



## ANL 488 FINAL PROJECT REPORT

Text Mining to Identify Factors That Contribute to the Growth of Renewable Energy Sector.

Submitted by

**JANINE NG YOU EN**

School of Business Singapore University of Social Sciences

Presented to Singapore University of Social Sciences  
In partial fulfilment of the requirements of the  
Degree of Bachelor in Science in Business Analytics

2021

**Commented [MK1]:** To be frank, this topic is very interesting. As someone deeply entrenched in the energy industry, I find it fascinating to look at all aspects of energy, policy or otherwise. My only criticism would be that I wish you had looked at some economic factors as well, but maybe that's an expansion of this topic

Grammar and errors in language are unavoidable sometimes, but please take more care in writing such documents next time as it just impedes the flow of an otherwise beautiful argument.

Your discussion and implication section needs to be better tied in to the analytics part. Aside from just using NLP to get the 5 topics, some stats would have helped. For example, for Government intervention, how strong a correlation did you obtain?

Overall, well written and argued.

TABLE OF CONTENTS

	Executive Summary	2-3
Chapter One	Introduction	4-7
Chapter Two	Literature Review	8-13
Chapter Three	Data Understanding and Preparation	14-16
Chapter Four	Topic Modelling	17-21
Chapter Five	Results	22-23
Chapter Six	Discussion and Implications	25-30
Chapter Seven	Conclusion and Limitations	31-32
	References	33-35
	Appendix	36

## EXECUTIVE SUMMARY

Renewable energies are the major drivers to mitigate climate concerns. As countries aim to reduce their reliance on fossil fuels and incorporate renewable energy sources, the renewable energy sector has experienced exponential growth in recent decades. The study aims to use text mining to identify the factors contributing to the success of renewable energy despite the difficulties of energy transportation and the subpar performance of the renewable energy plants.

With the growing database of research articles on renewable energy projects, this research tapped into existing scientific research data to form the dataset. It analysed a collection of published scientific papers with “renewable energy success” in its subject matter from the Singapore University of Social Sciences (SUSS) library. The project employed the Latent Dirichlet Allocation(LDA) model and the Non-Negative Matrix Factorization method to identify common topics in renewable energy scientific papers. Topic modelling essentially analyses words in a text document and clusters them into groups or topics.

The 5 topics identified were “Financial Viability”, “Energy Policies”, “Government Intervention”, “Community Engagement” and “Investor Perceptions”. The trend identified from the current study is was financial factors alone do not contribute to renewable energy success. Rather, many non-financial factors are also equally contributing to the progress of the sector. As most studies discuss financial factors that represent the success of implementing renewable energies, this study’s discussion focused on the non-financial factors that contribute to renewable energy project success.

**Commented [MK2]:** This is interesting

“Energy Policies” were highly related to “Government Intervention” as national green policies have contributed to the growth of a country’s renewable energy usage. Different aspects of government intervention were discussed, such as carbon pricing initiatives, energy legislations and financial support policies. Studies from the European Union, United States and Singapore showed that government interventions boosted their adoption of renewable energies. Community Engagement in renewable energy projects was also an important topic identified in current scientific research data. Community Engagement allowed locals to feel ownership towards the energy projects and the involvement helped locals develop trust towards the institution. Community inputs and participation resulted in greater adoption and sustainability

of the projects. Lastly, Investor Perceptions was discussed to better understand how perceptions affect the decision-making process. Investors needed to have confidence in policies and technologies to invest in renewable energy innovations. Psychological attitudes and cognitive behaviours such as attitudes, social standards, a sense of behavioural control, and personal norms are all factors that impacted their investment decisions.

This study ends with its limitations caused by dataset size, query-based constraints and exposure to personal bias. It concluded with the learning points that non-financial factors are equally important in affecting renewable energy adoption and should receive more attention. It further highlighted the importance of social science perspectives that can value add to boost the renewable energy sector to combat global climate change.

**Commented [MK3]:** Interesting and quite a valid conclusion

## CHAPTER ONE: INTRODUCTION

Ever since the Industrial Revolution, fossil fuels have been a major driver of global economic development. Fossil fuels had played an indispensable role in industrialisation and the development of energy systems, but the world is now experiencing the negative impacts of burning too much of it. Over the years, the accumulation of carbon dioxide produced from burning fossil fuels has led to global climate change (United Nations, 2021). Greenhouse gasses (carbon dioxide, nitrous oxide and methane) pollute the air and water, where rising temperatures and sea levels are evidence of the negative and lasting effects of burning fossil fuels (Sunseap, 2021).

As climate concerns increase, most countries are aiming to slow down the effects of global warming. International treaties such as the Kyoto Protocol and Paris Agreement are strategies that ensure countries participate in a goal to achieve a climate-neutral world by the mid-century (United Nations, 2021). As such, many countries are in a race to reduce their greenhouse gas emissions by transitioning from burning fossil fuels to renewable energies that cause little to no environmental damage. Corporations and governments are seen making large investments in renewable energy technologies such as solar, wind, hydro and biomass. The demand for renewable technologies have even contributed to solar and wind energy production generating cheaper electricity than the cheapest new coal farms (Ambrose, 2021)

However, renewable energy outputs tend to be unreliable due to the volatility of natural conditions. Solar energy cannot be produced at night and on cloudy days, while wind turbines will not move unless it is windy. Moody Investors Service (2021) found that India's renewable energy has grown by 20% in the past 5 years. However, close to 15-20% of wind and solar projects underperformed in 2019-2020. Low radiance was responsible for 68% of solar project underperformance while wind generation curtailments were responsible for 56% of

Commented [MK4]: good

underperformance (Jai, 2021). Renewable energy projects underperform compared to their initial forecasts, thus are not as reliable as fossil fuels that can be burnt constantly to produce energy.

**Commented [MK5]:** good

This raises an immediate response to generate energy when it is sunny or windy and store it for days when the weather is not optimal. However, storing energy is an expensive and difficult process. Currently, the most common method of storing electricity is batteries, but batteries have yet to reach the stage at which electricity storage is developed enough to sustain households reliably (Gates, 2021). Based on a United States household electricity usage study, an average household typically uses 210 kilowatt-hours of electricity per week, but best performing lithium-ion batteries can only store 0.2 kilowatt-hours of electricity per kilogram. Therefore, a battery must weigh 1050 kg ( $210\text{kwh} / 0.2$ ) to power a house for an entire week, and that raises electricity bills by up 300% (Gates, 2021). This makes renewable energies less efficient than non-renewables due to the storage limitations and natural weather reliance.

**Commented [MK6]:** don't understand this point or your calculations

Furthermore, renewables may not have the expected outcome of reducing electricity usage. Kealy (2015) conducted a study to analyse an embedded wind turbine's effectiveness in reducing their vicinity electricity bills in Ireland. They were disappointed with the finding that the turbine exceeded their maximum import capacity limit and even caused a deterioration of the power factor. Although the costs were offset by their energy policies, the addition of the wind turbine did not reduce their electricity bills nor yield notable benefits aside from aesthetics used for marketing content (Kealy, 2015).

**Commented [MK7]:** interesting

Since renewable energies are not easily transported, nor do they produce the desired results and new energy farms are expensive to build implement, what helps relevant stakeholders provide support for renewable energy projects? This paper aims to discuss this

question using text mining analysis on factors that determine the success of renewable energy implementation.

Commented [MK8]: ok good

Text mining has become a very popular tool to drive decision making in widespread fields of study. Contrary to data mining that identifies patterns from structured data such as numbers, text mining is the process of understanding large amounts of unstructured text data such as emails, conversations or reviews (Stedman, n.d.). Similar to data mining models, text mining models aims to analyse text data to derive insights that drive improved strategies and actions. Text mining typically uses Natural Language Processing (NLP) algorithms to transform unstructured text into structured data to allow machine learning to interpret the datasets. NLP essentially automates the procedures of categorising, clustering, tagging and classifying texts and extracting information on sentiment, topics or intent.

Text mining has also been used in the area of information extraction from scientific journals, which is the statistical analysis of books, articles or publications. With the increasing quantity of scientific publications or research articles in many areas of study, there is an opportunity to analyse and understand publications filled with insights. Since it is difficult and time consuming for researchers to process and understand large amounts of textual data through manual reading, text mining has been beneficial in efficiently reducing the time spent to glean an understanding from these publications.

