AN EXAMINATION OF THE RENEWABLE ENERGY SECTOR IN MALAYSIA: A CASE STUDY ON RESEARCH AND DEVELOPMENT.

Guo Chen, Amiya Bhaumik

[1]Lincoln University College, Petaling Jaya, Malaysia.

ABSTRACT

Due to the increasing demand for energy in the peninsular region and the dwindling supply of fossil fuels in Malaysia, the nation has become a case study in which energy security problems are being addressed. In terms of carbon dioxide emissions, Malaysia ranked third among the nations that are located in Southeast Asia in the year 2014. The purpose of this thesis is to study the possibility of lowering the reliance on fossil fuels by 73.8% via the production of power from renewable sources such as wind, biomass, solar, and hydro. This will be done in accordance with these two tenets. The researcher will analyse solar power in comparison to other options and balance its pros and cons in order to meet the rising demand in peninsular Malaysia. This study will be conducted in order to handle the growing need. Both the reduction of the likelihood of energy shortages and the improvement of environmental conditions are among the most important concerns of the worldwide community. Both the first and second halves of the research project will be separated into two distinct sections: the first section will cover the years 2030, and the second section will cover the years 2040. The objective of this division is to conduct an investigation into the various combinations of hybrid energy generation systems and environmentally friendly technologies. The HOMER algorithm, which stands for Hybrid Optimisation of Simulated Using Multiple Energy Resources, will be used in order to mimic the many scenarios that are included in both parts. A twenty-year demand projection from the Malaysia Electricity Management Handbook (MEIH) and growth indicators from the Malaysian Electricity Council that are accessible to the public were used in the construction of the model and were included into the model. Many prominent agencies, like the EIA and IRENA, have suggested the use of renewable energy sources and the expenses that are connected with them.

Keywords: Malaysia Electricity Management Handbook, Renewable Energy, Fossil Fuels, Hybrid Energy Generation Systems.

INTRODUCTION

According to projections made by the International Energy Agency, rising countries would be responsible for 70 percent of the anticipated 53 percent increase in global energy consumption by the year 2030. When purchasing power parity is taken into account, Malaysia has the second-highest GDP per capita among ASEAN member

nations, with Singapore being the highest. The contribution of imported products and services to the expansion of the GDP in 2009 was 4.6%. Assuming that Malaysia's gross domestic product (GDP) rises by 5% in 2005, economists anticipate that the nation's energy consumption would increase by 6% annually across the country. The final energy consumption of Malaysia increased by 5.6% to 38.9 Mtoe in 2005 as a result of the rapid economic boom that the nation experienced during the years 2000 and 2005. When compared to the quantity that was used in 2002, the global energy consumption is expected to nearly triple by the year 2030, reaching 98.7 Moet, as stated by (Zhou & Lee, 2024). According to the projections, the industrial sector will see the highest rate of growth, which is 4.3% overall. In the year 2007, industrial usage was responsible for 48 percent of the overall consumption. The present pace of oil consumption will exhaust the resource in sixteen years, although the estimated supply of natural gas is more than seventy years. This is in contrast to the current rate of oil use. When it comes to sustainability, the primary goals of Malaysia's power industry are to guarantee a consistent supply of electricity and to diversify the sources of energy. In order to ensure that development projects are carried out without a hitch and that the economy improves, the researcher need to diversify the energy sources so that Malaysia is not dependent on any one item. Additionally, the researcher needs to find out how to make the supplies more dependable. Green technology is the solution to the problems that Malaysia and other nations are facing in terms of energy and the environment, according to such governments. In an effort to give back to its origins, Malaysia has reaffirmed its commitment to developing its very own "green economy." As a result of the country's vulnerability to pollution and climate change, there is an increasing need placed on the government to improve the country's revenue and position within the global value chain. Up to this point, the focus of the investigation has been mostly on two primary areas: the proliferation of renewable energy sources in Malaysia and the many energy regulations that have been implemented by the government. An growing number of people are turning to renewable energy sources as a means of coping with the effects of rising global temperatures and the depletion of fossil resources. In addition to this, RE are abundant, the most of them are unexplored, and they are safe for the environment. One of the decisions that was made in 1999 was to replace the Four-Fuel Strategy with the Five-Fuel Diversification Approach. By 2010, the objective is to achieve a five percent increase in the entire energy mix. Within the framework of the eighth Malaysia Plan, which was in effect during the years 2001 to 2005, renewable energy was one of the energy sources that was supported. There is a moderate but steady increase taking place in the Malaysian real estate industry, which is still quite young. In this section, the researcher will talk about where the researcher is now located in RE (Abdullah & Saidur, 2023).

