innovations of new technologies.

Since the 2000s, USA has made efforts to bring in federal policies to incentivize adoption of renewable energy technology and installation of renewable projects. Although there were state level Renewable Portfolio Standards, the first federal policy came into effect in 2005. Some significant federal policies (and policy shifts) include:

- **Energy Policy Act of 2005** - provided tax incentives to own hybrid vehicles, and loan guarantees for "innovative technologies" that avoid greenhouse gases, which might include advanced nuclear reactor designs as well as clean coal and renewable energy.
- **Energy Security and Independence Act of 2007** - provided additional supply of alternative fuel sources (in accordance with Renewable Fuel Standards), and further incentives for the development of renewable energy technologies.
- **American Recovery and Reinvestment Act of 2009** - Funding allocated towards energy infrastructure, energy efficiency (smart grid development) and renewable energy technologies
- **Withdrawal from Paris Agreement** - In 2017, President Trump withdrew from the commitments made in the Paris Agreement. President Trump made the argument that USA had already reduced emissions significantly and will continue to work towards efficient and cheaper energy.
- **Inflation Reduction Act of 2022** - this was to-date the single largest investment in climate and energy in American history. It assigned significant loan structures and tax credits for clean energy production.

Research Question and Hypothesis

Many of the policies mentioned above are focused on increasing R&D and implementation of renewable projects. Through this project, I would like to analyze if introducing such federal policies leads to shift in the research and scientific focus on renewable energy technologies.

Therefore, my hypotheses for this project are the following:

1. There will be more themes around oil and gas production before 2005 and during the withdrawal from the Paris Agreement.
2. There will be more themes around renewable energy and technologies (wind, solar, etc.) during the years when a federal energy policy is instated.

Since the clean energy transition is very capital and technology intensive, it is important to encourage and incentivize research within these areas. This project can help potentially understand if federal policies lead to an increase in technological research or innovation. Understanding if federal policies lead to this shift in research is important to evaluate the long term efficacy and benefits of the policy. It will also help understand which research areas are prioritized across different time periods and also possibly if and how policies can shift the focus of research taking place.

Methodology

I sourced my data through ProQuest and used the TDM Studios' Jupyter Environment to process the data and its subsequent analysis. I sourced articles and documents from the following databases within ProQuest:

- *Agricultural and Environmental Science Collection,*
- *Earth, Atmospheric & Aquatic Science Database,*
- *Environmental Science Collection,*
- *U.S. Climate Change Diplomacy: From the Montreal Protocol to the Paris Agreement, 1981-2015*

I believe these database of journal articles and documents would be most relevant to assess the scientific narratives and research being conducted on renewable energy technologies (or other environmental related research being conducted). I filtered the databases from 2000-2024 and the location - United States of America to limit to just the one country.

The initial dataset generated around 1.2 million documents based on the filters and sources taken. I then used this dataset to build a relevant corpus. I used xml and beautiful soup packages to first strip and export the data and subsequently create a pandas dataframe of 10,000 randomly sampled documents. Next, I used nltk next to remove stopwords (standard and custom), lemmatize and add the processed tokens to the dataframe. Once I had all the data processed in a

dataframe, I categorized the documents by the defined time periods. My final processed data consisted of 3618 rows of processed tokens. I defined the time periods as following -

- **2000 to 2004 - Before Federal Energy Policy**
- **2005 to 2008 - Energy Policy Act of 2005 and Energy Security & Independence Act of 2007** (I combined two policies here due to the shorter time period and since it is not relevant which specific policy led to any changes for the scope of this project)
- **2009 to 2010 - American Recovery and Reinvestment Act of 2009**
- **2017 to 2018 - Withdrawal from Paris Agreement** (I considered this because although it is not a federal policy, it is a significant policy shift and could have a significant effect on the research being conducted.)
- **2022 to 2024 - Inflation Reduction Act**

I used topic modeling (LDA and Tomotopy) to analyse the processed tokens and run 5 topics for each time period. While running this analysis, there were multiple words repeated across the analysis ('doi', 'ncbi', 'http', 'ce') and were added as custom stopwords. Finally, I run a interactive visualization chart using pyLDAvis for each time period.