Topic modelling is an unsupervised learning technique of text mining that has been applied in studies of scientific journals to discover hidden structures and commonalities underlying the texts (Yse, 2019). In essence, topic modelling intends to analyses large amounts of text data by clustering the data into groups. Text are grouped based on common topics by processing individual words and assigning it weights based on its distribution (Yse, 2019).

Commented [MK9]: good

The most commonly used algorithm is the Latent Dirichlet Allocation (LDA) method and Non-Negative Matrix Factorization, both unsupervised statistical learning methods that identify topics in a collection of documents. This paper will apply both methods of topic modelling to analyse research papers regarding renewable energy success factors to identify common topics within current scientific publications. As renewable energy is a popular topic in scientific research, rather than collecting data from an energy plant and starting the research from the beginning, this study will process the large amounts of readily available textual data from scientific journals to understand common factors of success in renewable energy projects. The results of this study would improve knowledge on the factors that induce support for renewable energies despite the high costs and less than reliable performance.



## CHAPTER 2: LITERATURE REVIEW

### Energy Investments On Economic Growth

There have been extensive environmental studies on the renewable energy industry and its impact on the economy. In the past, non-renewable energy sources drove the economy and fuelled the Industrial Revolution. Tugcu et al. (2012) compared renewable and non-renewable energy sources to rank their significance for economic growth in the G7 countries (United States, Canada, France, Germany, Italy, Japan and the United Kingdom) from 1980 to 2009. Using a classical production function, the team identified a bi-directional causality between non-renewable energy consumption and economic growth for each country (Tugcu et al., 2012). A bi-directional causality relationship is visualized in figure 1, it depicts a mutual dependent relationship between the two factors, where increase in use of non-renewable energies lead to economic growth and increase in economic growth leads to higher consumption of non-renewable energy.

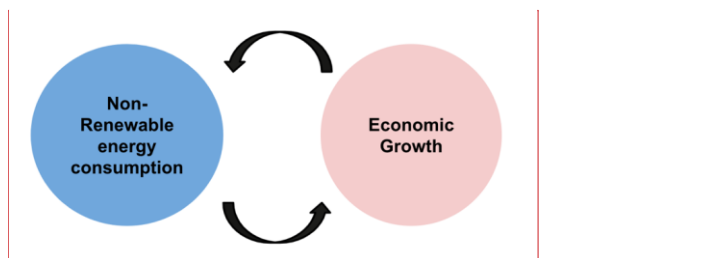


Figure 1: Bi-directional causality between non-renewable energy consumption and economic growth

This reveals that non-renewables have had a strong historical track record of providing the necessary resources to drive industries.

Recent shifts towards lowering carbon dioxide emissions through alternative energy sources have energized the renewable energy industry. The growing demand for renewable energies

Commented [MK10]:

created an entirely new industry with economic opportunities that attracted investment and trading. A study by Ben Jebli & Ben Youssef (2013) explored a production modelling framework using stationary tests, cointegration tests, estimations and causality tests to identify causalities between renewable energy and trade. They identified a one-way causality from renewable energies to trade in the short-run, where a cause and effect relationship exists between energy adoption to trade. While in the long run, a bidirectional causality will occur, whereby a mutual symbiotic relationship exists between the two factors. Lastly, in the future, they predicted that increasing trade will contribute to increasing consumption of renewable energy (Ben Jebli & Ben Youssef, 2013). Thus, when comparing renewable sources and non-renewable sources, aside from the obvious environmental benefits, renewables have also generated economic benefits. Due to its many advantages, there is a need to better understand the factors of success in renewable energy investments.

**Commented [MK11]:** this statement is a bit redundant. The way I look at s energy is just being swapped from one form to another; the obvious and fundamental relationship to economic growth should not change.

### Financial factors that determine renewable energy investment decisions

Scholars in the green energy field have mostly concentrated on the technical and economic characteristics of renewable energy investments, and have typically utilized full rationality as the paradigmatic approach to explaining how stakeholders have made investment decisions. Usually, economic constraints are a barrier to renewable energy infrastructure development, this includes the high capital and maintenance cost of the technology (Jacobson & Johnson, 2000), limited experience in green technology (Jagadeesh, 2000) and under-valuing the benefits of environmental investments (Bradshaw & Brochers, 2000).

**Commented [MK12]:** correct

The role of government policies is also often used to understand the capacity and predict the sector performance. This is seen from Shrimali et al., (2014) who explored India's state and federal policies in solving the financing challenges faced by their renewable energy sector. The

study used the support levels percentage of each available policy and projects developer cash flow analysis to identify the cost-effectiveness, subsidy-recovery and budget efficiency of each policy. It was identified that all policies (reduced costs, extended-tenor debts, interests subsidies) were effective in supporting renewable energies and they have led to incentivize productions and meet viable gap findings. The study emphasised that any government interventions is impactful to promote the usage of renewables due to lack of resources businesses have to finance such projects.

Financial attributes are also commonly used to determine investment decisions in renewable energy projects. In the study on risk-return expectations of renewable energy investors in Germany (Salm et al., 2016), a survey was conducted with over 1000 participants using an Adaptive Choice-Based Conjoint Analysis (ACBC) method. The study identified the ranking of average importance for energy projects. From most important to least important factors, return on investments, holding period technology preferences, project location and partnering investors. This shows that financial returns play a significant role in financial projects.

**Commented [MK13]:** what is this method about?

The main critique with using only financial drivers to determine investment or success renewable projects is that attitudes and motivations of investors are not considered. This gap could be a great opportunity for research to better understand stakeholder motivations when investing in renewable energy, which is deemed to be less reliable in both energy and financial perspectives but remains a booming sector.

### Non-Financial factors that determine the renewable energy investment decisions

Groups of research have found that traditionally used economic, financial and technical analyses of energy alternatives are not sufficient in explaining adoption barriers and diffusion of RE projects. This perspective suggests the inclusion of behavioural and social aspects of motivation using sociological and psychological methodologies to examine the views people have on RE (West, Bailey, & Winter, 2010) (Masini & Menichetti, 2012).

Commented [MK14]: good

Perhaps for green energy, the growth of the overall market is not only influenced by technological performance or market output. Rather, the perceived potential influence of renewable energies also led to the expansion of the industry (Masini & Menichetti, 2012). Social science perspectives could contribute to the field of study of energy usage and provide deeper insights into motivations that affect the success of renewable energy investments. Masini and Menichetti (2012) explored an empirical analysis of the non-financial drivers behind investment decisions in the renewable energy sector. Their study included measures such as: (1) Confidence in the effectiveness of existing policies and technological effectiveness, (2) Attitudes toward radical technological adequacy, (3) Investor's experience, (4) Knowledge of renewable energy, (5) Institutional influence of peers, outside consultants and technical information.

Commented [MK15]: interesting

Their data was collected from questionnaires given to 93 respondents from various sectors from venture capitalists, private equity managers, banks and energy companies. Using multiple sources logistic regression methods, regression models to study the 93 respondents. They found that scientific beliefs towards technical adequacy for green technologies had a greater relationship with driving investments than the effectiveness of renewable energy policies. This implies that knowledge transfer or training for green technologies is a more important element than providing the policies to incentivise renewable energy adoption.

Moreover, the study identified a group of investors who are extremely affected by institutional pressure from peers and consultants in their investment decisions. This reveals that investors are not solely affected by the numbers and outputs, more likely they are affected by societal motivations to adopt renewable energy investments.

Commented [MK16]: ok

Maqbool et al. (2018) further created a hypothesis and causal model to identify critical success factors behind renewable energy projects. Using questionnaires and a sampling technique, the responses from 272 firms working on renewable energy projects in Pakistan were collected. A structural equation modelling method identified that all five factors (communication, team, technical, organizational and environmental) were significant towards the project success in their experience. It also found that environmental factors significantly mediates the connection between communication factors towards project success. This shows that there is a common motivation for the environment needed to facilitate communication for project success.