BACKGROYND OF THE STUDY

In May 2001, the Special Committee on Renewable Energy (SCORE) created the Small Renewable Energy Program (SREP) to aid in the administration's goal of promoting

the utilisation of renewable energy (RE) as a fuel resource for generating electricity. Renewable energy barely makes up 1% of Malaysia's overall energy mix, according to Lorenzo-Sáez (2020), despite the fact that the country's fifth fuel plan was enacted a decade ago. Sustainable development and the elimination of Malaysia's energy crisis are two of the goals of the 9th Malaysian Plan (2006–2010). In 2009, the Ministry of Energy, Communications and Multimedia made pronouncements about Malaysia's goal of a "clean and green" economy that emphasises sustainable solutions. In response, a new ministry was formed to oversee water, sustainable technologies, energy, and communications. The current prime minister of Malaysia, Datuk Seri Najib Tun Razak, proposed a new plan for environmentally friendly technologies in April 2009. After his statement comes this (GlobalData, 2023).

Provide suggestions to lessen the burden on the environment and boost economic growth. In order for the country's economic growth to be positively affected by the advancement of environmentally friendly technology. Some of the objectives include making Malaysian green technology more competitive on a global scale and enhancing the country's capacity for innovation. Environmental protection for future generations and the longevity of the efforts should take precedence over public outreach and education programs aimed at increasing the use of eco-friendly technologies. As a result of renewable energy sources including wind, solar, biomass, biofuel, and geothermal heat, its size is projected to treble by 2030. However, only around 5.9% of the world's energy will come from these sources, according to analysts. But for the time being, fossil fuels will likely continue to reign supreme. Here the researcher can find all of the energy policy proposals: In 1974, the company changed its name to Petronas from Petroleum Company Berhad. Petroleum, energy, depletion, the four fuels, and diversification were some of the topics covered by national policies enacted between 1975 and 1981. From 1995 to 2005, the primary topics of debate were on the various fuels used to produce electricity. From its start in 2000 till now, renewable energy sources have been the Fifth Fuel Policy's top priority (Kamarudin & Sopian, 2023).

PURPOSE OF THE STUDY

They will examine the main barriers to renewable energy adoption in Malaysia from several angles, including technological, economic, and societal. From a technical standpoint, it is of the utmost importance to choose a technology that is compatible with Malaysia's resources. Consider the force of the wind. Because its wind resources are lower than those of other nations, Malaysia need a dependable system that can endure conditions of low wind. Research or small-scale pilot projects are necessary to establish the true applicability of biogas and BESS to Malaysian circumstances, since they are still in their early phases of use. Most problems will be solved by the business sector. Since it is a novel kind of energy, renewable energy (RE) presents an intriguing investment potential for Malaysia. The commencement of a deployment is dependent on government incentives. Although the FiT technique

seems to be effective during implementation, it is possible that some technologies may still fail to meet rates when all other factors are included. For instance, micro hydro projects may go over budget due to compensation payments made to Aboriginal and other impacted communities.