Results

The Topic Modeling analysis does not show any significant themes around renewable energy technologies within the time of implementation of a federal energy policy in the US. There are energy related keywords present during different time periods, however the themes seem to be diffused.

Topic #4 under the first time period (Before Federal Energy Policy) has top words such as 'energy', 'gas', 'high', 'cost'. The [pyLDAvis visualization chart for the first time period](#) however shows that the highly frequent within Topic #4 could possibly be about high costs of some other product (possibly health care or even gas, but it does not point to any significant research). Similarly, there are more key words such as 'energy' under Topic #3 as well according to the visualization but again the key words are spread across themes suggesting that the model maybe possibly picking up themes within a few specific articles skewing the distribution of key words.

The second time period (Energy Policy Act of 2005 and Energy Security & Independence Act of 2007) seems to be the only one where multiple keywords ('oil', 'gas', 'well', 'energy') within topic #5 seems to mention the energy sector. However, the keywords suggest an uptake in research or atleast narratives around traditional energy sources. One could argue that it maybe related more to its pricing and cost given theses were also keywords under the same topic, but a more detailed analysis maybe required to understand the source of this topic within this time period.

For the third time period (American Recovery and Reinvestment Act of 2009), I would maybe consider topic #2 relevant based on the keyword ‘energy’ but however as seen in the [visualization chart](#), the topic may not be relevant for the scope of the hypothesis. Similarly for the fourth time period (Withdrawal from Paris Agreement), [there seems to be no topic relevant to the scope of the study](#), even though there is mention of ‘epa’ which could be referring to the Environmental Protection Agency (EPA). Similarly, there seems to be no relevant topic for the fifth time period (Inflation Reduction Act), [however there seems to be more research on emissions and water and air standards](#). A more detailed analysis would be required to understand the context behind the keywords within the topics being displayed.

Limitations

Given the wide scope of the research question and hypothesis, multiple limitations can be considered.

1. It may serve the purpose of the research question better to select energy based journals (based specifically in the USA) and documentation to prevent noise from other areas of research within environmental science and maybe better to see a more direct correlation between federal energy policy implementation and the research and development taking place in the energy sector specifically. If such specific documentations are analyzed, there could also be merit in widening or shortening the time horizon to specific dates of when the policy is announced, when it comes into effect, and when it is implement to adjust for leads or lags.
2. Although not done here, there maybe some merit to pre-select documents, articles based on the mentioned policies and policy shifts to specifically analyse the narrative or themes around them. However, this runs the risk of pre-selecting your data based on the hypothesis and running into reverse causation or correlation but could possibly be avoided through sophisticated data selection methods. This was not done here to keep the data collection process more simple and avoid risk of reverse correlation.
3. There is scope to run more detailed LDA analysis on each topic and understand if the energy related keywords are related to the energy sector or a different connotation of the word (biological or chemical meaning). Adding more custom stop words based on the LDA analysis results help refine the results of the analysis significantly. However this was a time consuming process in terms of effort (multiple reiterations and manually adding each custom stop word) and run time (since it was a large dataset, the code would take a lot of time to run for each iteration). A more sophisticated code script to identify and delete stop words may reduce this iteration process significantly.

Conclusion

Federal Policies have a big role to play in the systems shift required to adopt cleaner energy sources. This research was an attempt to analyze if federal policies are paving the way for this adoption by leading to research or uptake in renewable energy technologies. This study does not

present any conclusive results on whether federal energy policies in the USA have led to research on renewable energy technologies, however I believe working on the limitations of the study may lead to more significant results.

References

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Code adopted from -

Rebecca Krisel's Tomotopy workshop

Chatgpt

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