### Topic Modelling on Renewable Energy

Previous research completed on renewable energy using topic modelling is seen from the works of Bickle (2019). The study used topic modelling to identify trends in academic landscape of sustainable energy. Abstracts from 26533 published research articles from the Scopus bibliographic database were used as the dataset. Using the LDA method, 300 topics were identified using the current topic trends, differing themes within the field and emerging work in the field (Bickle, 2019). The study reflects the popularity of topics in the sustainable energy field. Bickle (2019) also highlighted that the focus of researches being carried out on sustainability has transitioned from technological development to establishing and optimizing renewable energy systems. Four key topics to improve optimization were identified, (1)

material science process engineering, (2) biological process engineering, (3) digital monitoring and optimization of power systems and (4) decision-making in carbon transitions towards sustainability. The first three factors explained the technical aspects of sustainability such as the technology, engineering, manufacturing. While the final topic addressed systematic management of sustainability including initiatives, strategies and frameworks introduced, as well as consumer decisions and business development. It further suggests the need to introduce social science perspectives in the field of general research, with greater interdisciplinary studies of technological research and social sciences.

**Commented [MK17]:** very good point

These papers imply that there are much more non-financial factors impacting RE sector success that is worth analysing. Due to resource constraints, the study is not able to create surveys for the stakeholders involved in adopting renewable energies. Rather, topic modelling will be conducted on 80 scientific papers on the topics of renewable energy research, energy policies and risk preferences. The study will collate the current findings in empirical evidence about factors affecting renewable energy adoption, with the aim to fill a scholarly gap of identifying and understanding the factors that affect RE adoption.

**Commented [MK18]:** ok

## CHAPTER 3: DATA UNDERSTANDING AND PREPARATION

### Data Collection

The dataset used in this study was a collation of 80 published scientific papers regarding non-renewable energy success. The dataset was collected from Singapore University of Social Sciences (SUSS) online library. Using the library's search filter function, articles had to contain the term "renewable energy success" in its subject matter. The selection of scientific articles were based on the criteria that each research article should explain factors of success in renewable energy projects, and the understanding of success was from each article's own definition of success. Each article was also briefly checked to ensure their relevancy to the topic.

**Commented [MK19]:** ok good

Research articles are lengthy and contain large amounts of text data along with unnecessary data such as tables, references and hyperlinks. Using an entire report may lead to having too much data, causing cause extended processing time. Furthermore, as research articles vary in length, results would be skewed towards longer reports with higher wordcounts. Hence, this study only used text from the "Abstracts" and "Conclusions" parts of an article. The parts were chosen on the assumption that they were the most succinct and informational aspects of an article. They are also a good representation of the entire document and will produce insightful topics.

**Commented [MK20]:** wouldn't call it unnecessary....

**Commented [MK21]:** An example of what I mean by errors in grammar and languagea that I alluded to at the very start. There are MANY such errors unfortunately.

**Commented [MK22]:** Is this true?

### Data Preparation

The information from the text data was prepared and analysed using Python codes. Figure 2 shows a summary and example of the text preparation process. Punctuations were first removed to reduce the quantity of text data. All texts were then converted to lower case texts as python modelling functions are case-sensitive, where words such as "Energy" and "energy" are recognized as different words.

Subsequently, stop words such as "the", "all", "i" which do not give meaning to the study were removed. The default English stop words library from Python was used. After the initial data exploration, words such as "renewable", "energy", "success" appeared as words with highest frequency. Since these were common words in the subject matter which would

not be meaningful for the aim of this research, additional words were added to the stop words library and were removed from the study.

The text data underwent the process of tokenisation, where each word in the sentence is recognize as individual tokens. Finally, words are lemmatized, where words are converted to its root word to help words that carry the same meaning like “improving” and “improved” will both be recognized as “improve”.

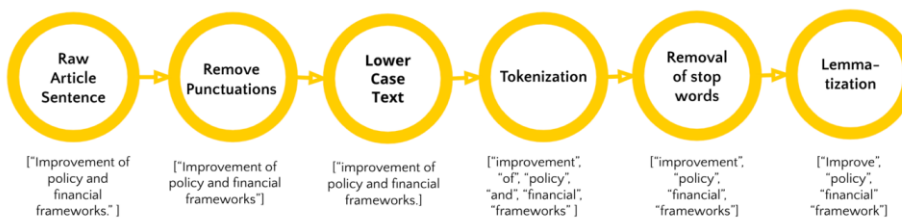


Figure 2: Data preparation text processing summary

## Data Exploring

The word cloud in figure 3 was created to visualize the top ten most frequent words in the text data. The largest and darkest words represents words with highest frequency followed by the smaller and lighter coloured words representing the decreasing frequency. This word cloud was used as a preliminary assessment to identify the most used words the scientific articles.



Figure 3 : Word Cloud showing the Top 10 words with highest frequency.



Results show the most common words are “Policy” and “Development”, these could be a growing trend on the importance of energy policies and the development of the general industry. There are also words such as “Financial” and “Technology”, indicating a definite need for returns of investment and advancement of technology in the success of RE projects. Interestingly, “Community” and “Local” were more frequent than the sectors more traditional discussion on “Finance” and “technology”. This represents a growing interest in involving the support of local communities in ensuring success of RE implementations.

**Commented [MK23]:** interesting

## CHAPTER 4: TOPIC MODELLING

### Latent Dirichlet Allocation (LDA) using Gensim and Mallet libraries

The LDA uses generative statistics to identify hidden structures in a set of text data (Ruchirawat, 2020). It is an unsupervised learning technique of machine learning, where there is no fixed output that guides the algorithm to identify patterns (Yse, 2019). The LDA aims to cluster words into topics based on their similarities by processing individual words and assigning them weights. The highlight of LDA is its ability to process an increasing number of words in the collection.

LDA topic model method consists of two inputs, which are the dictionary and corpus. Corpus represents the collection of words in the document while a dictionary maps the words to their unique id (Prabhakaran, 2018). As shown in figure 4, LDA functions on the assumption each text document contains a set K number of topics and each topic is represented by a distribution of words. Hence, repeatedly appearing sets of wordy will likely form topics.



Figure 4 : The LDA Assumption of documents, topics and keywords.

There three key steps of the LDA algorithm (Prabhakaran, 2018) :

Commented [MK24]: good I like this

1. Users have to assign K, the amount of topics in the dataset. Each K produces a different coherence score and the user can adjust the K value with after a topic quality.
2. The algorithm passes through each document and randomly assigns each words to a K topic. The simple mathematical distribution is calculated as  $p(w | t)$ , where p is the probability of words (w) in the text data that are allocated to topics (t). Secondly is  $p(t | d)$ , where the probability of words in each document (d) that are assigned to a topic (t).

3. The algorithm is iterated repeatedly and each words and documents are assigned to a new topic  $K$ . From the first random iteration, topics go through a distribution where probability  $p(t|d) * (w|t)$ .

The algorithm runs repeatedly until the word and topic assignment stabilises and becomes more constant. The results will show a final stable assignment of % of words in each  $K$  topic within each document.

In this study using LDA, two python open source libraries were used to better understand the data. Firstly, the Gensim library is an inbuilt LDA algorithm that creates for each word the unique ID and term frequency. Each word would be assigned an ID and the frequency.

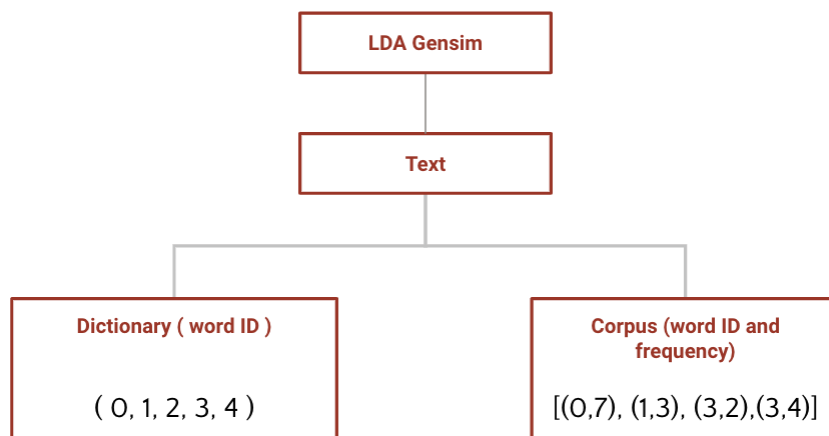


Figure 5: Visualisation of the Gensim.topic modelling output

For example in figure 5, the corpus results in a ( unique ID\_ term frequency ), where word 0 occurs 7 times. Gensim library provides the users with flexibility in being able to produce data visualisations to make the results and trends easily understandable.