LITERATURE REVIEW

It was easy to see that 2018 had record-breaking energy consumption. The demand for energy throughout the globe surged dramatically as a result of fuel consumption that was almost double the pace of the previous decade. Renewable energy has completely eclipsed all other energy-related metrics since 2010, while fossil fuels continue to provide more than 80% of the world's primary energy consumption. Energy consumption is the primary cause of air pollution and global warming, according to the United States Environmental Protection Agency. One 25% of the world's greenhouse gas emissions are caused by power plants and other energy-intensive activities, which utilise fossil fuels. According to the World Energy Outlook, worldwide energy consumption increased by 2.3% in 2018. Seventy percent of the increase in global energy consumption was attributable to the US, China, and India. With an expected 4.0 Gtoe in the 2040s, China is expected to maintain its position as the world's biggest consumer, according to the Institute of Energy Economics Japan. An increasing number of people in the middle class and in India, as well as in Southeast Asia, are expected to boost spending. On the other hand, lower energy use in the US and EU is expected (Loh & Ho, 2023). Rising energy consumption and housing expenses are two outcomes of the recent worldwide population growth. The construction industry ranks high in terms of worldwide energy use. Forty percent of the energy consumption in the United States and the European Union is attributed to the demands of business and residential structures. Learning about the building's interfaces, layout (including location), and occupant habits is necessary for making accurate energy recommendations. In the European Union, the energy sector is responsible for 80% of all greenhouse gas emissions. Just one sector accounts for the vast majority of the European Union's energy output (almost 40%) and carbon dioxide emissions (36% of the total). However, results below the 2020 objective have already been recorded. In 2006, consumption was 1.046 Mtoe, which is 9.1% more than the 2020 goal. Malagasy researchers looked at commercial and residential building energy use to create a database detailing overall energy use and to determine individual structures' cooling energy needs. While commercial buildings used the most energy overall, the research found that cooling energy usage increased the fastest in residential structures. The primary driver of energy demand will continue to be fossil fuels until at least 2050. The researcher examines and assesses the concept of national development from several angles, including technical, economic, sustainability, and social. One way to look at "development" is as a catch-all term for any kind of national progress, not simply economic ones. Development has been defined in literature as prosperity, which encompasses not just economic growth but also social dimensions, ecological sustainability, and quality of life, in an

effort to be more inclusive (Zhou & Lee, 2024). Researchers have concluded that consumption, rather than total primary energy, is the most appropriate statistic to use when assessing development (2016), due to factors such as globalisation and the transportation of goods and services. For low-income nations (HDI < 0.8), there is a high association between reduced energy use and improved development. However, for developed countries (HDI ≥ 0.8), this correlation peaks when energy intensity is minimised and efficiency is maximised. According to Steinberger's 2012 analysis of 137 nations' HDI and energy consumption per capita, there is a strong positive association for low levels of energy consumption f. On the other hand, the HDI reaches a peak at about 0.8 before the correlation stops improving, in accordance with the principle of diminishing returns (ibid). It is important to note that this study did not distinguish between renewable and fossil fuel energy sources; rather, it just examined total energy consumption per capita (Rohani & Othman, 2023).

RESEARCH QUESTION

How can innovation in energy storage improve the efficiency of Malaysia’s renewable energy sector?

METHODOLOGY

The foundation of quantitative research is the measurement of mathematical variables. Later on, statistical models are used to determine the relationships and correlation coefficients between the variables. Quantitative research aims to fill gaps in the understanding of society. When studying topics that affect humans, researchers often use quantitative approaches. Data visualisations based on quantitative studies provide evidence. The foundation of quantitative research is the collection and analysis of numerical data. Possible applications include averaging data, making predictions, investigating relationships, and extrapolating results to larger populations.

SAMPLING

The study's final sample included 520 personnel from the energy sector; 20 people from Malaysia's energy industry participated in the survey's pilot study. Using a systematic random sample approach, surveys were sent out to individuals engaged in the energy business. For the sake of this research, only surveys that had all of the necessary information were used; surveys that were missing any necessary information were immediately eliminated.