Secondly, the Mallet library is the acronym for “Machine Learning for Language Toolkit”. It acts as a complementary to Gensim for better topic understanding. The Mallet method produces higher coherence scores for topics which equate to better quality topics. The coherence score for 5 topics using Mallet is 0.359, which is higher than the Gensim’s 0.279

score. However, it is a fixed program without the ability to produce visualizations. Hence, the top 10. Key words from Mallet library will be an important factor of consideration while Gensim's topic visualisation will aid in hidden insight finding.

Coherence scores are used as the measure to determine effectiveness of the topic model. Coherence scores measure the degree of semantic similarity between the top scoring words in each topic. The coherence scores also facilitates the decision to determine optimal amount of  $k$  topics in the text data. Each  $k$  topic produces a different coherence scores, where higher coherence scores generally represents a better model. Figure 5 shows the coherence scores across the each number of topics, this is used to determine the optimal number of topics for the text data.

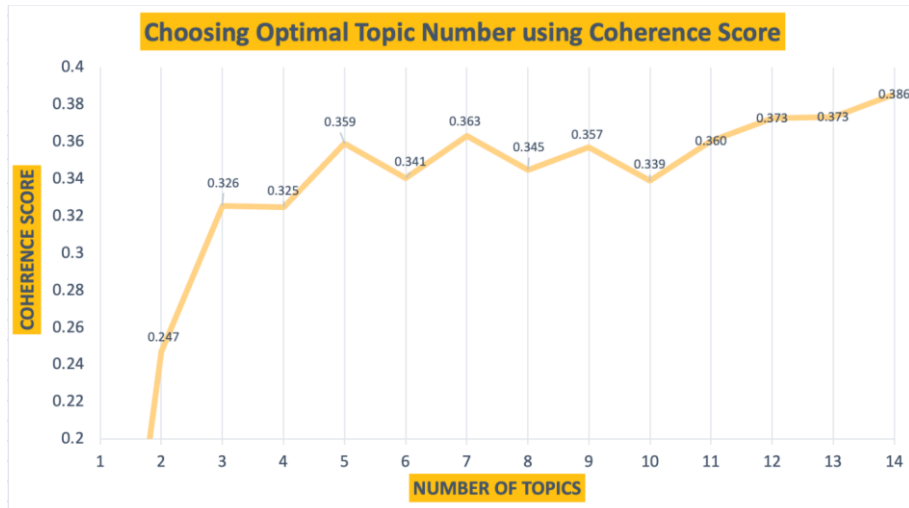


Figure 5 : Graph of Coherence Score for each topic

Coherence scores do not increase significantly after 7 topics. Although 7 topics seem to be optimal with the highest score, upon inspection of the words, there was more overlap in words used in multiple topics, and the topics were not as distinct. Hence, 5 topics were chosen instead due to its clearer distinction as shown from the data visualization.

A distance map shown in figure 6 was created to visualize the topic distinctiveness and prevalence of topic in the text data.

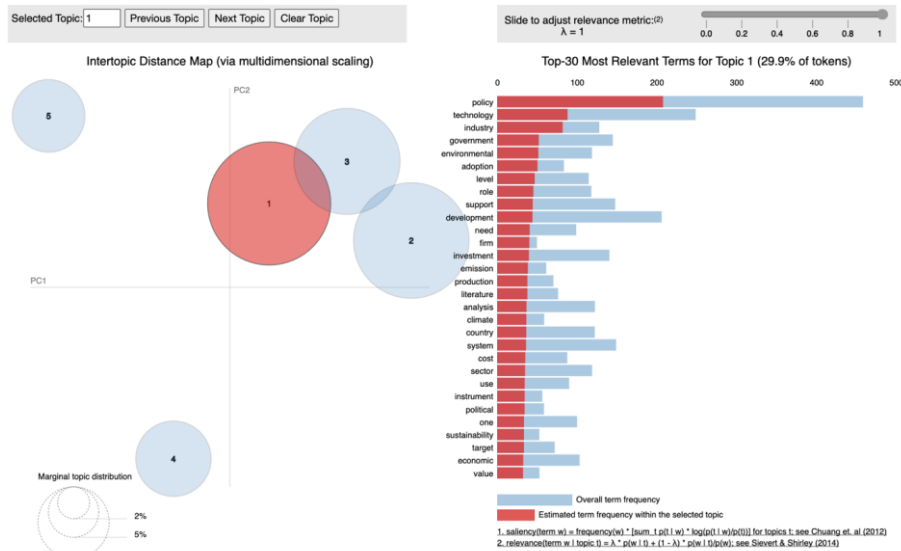


Figure 6 : Topic Visualization using a Bubble map and the corresponding top 30 terms in each topic

Each bubble represents a topic, where the distance between the circles visualizes the topic relatedness. For example, in figure 6, topics 1 and 3 are slightly related while topic 4 and 5 is very distinct from the other topics. The data visualisation is created using multidimension reduction scaling (PCA/t-sne) on the distance between each topic's probability distribution (Ruchirawat, 2020). Moreover, the bubble size represents the prevalence of the topic in the text. For example, topic 1 is the most prevalent topic being identified in the collection of documents, constituting 17.1% of the tokens. The aim is to have bubbles that are distinct from one another and contain minimal overlapping. In this visual, bubble 1 and 3 are overlapping, however there was still a significant distinctiveness between the terms found in both topics. Hence, the quality of the topic model is acceptable.

Commented [MK25]: good

The complementing visual of stack bar charts in Figure 6 show the words in each topic. Each word in the topic is measure using the relevancy metric ( $\lambda$ ). The lambda score can be adjusted to identify terms that are more unique to the topic. Common words tend appear as top relevant terms in a topic due to its high overall term frequency, as depicted from the blue part of the bar. The estimated term frequency in red bars are used to identify terms more exclusive to the topic. The lambda adjustment is thus used to identify the distinct words unique

Commented [MK26]: good, excellent

to a topic. For example in figure 7, by adjusting the lambda, the ranking of words change, where a lower lambda will reveal words more exclusive to the topic.

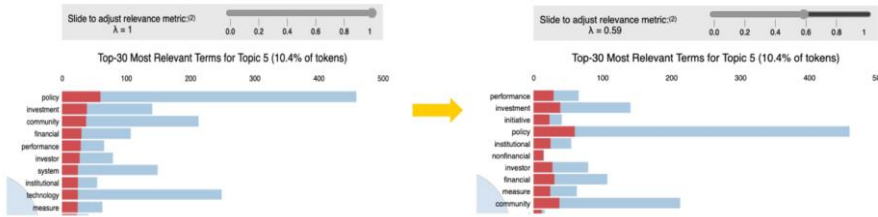


Figure 7 : The relevance metric adjustment results in changes of top keywords

### Non-Negative Matrix Factorization

An additional topic modelling method used was the Non-Negative Matrix Factorization (NMF). The NMF is an statistical method of machine learning. Similar to LDA, it also aims to identify hidden structures in the text data. The highlight of NMF algorithm is that its ability to reduce the input corpora dimension, which is the size of text data. The NMF uses a factorization method to create their topics by assigning words with lesser coherence with a lesser weightage. Hence, the words with higher coherence will be grouped together into a topic (Salgado, 2020).

Using a generic formula of  $W \times H = V$ , where  $V$  Matrix is the term-documents matrix,  $W$  Matrix the words-topics matrix, and  $H$  is the topics-documents matrix. Each column in  $W$  represents the weightage of each word in a sentence, each row in  $H$  represents the words in each column.  $W$  and  $H$  are factorised to produce  $V$ , which would be the term-document matrix that essentially creates the topics (Goyal, 2021).

In the process of factorizing, the algorithm assigns a weight to each words based on their relationship, words with highest weights are grouped as a set of words that forms the topic due to its strong relationship with one another. This linear algebra model will provide a different test result compared to the LDA models as the algorithm functions differently. Results from the NMF model will be used as a compare and contrast with LDA.

Commented [MK27]: ok

## CHAPTER 5: RESULTS

The topic models results will display the top 10 keywords for each topic and the weightage of each keywords.

For example:

$0.014 * \text{"policy"} + 0.009 * \text{"investment"} + 0.009 * \text{"community"} + 0.007 * \text{"financial"} + 0.007 * \text{"performance"} + 0.007 * \text{"investor"} + 0.006 * \text{"system"} + 0.006 * \text{"institutional"} + 0.006 * \text{"technology"} + 0.006 * \text{"measure"}$ .

The weight of each word reflects its importance to the topic. This shows that the word “policy” has double the importance in the topic than the second word “investment”. While “investment” and “community have an equal importance in the topic.

The results from the each method used are shown as in Tables 1, 2 and 3. Notably, numeric counts when using python begin from 0 instead of 1, thus topics begin from 0. Concepts were inferred from the keywords based on personal topic understanding.

### Gensim LDA Results

Commented [MK28]: good

Topic	Words	Concept
0	'policy', 'investment' , 'community', 'financial', 'performance', 'investor', 'system', 'institutional', 'technology', 'measure'	Financial Performance
1	'policy', 'technology', 'industry', 'government', 'environmental', 'adoption', 'level', 'role', 'support', 'development'	Environmental Technologies Policies
2	'policy', 'stakeholder' , 'community' + 'development', 'process', 'local', 'management', 'support', 'government', 'technology'	Community Development Policies
3	'technology', 'policy', 'system', 'development', 'community', 'traceability', 'group', 'social', 'support', 'case'	Technology and social policies
4	'state', 'policy', 'technology', 'investor', 'expansion', 'government', 'plant', 'country', 'electricity', 'community'	Technological Policies and investors

Table 1 : Top 10 significance words in descending order using Gensim.

### Mallet LDA Results

Topic	Word	Concept
1	'sector', 'policy', 'electricity', 'development', 'country', 'source', 'production', 'support', 'data', 'emission'	Energy policies
2	'technology', 'financial', 'impact', 'performance', 'cost', 'measure', 'plant', 'adoption', 'system', 'importance'	Financial performance
3	'policy', 'technology', 'investment', 'industry', 'environmental', 'investor', 'role', 'potential', 'framework', 'change'	Technology investment policies
4	'stakeholder', 'process', 'social', 'management', 'community', 'model', 'relationship', 'literature', 'analysis', 'sustainable'	Stakeholder Perception
5	'community', 'local', 'system', 'government', 'development', 'support', 'transition', 'policy', 'national', 'state'	Community Involvement

Table 2 : Top 10 significance words in descending order using Mallet.

### Non-Negative Matrix Factorization Results

Topic	Words	Concept
1	'environmental', 'mix', 'state', 'government', 'country', 'development', 'technology', 'industry', 'sector', 'policy'	Country Environmental policies
2	'process', 'development', 'technology', 'management', 'program', 'partnership', 'social', 'beneficiary', 'local', 'community'	Technology development
3	'influence', 'green', 'satisfaction', 'relationship', 'proposed', 'network', 'twomode', 'method', 'retrofit', 'stakeholder'	Stakeholder Relationship Satisfaction
4	'market', 'retail', 'portfolio', 'policy', 'performance', 'financial', 'technology', 'preference', 'investor', 'investment'	Investor preference
5	'expansion', 'fit', 'power', 'state', 'price', 'promotion', 'electricity', 'capacity', 'plant', 'system'	Energy systems

Table 3 : Top 10 significance words from Non-Negative Matrix Factorization

The Gensim and Mallet LDA methods provided similar keywords and concepts, while the Non-Negative Matrix Factorization provided slightly different word combinations. However, the concepts derived from the topics are still largely similar across the three methods.

Figure 8 visualizes the breakdown of one topic's keywords and word weightage using the gensim method. The graphs for each topics are listed in the appendix. The graph was examined to derive a more distinct concept of each topic.



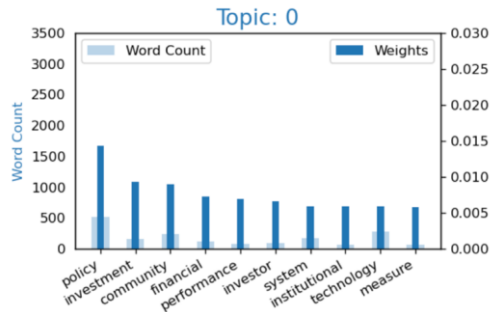


Figure 8 : Weightage and frequency of top 10 words in Topic 0

The dark blue bars signify the weight of the word in the topic, while the lighter words signify the frequency of words. In topic 0 in figure 8, although the word “technology” has a much greater frequency than most words before it. It showed a lower weight for this specific topic. And words like “investment” is more representative of the topic due to its exclusiveness to the topic.

After comparing and understanding the results from all three methods, 5 main topics were concluded and chosen based the keywords frequency and weightage. They are (1) Community Involvement, (2) Renewable energy policies, (3) Government Intervention, (4) Investor Perceptions and (5) Financial Performance. A document distribution table was created from the keywords from each topic as shown in figure 9. This displays the number of documents that were allocated to each topic. The figure shows that topic 1 is the most prevalent topic in the text document while topic 0 is the smallest topic in the dataset.

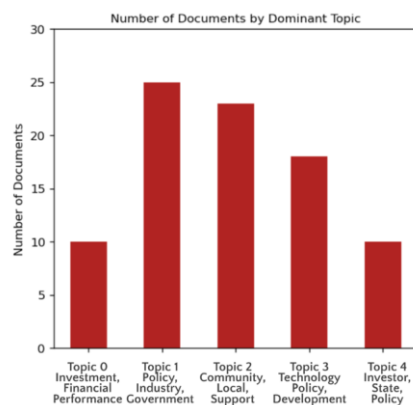


Figure 9 : Top 10 significance words from Non-Negative Matrix Factorization

Commented [MK29]: interesting result.

## CHAPTER 6: DISCUSSION AND IMPLICATIONS

The 5 main topics identified from the scientific papers discussing successful renewable energies are (1) Community involvement, (2) Energy policies, (3) Government Intervention, (4) Stakeholder Perceptions and (5) Financial Returns. Financial security and return of investments are still definitely important aspects to ensure investments have the adequate return of investments and businesses can be sustainable. Economic reasons are still important, however out of the 5 topics, 4 were non-financial factors. These results show a trend that more non-economic reasons drive renewable energy businesses than economic reasons. As there is already much research being carried out about financial factors, this study, therefore, focuses on discussing the non-economic reasons. Furthermore, government intervention and renewable energy policies are highly correlational, and therefore will be discussed simultaneously.

### Government Intervention and Renewable Energy policies

The word “Policies” is the most commonly seen word throughout the topics from all three LDA and Non-Negative Factorization Matrix topic modelling tests. It also appeared as the most frequent word as shown by the word cloud in Figure 3. Evidently, ‘Policies’ is a key topic that requires greater dissection and inspection. Policies are largely proposed and enacted by the government and are a crucial driver for energy investments (International Energy Agency, 2021). Renewable energy policies govern the standards of operation for consumers to adopt and utilise the specified form of renewable energy. Energy policies can also act as roadmaps to help steer the country to meet its energy goals. Government intervention in creating policies can consist of financial strategies and energy policies affecting technological research and development, infrastructure, consumer adoption rates, socio-economical acceptance and the overall development of the industry. The two topics identified from the study, ‘Renewable Energy policies’ and the ‘Government Intervention’ are seen to be highly interrelated and will be discussed together.

With the introduction of the Kyoto Protocols (1997) and the Paris Agreement (2015) to combat climate change, many governments have allocated large budgets for renewable energy investments and have set goals to utilise more sources of renewable energy. On the global level, renewables make up 70% of total power sector investments that amounting to USD 820 billion (International Energy Agency, 2021). Moreover, government subsidies that support the

**Commented [MK30]:** So this chapter is the most important, but needs to tie in better with your analytics above. For instance, from your 80 articles, how many ranked **Government Intervention and Renewable Energy policies** As the most important success factor? Was this locale specific?