DATA AND MEASUREMENT

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STATISTICAL SOFTWARE

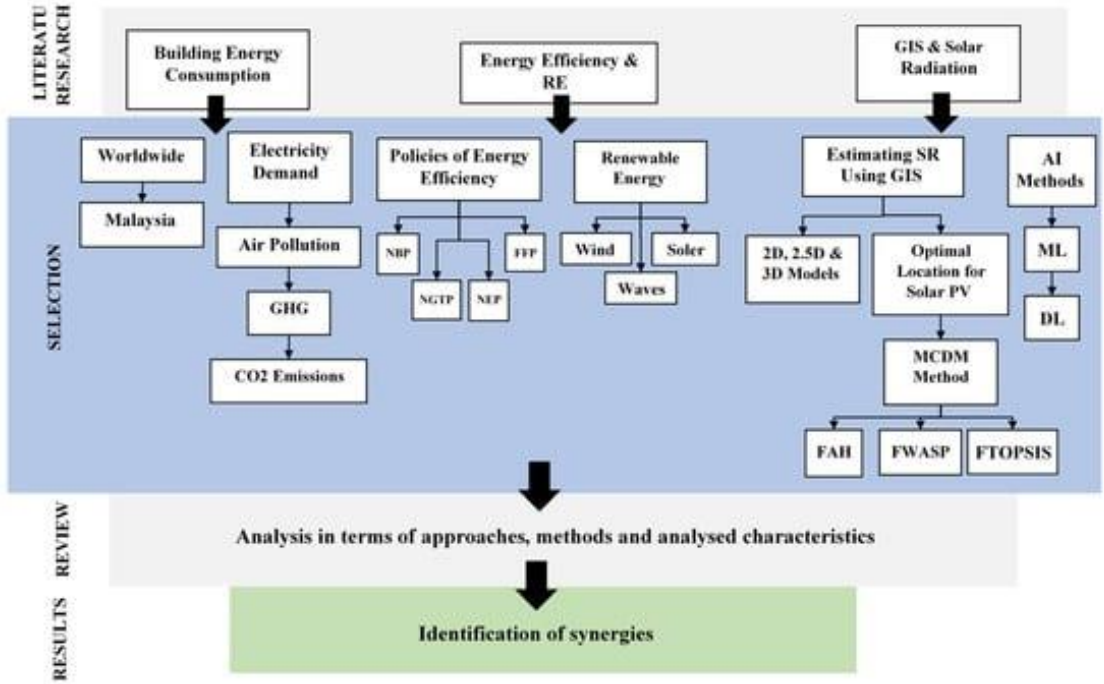
The researcher used SPSS 24 and MS-Excel to do the statistical analysis.

STATISTICAL TOOLS

In order to grasp the fundamental character of the data, descriptive analysis was used. Researchers used factor analysis to ensure validity.

The research heavily uses the following keywords: energy efficiency, limitations, consumption, utilisation of geographic information systems, greenhouse gas emissions, and energy. The researcher began by looking into the environmental impacts of buildings' main energy consumption, particularly in Malaysia. In order to calculate energy efficiency and forecast future solar radiation, this part will show the researcher how to use a GIS. Alternatives to traditional energy sources were briefly discussed, including renewable power and energy efficiency. Figure 1 shows the general layout of this study.

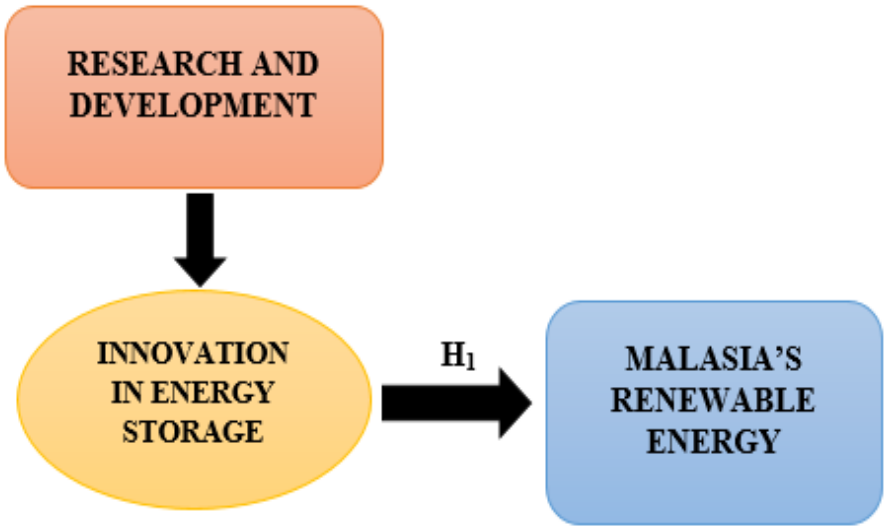
Figure 1: Identification of synergies.



Malaysia, a country in Southeast Asia, has an area of 329,750 square kilometres and is roughly positioned around the equator, between 2°30′ N and 112°30′ E. The weather is always hot and muggy, with an average of 250 cm of rain per year and 27°C of temperature. The country of Malaysia is enormous, spanning 329,847 square

kilometres. In 2019, Malaysia ranked fifth internationally for liquefied natural gas exports and second in Southeast Asia for natural gas and oil output.