Right now, you have used data science to get to these 5 topics, but then explained the rest in a social science-y way. Don't silo the topics pls

**Commented [MK31]:** This is an interesting result

**Commented [MK32]:** good

deployment of renewable energy technologies have totalled US\$180 billion in 2020 (International Energy Agency, 2021). The level of government support has propelled the global growth of the industry. Thus, emphasizing the impact of government intervention for renewable energy adoptions.

On a single country level, the United States has funding and financing opportunities that are widely available to support renewable energy projects. One of many examples is the State Energy Programs that provide both financial and technical assistance for energy projects that are coherent with their green energy goals (U.S. Department of Energy, 2021). There are also federal policies such as the Energy Policy Act of 2005, where congress established a legal requirement for federal agencies to derive at least 7.5% of energy consumption from renewable sources (U.S. Department of Energy, 2021).

This resulted in renewable energy usage growing by 42% from 2010 to 2020. The introduction of energy legislation with legal consequence and government financing support has allowed renewables to become the fastest-growing energy source in the country, making up close to 20% of their energy source (Center for Climate and Energy Solutions, 2021).

Another example of Singapore, which relies on fossil fuels for 95% of its energy sources, has also been introducing national initiatives towards more reliable energy sources. (Energy Market Authority Singapore, 2021). Being a small nation-state, it is difficult for corporations to create large scale natural renewable energy sources. Therefore, the government plays an indispensable role in its transition towards higher renewable energy usage. The government has been investing in research and development in alternative energies. Namely switching to more cost-competitive shared regional power grids, opting for low-carbon alternatives such as natural gas which is the cleanest fossil fuel, introducing more efficient alternatives to energy storage technologies and tapping on their most promising renewable energy source, solar power fuels (Energy Market Authority Singapore, 2021). In a nation lacking natural resources and land space, the most viable renewable energy source for the island is solar power. By 2030, the government aims to increase their solar usage by 7 times from the current usage in 2019. This increase will provide the power needs of 350,000 households and cover 4% of Singapore's electricity demand (Tan, 2019). The nation's two main solar initiatives are the solar panel installations on public housing rooftops by the Housing and Development Board (HDB) and the floating photovoltaic solar farm the size of 45 football fields in Temeh Reservoir by the Public Utilities Board (PUB) (National Climate Change Secretariat, 2021).

**Commented [MK33]:** good point

These large scale projects in Singapore is mainly successful due to governments intervention and financing for infrastructure. Thus, it is evident that government financing measures are an important explanation for the steady growth in renewable energy adoption.

This then begs the question, if government financing the only driver of renewable energy projects? Can the renewable energy sector be successful without government financing? It is important to note that government intervention does not only include financial support. An interesting perspective to consider is the absence of government financing in some countries due to the lack of financial ability. Some countries are in debt and have other more pressing social issues that require their financial support compared to renewable energy initiatives. How then can renewable energy be implemented in such countries?

**Commented [MK34]:** good questions all

In 2017, the study by Samuela Bassic from the Grantham Research Institute identified carbon pricing through the European Union Emissions Trading System as the more cost-effective way to reduce carbon emissions compared to renewable energy subsidies. Increasing the usage and developing mature low-carbon energy sources are also effective methods of decarbonisation (London School of Economics and Political Science, 2017). Thus, policies on carbon tax, fossil fuel subsidies removal and electricity pricing reforms can be less financially straining type of national energy policies. Carbon pricing is a tax that sets a price on the number of carbon emissions produced. The carbon tax pays for the external costs of greenhouse gas emissions such as healthcare costs from rising temperatures or loss of property or crops from floods and droughts that cause damage to the public (The World Bank, 2021).

Carbon taxes are a cost-effective measure that can be used across the globe, regardless of a country's economic development. Carbon Taxes are effective due to their lower administrative costs for authorities and businesses (United Nations, 2016). Compared to the large funding required in research and development for advanced technologies and new infrastructures and energy farms, carbon emissions can be calculated and measured by common weight or volume units. Thus, a carbon tax can be regulated in the same way that fossil fuel energy tax is levied. Moreover, the taxpayers would be distributors and large corporations that have the wealth to be taxed (United Nations, 2016). This is important as the carbon taxes should not negatively impact the poor and vulnerable in society. Taxes can be introduced steadily and start from low prices to smoothen the adoption of carbon pricing. Subsequently, the tax revenues can be used to support the public and implement other sustainable initiatives.

In a nutshell, it can be seen that these extensive projects across various countries further emphasize the truth that large government backing plays a big role in driving renewable energy implementation. Outside of government financing, carbon pricing policies are also a great way governments can intervene without providing financial support.

Commented [MK35]: good

### Community Engagement in projects.

Community participation has recently gained attention as a major factor in project success. Traditional top-down executive-run projects seem to be becoming less effective due to their inability to identify and meet the community's needs. Collaborative approaches in decision making are slowly becoming more popular and effective in problem-solving (SocialPinpoint, 2021). The community has been identified as a key success factor from renewable energy research in Nepal (Bkeyutchers, Williamson, & Booker, 2021), and rural areas in Indonesia (Hermawati & Rosaira, 2017).

Commented [MK36]: interesting

Solutions involving the community tend to be more effective due to the addition of local inputs. Each community has their own needs and social perceptions relating to the use of renewables. The baseline is that locals know their communities best. Hence, involving them in the planning process is a logical and simple way to create effective solutions. Getting the community involved in project design helps is part of the process that creates more user-centric solutions. In Nepal's micro-hydropower project as studied by Butchers, Williamson, & Booker (2021), the grassroots community collaborating with the institutions were representatives from neighbouring villages who have a common interest to be more sustainable. Several of their own villagers was chosen as plant operators and managers to plan and curate parts of the hydropower project. Their active participation and collaboration have promoted positive engagement which resulted in the completion of the project. Hence, this level of involvement by the community has its returns which benefits both the institutions and the people.

Additionally, the diversity that comes with involving different representatives using a bottom-up approach introduces more perspectives to the project (SocialPinpoint, 2021). Having the locals being part of the planning and inverting the traditional top-down approach facilitates a levelled field between institutions and people to facilitate sharing of ideas. Collaborations as such create more effective solutions as the knowledge unique to locals is

being tapped upon. More often, local knowledge produces solutions more practical and effective than plans curated solely from large institutions and governments.

Secondly, projects with effective community engagement create a greater sense of ownership for the community, which increases acceptance and utilisation of the solution. In the Indonesian provinces of East Java and East Nusa Tenggara, the trust of the community was key for the commencement of their renewable energy projects. One of the crucial initiatives of their project managers was to provide the community with support through training and the development of skills. For example, members of communities are involved in the installation of their biogas and micro-hydro systems. The flow of knowledge develops the communities trust towards the organisation This allowed their projects to be easily passed on from the authorities to the community organisation to sustain (Hermawati & Rosaira, 2017). As locals feel a sense of contribution to the renewable energy systems and feel responsible for sustainability. This increases the long-term sustainability of the usage of their renewable energy systems.

Moreover, community engagement initiatives are also impactful as the work is by the community and for the community, which directly impacts the people. Especially in developing areas, community projects empower the locals with leadership skills and job opportunities, thus boosting the overall livelihoods of the locals. Certainly, involving the community is a critical success factor as it creates better solutions, promotes renewable energy adoption, and has long term benefits that directly benefit the community

Commented [MK37]: interesting

### Investor Perception

The “Investor Perceptions” topic reflects the ability of perceptions to impact renewable energy projects. In behavioural finance, non-financial factors such as perceived impressions towards the renewable energy industry can affect investment decisions. As found by Masini and Menichetti (2012), the knowledge of renewable energy technologies, confidence towards policies, institutional pressures and investor experience influenced investor decision-making.