CONCEPTUAL FRAMEWORK



RESULT

Factor Analysis: Confirming the latent component structure of observable data is a prevalent use of Factor Analysis (FA). Regression coefficients are often used to produce scores when visual or diagnostic indications are not easily observable. Achievement in Financial Analysis necessitates models. The objectives of modelling are to detect flaws, intrusions, and discernible connections. The Kaiser-Meyer-Olkin (KMO) Test is an instrument for assessing data sets derived from multiple regression analyses. The researcher assesses the representativeness of the variables in the sample and the model. The statistics demonstrate data overlap. The data is more comprehensible when the proportions are reduced. The KMO output ranges from 0 to 1. If KMO values range from 0.8 to 1, the sample size is enough. Kaiser delineates the permissible thresholds as follows:

The following are the acceptance criteria set by Kaiser:

A pitiful 0.050 to 0.059, below-average 0.60 to 0.69

Middle grades often fall within the range of 0.70-0.79.

With a quality point score ranging from 0.80 to 0.89.

They marvel at the range of 0.90 to 1.00.

Testing for KMO and Bartlett's: Sampling Adequacy Measured by Kaiser-Meyer-Olkin.530

The results of Bartlett's test of sphericity are as follows: approx. chi-square

df=190

sig.=.000

This proves that claims made for the sake of sampling are legitimate. The researcher used Bartlett's Test of Sphericity to make sure the correlation matrices were relevant. The sampling adequacy value according to Kaiser-Meyer-Olkin is 0.530. According to Bartlett's sphericity test, the p-value is 0.00. The correlation matrix is not an identity matrix, as shown by a significant test result from Bartlett's sphericity test.

Table1: KMO and Bartlett's Test.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.530
Bartlett's Test of Sphericity	**Approx. Chi-Square**	6524.542
	df	190
	Sig.	.000

This substantiates that assertions made for the purpose of sampling are valid. The researcher used Bartlett's Test of Sphericity to ascertain the relevance of the correlation matrices. The Kaiser-Meyer-Olkin sample adequacy value is 0.530. The p-value from Bartlett's sphericity test is 0.00. The correlation matrix is not an identity matrix, as shown by a significant outcome from Bartlett's sphericity test.

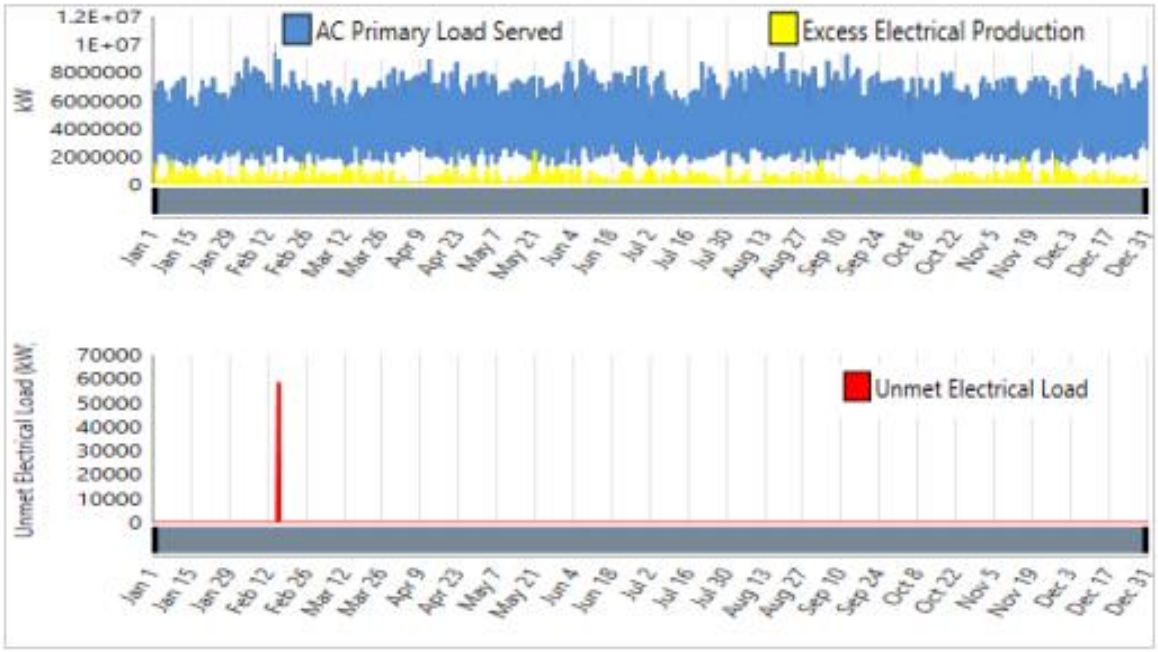
INDEPENDENT VARIABLE

Research and Development: Research and development is often linked to innovation in both the public and commercial sectors. By investing in R&D, a company may stay ahead of the competition. The research and development (R&D) program of a company determines its innovative capacity. In its absence, the firm faces the risk of failure and may need to pursue less viable options, such as partnerships or mergers and acquisitions (M&A). Companies may make better and newer products via investing in R&D. The research and development department operates independently from the rest of the company's operational activities. Research and development efforts often do not aim to generate a profit. The prevailing belief is that it will ultimately benefit a company's financial line. A lot of companies get patents, copyrights, and trademarks for their products and concepts because of their R&D efforts. Establishing and staffing research and development divisions requires substantial financial investment from businesses. Capital risk is inherent in the process of calculating return on investment (ROI) after risk adjustments. This is because the return on investment (ROI) and payment are not

visible at first glance. There is an increase in capital risk for every dollar spent on research and development. Other companies may choose to hire other firms to do their R&D for a variety of reasons, including budgetary constraints and sheer scale.

The NGG scenario was selected as the baseline since natural gas is presently used to generate more than half of peninsular Malaysia's electricity. It was determined that the 10 GWh NGG plant could meet the required demand since the annual capacity gap was less than 0.1%. This shouldn't be too worrisome since the system is connected to the existing electrical grid, which can stabilise a sudden surge, and because the peak unmet power demand for 2030 is just 60 kW higher than the capacity (GlobeNewswire, 2023).

Figure 2: Unmet Electrical Load.



Due to its dispatchable nature, NGG is able to adjust its power production in response to changes in demand. As a result, 0.74% less excess power and 0.07% less unmet electricity each year are possible. The initial investment of USD 11.7 billion for this system is reasonable, and there was little need to invest in infrastructure, since peninsular Malaysia already has a well-established gas network. However, this power plant contributes significantly to atmospheric carbon dioxide levels due to the usage of natural gas as its principal fuel. An annual emission of 29.18 billion kg of CO_2 is shown by the NGG plant in this case. This huge emission would make it unfeasible to start the project because of all the environmental impact studies that would have to be done and the mitigation plans that would have to be made. This mechanism was also having an effect on global warming over the long term (Chen & Bhaumik, 2025).

FACTOR

Innovation in Energy Storage: "Innovation in energy storage" refers to the development and enhancement of technologies meant to make energy storage more capable, efficient, long-lasting, environmentally friendly. Supercapacitors, hydrogen storage, and thermal energy storage are a few examples of alternative storage technologies; developments in battery chemistry include flow, solid-state, and lithium-ion batteries are also part of this group. By addressing issues with energy density, cost, environmental impact, and integration with renewable power sources, these developments should enable a more reliable and sustainable energy infrastructure throughout time (MK Renewable, 2023).

DEPENDENT VARIABLE

Malaysia's renewable energy: Compared to industrialised countries, emergent Malaysia's energy consumption has grown due to the country's rapid economic growth. Putting an end to sustainability in the long run because of an energy crisis and producing massive amounts of carbon emissions. The Malaysian power sector continues to rely on fossil fuels as its primary source of electricity production. Use of fossil fuels quickly became unsustainable due to their detrimental impacts on the environment and their dwindling availability. Malaysia has to look into alternate energy sources if it wants to meet the energy demands of its expanding population and businesses. Renewable and alternative energy sources account for 10% of Malaysia's overall energy usage. The two primary renewable energy sources currently used by Malaysia are hydropower and solar electricity (Shezan et al., 2021).