The importance of investor confidence is further enforced in the study by Baumli and Jamasb (2020) on the decision analysis of private investments in African renewable energy

infrastructure. The lack of confidence in policies has caused a perceived absence of renewable energy investment opportunities in Africa. This stems from low government effectiveness in policy creation and implementation. The general management of Africa's public energy market also showed a shortage of skills and knowledge for renewable energy development. This knowledge further drops investors' confidence in energy projects (Baumli & Jamasb, 2020). Yet again, effective energy policies and transparency from government initiatives play a role in investment decisions. Even general marketing and promotion of the availability of government initiatives are important to improve investor awareness. In order to address this, governments require frameworks that can effectively enhance the overall attractiveness and effectiveness of the renewable energy industry.

Commented [MK38]: good

In addition, the topic of Investor perceptions also reflects the importance of cognitive and behavioural studies towards acceptance of renewable energy. Social perceptions of environmental and sustainability issues would likely influence the acceptance of sustainable energy. Huijts, Molin, & Steg (2012) explained that "attitudes, social norms, perceived behavioural control, and personal norms" influenced acceptance towards green energy. Attitudes were formed from the perceived financial costs and benefits, sentiments towards technology, trust, and moral evaluations on fairness in the industry. Social norms were affected by the overall acceptance and knowledge of renewable energies. Personal norms were influenced by their awareness of climate change and its consequences. They expounded on the connection of these factors to different psychological theories, such as the theory of planned behaviour (Ajzen, 1991), the Norm Activation Theory (Schwartz, 1977) and human hedonic goals. Hence, the study of social sciences also has an opportunity to provide different perspectives that can be useful to impact the renewable energy sector

Investors are the vital to the development of renewable energy technology and it is important to understand the reasons why they make the decisions that they make. Since behavioural and psychological factors are key to studying investors' perceptions, social sciences are worth addressing and incorporating into new renewable energy research to improve the overall adoption of new initiatives.

## CHAPTER 6: CONCLUSION, LIMITATIONS.

This study adopted a topic modelling method to identify common topics in current scientific research on successful renewable energy. The study aimed to use text mining to discuss factors that contribute to the success of renewable energy despite its less than desirable results and high barriers to implementation. It moved away from the traditional approaches of discussing renewable energy success using financial returns and breakthrough technology advancements and essentially used a social science perspective to better understand the renewable energy sector.

**Commented [MK39]:** This is a good summary

The study had fulfilled its aims and identified that financial factors alone do not guarantee returns in renewable energies. In fact, more non-financial factors were found to contribute greatly to the success of renewable energy projects. Results from the LDA and NMF model and discussions show that aside from financial viability, energy policies, government intervention, community engagement and investor perceptions were strong determinants in driving renewable energy. It discusses that government financial support contributes greatly to renewable energy adoptions and carbon pricing strategies can be adopted by nations lacking financial resources. Community involvement from project development to implementation is also critical for the long term sustainability of renewable energy implementations. High engagement of the community through the training of locals to take up leadership positions benefits the projects and also boosts the overall livelihoods of the community. Lastly, investor confidence in policies and technologies also impacts decision making. The psychological study of cognitive and behavioural attitudes can also be further expounded to understand investor behaviour. The results show that increasing study on attitudes, social norms and personal norms of investors have the potential to optimize the renewable energy sector and mitigate climate change

This study has limitations that should be addressed in future research. Firstly, it is constrained by its query phrase search. If relevant articles do not have any of the query phrases “renewable energy success” in their subject, they will not be included in the dataset, which may result in data inconsistency or data bias. However, it is estimated that only a small number of publications will be lost and that will have no substantial impact on the study's outcomes. Secondly is a database constraint. The analysis is limited to publications in the Singapore University of Science Library collection. Future research could look into more databases, for



example, SAGE Journals and Science Direct for more articles and proceedings. The data size is also relatively small with only 80 suitable research articles collected. Future studies should also include a larger dataset to increase the legitimacy of data which will provide more representative topics to the current renewable energy market. The concepts for each topic are also susceptible to personal bias in analysing the keywords of each topic. Improvements can be made through a predictive model to identify the fit of key topics, where statistics can be used to estimate the accuracy of concepts assigned to the keywords of each topic.

Given the complexity of the renewable energy sector with humans as their stakeholders, the study strongly recommends a more holistic approach for future discussions on the implementation of renewable energy infrastructures or policies. Beyond the technical, financial discussions, the study has found useful social science perspectives, thus recommends further strengthening the existing links of renewable energies to social sciences. Additional perspectives can have the potential to create a more balanced discourse in supporting the global climate change agenda. Future extension of a social perspective in renewable energy research can support future policies and systems that can propel sustainable transformations.

**(Word count: 8280)**

## References

- Ambrose, J. (2021). *Most new wind and solar projects will be cheaper than coal, report finds*. Retrieved from <https://www.theguardian.com/environment/2021/jun/23/most-new-wind-solar-projects-cheaper-than-coal-report>
- Baumli, K., & Jamasb, T. (2020). Assessing private investment in African renewable energy infrastructure: A multi-criteria decision analysis approach. *Sustainability*, 12(22), 9425. doi:10.3390/su12229425
- Ben Jebli, M., & Ben Youssef, S. (2013). Output, renewable and non-renewable energy consumption and international trade: Evidence from a panel of 69 countries. *Renewable Energy*, 83, 799-808. <https://doi.org/10.1016/j.renene.2015.04.061>
- Bradshaw, G. A., & Borchers, J. G. (2000). Uncertainty as information: Narrowing the science-policy gap. *Conservation Ecology*, 4(1). <https://doi.org/10.5751/es-00174-040107>
- Butchers, J., Williamson, S., & Booker, J. (2021). Micro-hydropower in Nepal: Analysing the project process to understand drivers that strengthen and weaken sustainability. *Sustainability*, 13(3), 1582. doi:10.3390/su13031582
- Center for Climate and Energy Solutions. (2021). Renewable energy. Retrieved from <https://www.c2es.org/content/renewable-energy/>
- Energy Market Authority Singapore. (2021). The future of Singapore's energy story | EMA Singapore. Retrieved from <https://www.ema.gov.sg/ourenergystory>
- Gates, B. (2016). *It is surprisingly hard to store energy*. gatesnotes.com. Retrieved from <https://www.gatesnotes.com/energy/it-is-surprisingly-hard-to-store-energy>
- Goyal, C. (2021). Topic modelling using NMF | Guide to master NLP (Part 14). Retrieved from <https://www.analyticsvidhya.com/blog/2021/06/part-15-step-by-step-guide-to-master-nlp-topic-modelling-using-nmf/>
- Hermawati, W., & Rosaira, I. (2017). Key success factors of renewable energy projects implementation in rural areas of Indonesia. *STI Policy and Management Journal*, 2(2), 111. doi:10.14203/stipm.2017.122
- Huijts, N., Molin, E., & Steg, L. (2012). Psychological factors influencing sustainable energy technology acceptance: A review-based comprehensive framework. *Renewable and Sustainable Energy Reviews*, 16(1), 525-531. doi:10.1016/j.rser.2011.08.018
- International Energy Agency. (2021). Energy subsidies – Topics. Retrieved from <https://www.iea.org/topics/energy-subsidies>
- Jacobsson, S., & Johnson, A. (2000). The diffusion of renewable energy technology: An analytical framework and key issues for research. *Energy Policy*, 28(9), 625-640. doi:10.1016/s0301-4215(00)00041-0
- Jagadeesh, A. (2000). Wind energy development in Tamil Nadu and Andhra Pradesh, India institutional dynamics and barriers — A case study. *Energy Policy*, 28(3), 157-168. [https://doi.org/10.1016/s0301-4215\(00\)00007-0](https://doi.org/10.1016/s0301-4215(00)00007-0)
- Jai, S. (2021). *Indian renewable firms underperformed but credit quality intact: Moody's*. Business News, Finance News, India News, BSE/NSE News, Stock Markets News, Sensex NIFTY, Latest Breaking News Headlines. [https://www.business-standard.com/article/companies/indian-renewable-firms-underperformed-but-credit-quality-intact-moody-s-121030901082\\_1.html#:~:text=%22About%2015%2D20%20per%20cent,the%20underperformance%20respectively%2C%E2%80%9D%20says%20Abhishek](https://www.business-standard.com/article/companies/indian-renewable-firms-underperformed-but-credit-quality-intact-moody-s-121030901082_1.html#:~:text=%22About%2015%2D20%20per%20cent,the%20underperformance%20respectively%2C%E2%80%9D%20says%20Abhishek)

- Kealy, T. (2015). Does an embedded wind turbine reduce a company's electricity bill? Case study of a 300 kW wind turbine in Ireland. *Journal of Business Ethics*, 145(2), 417-428. <https://doi.org/10.1007/s10551-015-2837-4>
- Kinyata, G. S., & Abiodun, N. L. (2020). The impact of community participation on projects success in Africa: A bottom up approach. *International Journal of Research in Sociology and Anthropology*, 6(3). doi:10.20431/2454-8677.0603001
- London School of Economics and Political Science. (2017). EU countries should focus on carbon pricing instead of subsidies for renewables. Retrieved from <https://www.lse.ac.uk/granthaminstitute/news/eu-countries-focus-carbon-pricing-instead-subsidies-renewable/>
- Maqbool, R., Rashid, Y., Sultana, S., & Sudong, Y. (2018). Identifying the critical success factors and their relevant aspects for renewable energy projects; An empirical perspective. *Journal of Civil Engineering and Management*, 24(3), 223-237. <https://doi.org/10.3846/jcem.2018.1691>
- Masini, A., & Menichetti, E. (2012). Investment decisions in the renewable energy sector: An analysis of non-financial drivers. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.2247461>
- Mitchell, C., & Connor, P. (2004). Renewable energy policy in the UK 1990–2003. *Energy Policy*, 32(17), 1935-1947. <https://doi.org/10.1016/j.enpol.2004.03.016>
- National Climate Change Secretariat. (2021). Singapore's approach to alternative energy. Retrieved from <https://www.nccs.gov.sg/singapores-climate-action/singapore-approach-to-alternative-energy/>
- Prabhakaran, S. (2018). Topic modeling in Python with Gensim. Retrieved from <https://www.machinelearningplus.com/nlp/topic-modeling-gensim-python/>
- Ruchirawat, N. (2020). 6 tips to optimize an NLP topic model for Interpretability. Retrieved from <https://towardsdatascience.com/6-tips-to-optimize-an-nlp-topic-model-for-interpretability-20742f3047e2>
- Salgado, R. (2020). Topic modeling articles with NMF. Retrieved from <https://towardsdatascience.com/topic-modeling-articles-with-nmf-8c6b2a227a45>
- Salm, S., Hille, S. L., & Wüstenhagen, R. (2016). What are retail investors' risk-return preferences towards renewable energy projects? A choice experiment in Germany. *Energy Policy*, 97, 310-320. <https://doi.org/10.1016/j.enpol.2016.07.042>
- Schmid, G. (2012). The development of renewable energy power in India: Which policies have been effective? *Energy Policy*, 45, 317-326. <https://doi.org/10.1016/j.enpol.2012.02.039>
- Shrimali, G., Goel, S., Srinivasan, S., & Neslon, D. (2014, March 24). *Solving India's renewable energy financing challenge: Which federal policies can be most effective?* CPI. <https://www.climatepolicyinitiative.org/publication/solving-indias-renewable-energy-financing-challenge-which-federal-policies-can-be-most-effective/>
- SocialPinPoint. (2021). 6 reasons why participation is important [community engagement]. Retrieved from <https://www.socialpinpoint.com/blog/6-reasons-to-participate-community-engagement/>
- Stedman, C. (n.d.). – Text Mining (text analytics) definition. Retrieved from <https://searchbusinessanalytics.techtarget.com/definition/text-mining>
- Sunseap. (2021). *Singapore's largest clean energy service provider*. Singapore's Largest Clean Energy Service Provider | Solar Systems & Solar Energy. <https://www.sunseap.com/SG/>
- Tan, A. (2019). Singapore to ramp up solar energy production to power 350,000 homes by 2030. Retrieved from <https://www.straitstimes.com/singapore/environment/solar-energy-to-meet-4-of-singapores-energy-demand-by-2030-up-from-less-than-1>

- The World Bank. (2020). What is carbon pricing? Retrieved from <https://carbonpricingdashboard.worldbank.org/what-carbon-pricing>
- Tugcu, C. T., Ozturk, I., & Aslan, A. (2012). Renewable and non-renewable energy consumption and economic growth relationship revisited: Evidence from G7 countries. *Energy Economics*, 34(6), 1942-1950. <https://doi.org/10.1016/j.eneco.2012.08.021>
- U.S. Department of Energy. (2021). Federal agency use of renewable electric energy. Retrieved from <https://www.energy.gov/eere/femp/federal-agency-use-renewable-electric-energy>
- United Nations. (2016). Carbon tax – a good idea for developing countries? | Financing for sustainable development office. Retrieved from <https://www.un.org/development/desa/financing/document/carbon-tax-good-idea-developing-countries>
- United Nations.(2021). *The Paris Agreement | UNFCCC*. <https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement>
- West, J., Bailey, I., & Winter, M. (2010). Renewable energy policy and public perceptions of renewable energy: A cultural theory approach. *Energy Policy*, 38(10), 5739-5748. doi:10.1016/j.enpol.2010.05.024
- Wüstenhagen, R., Wolsink, M., & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*, 35(5), 2683-2691. doi:10.1016/j.enpol.2006.12.001
- Yse, D. L. (2019). Your guide to natural language processing (NLP). Retrieved from <https://towardsdatascience.com/your-guide-to-natural-language-processing-nlp-48ea2511f6e1>

## Appendix

## Word Count and Importance of Topic Keywords

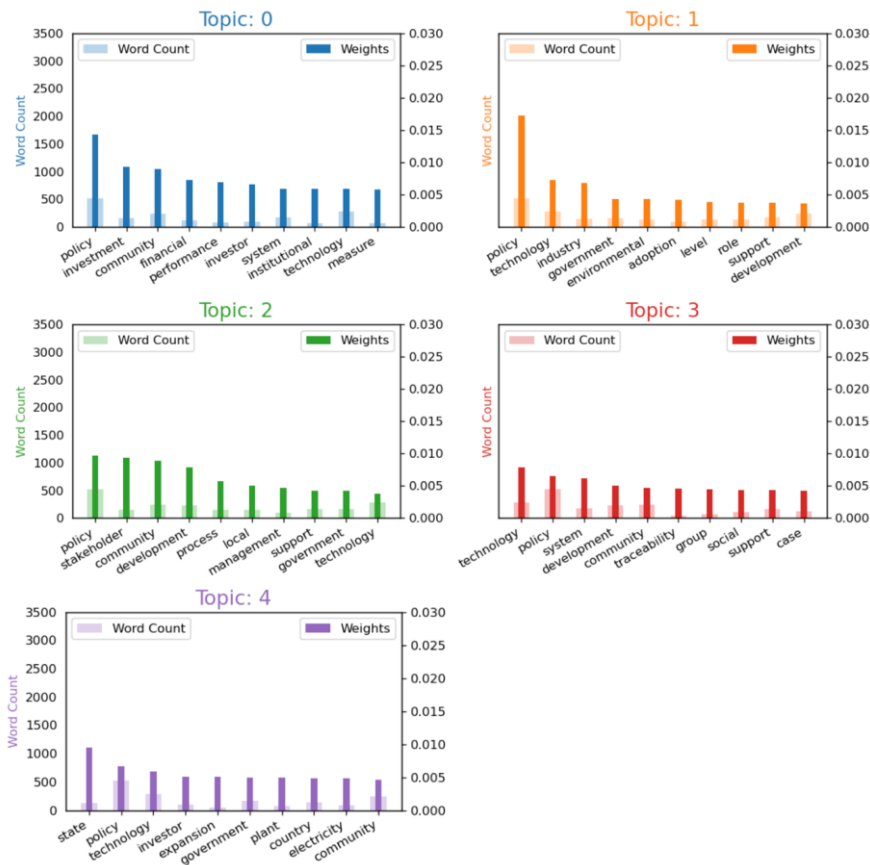


Figure 1 : Weightage and frequency of top 10 words in all 5 topics.