Relationship between Innovation in Energy Storage and Malaysia's Renewable Energy: The development of renewable energy in Malaysia is greatly influenced by technological advancements in energy storage, which help with intermittency, grid stability, and efficiency. As part of its Renewable Energy Transition Roadmap (RETR) 2030, Malaysia plans to rely more on renewable energy sources like solar, wind, and hydropower. To achieve this goal, the country needs efficient energy storage solutions that can store excess energy during peak production periods and use it during low-generation periods. Hydrogen fuel cells, pumped hydro storage, and advanced battery technologies like solid-state and lithium-ion batteries allow for more efficient energy management and less dependence on fossil fuels. Solar panels are becoming more common in homes and businesses thanks to these developments, which also help with the integration of renewable energy systems that are spread out. In addition, developments in energy storage help strengthen the grid by stabilising power supplies, minimising transmission losses, and balancing demand and supply changes. This is particularly important in rural and outlying regions where connection to the national grid is restricted. With a goal of reaching zero net carbon emissions by the year 2050, Malaysia is reiterating its call for innovative energy storage solutions to supplement its growing portfolio of renewable power sources. Innovative storage solutions are being developed and deployed thanks to government incentives, research programs, and partnerships with industry actors. This is helping

to promote economic growth and energy security. Malaysia can hasten its shift to a greener energy future, achieve energy independence in the long run, and lower its carbon emissions by embracing innovation in energy storage (Loh & Ho, 2023).

The following hypothesis, based on the preceding discussion, will be used to analyse the relationship between innovation in energy storage and Malaysia's renewable energy.

H_1: There is a significant Relationship between innovation in energy storage and Malaysia's renewable energy.

H_{01}: There is no significant Relationship between innovation in energy storage and Malaysia's renewable energy.

Table 2: H1 ANOVA Test.

ANOVA					
Sum					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	39588.620	141	5765.517	1056.7296	.000
Within Groups	492.770	378	5.456		
Total	40081.390	519			

The finding is noteworthy in this research. With a p-value of.000 (less than the.05 alpha level), the value of F, which is 1056.7296, approaches significance. Thus, it follows that **H_1: "There is a significant Relationship between innovation in energy storage and Malaysia's renewable energy."** is accepted and the null hypothesis is rejected.

DISCUSSION

Policy changes, new technology, and environmental concerns are driving rapid transformation of Malaysia's renewable energy sector. Mostly, this growth is a result of R&D investments—the independent variable influencing changes in Malaysia's renewable energy sector (the dependent variable). Solar, wind, and hydropower among other renewable energy sources depend mostly on research and development to raise efficiency, lower costs, and enhance their applicability. Key area of research and development with great impact on industry stability and scalability is innovation in energy storage. Effective storage solutions are essential to address intermittency challenges and provide a consistent energy supply because, under initiatives like the Renewable Energy Transition Roadmap (RETR) 2030, renewable energy output is expanding in Malaysia. Modern battery technologies—solid-state and lithium-ion batteries as well as alternate storage methods like pumped hydro storage and hydrogen fuel cells—allow the effective utilisation of renewable energy sources. Increased research and development help to improve energy efficiency, grid stability, and dependency on fossil fuels by means of which these discoveries are

produced. Digital technology research and development (R&D) including artificial intelligence (AI) and smart grids enhances energy storage, hence optimising demand-supply balance and lowering waste. Strengthening Malaysia's renewable energy scene entails government incentives and alliances between industrial players and research facilities. By giving research and development in energy storage technologies top priority, Malaysia may increase its commitment to reaching carbon neutrality and long-term energy security, therefore accelerating the change to a sustainable and resilient energy future.

CONCLUSION

Innovation in energy storage is one area where research and development (R&D) has been crucial in helping Malaysia's renewable energy economy advance. To combat the intermittent nature of renewable power sources like wind and solar, research and development drive the creation of innovative storage technologies including smart grids, hydrogen storage, and high-capacity batteries. These advancements pave the way for more effective energy storage, more stable grid operations, and the optimal utilisation of renewable energy sources in Malaysia. The Renewable Energy Transition Roadmap (RETR) 2030 sets out sustainability goals that Malaysia hopes to achieve by increasing its renewable energy capacity and decreasing its dependency on fossil fuels via research and development investments. Research and development in energy storage is essential if Malaysia is to construct an energy future that is dependable, sustainable, and resilient.

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