AN INVESTIGATION OF THE RESEARCH AND DEVELOPMENT PROCESS OF MALAYSIA'S RENEWABLE ENERGY SECTOR.

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ABSTARCT

In order to explore energy security challenges, Malaysia is being used as an example. This is due to the fact that Malaysia's fossil fuel reserves are decreasing and Peninsular Malaysia is expanding its residential energy use. The year 2014 saw Malaysia occupy the third spot among Southeast Asian countries in terms of the amount of carbon dioxide emissions it produced. In accordance with these two tenets, this thesis investigates the prospect of reducing the reliance on fossil fuels by 73.8% simply by supplying the homes and places of business with energy that is derived from renewable sources such as hydro, wind, biomass, and solar. As part of an attempt to satisfy the growing demand in peninsular Malaysia, this research analysed the benefits and drawbacks of solar power in comparison to other forms of renewable energy and fossil fuels. The countries have agreed that one of their primary objectives is to enhance the state of the environment and reduce the possibility of experiencing energy shortages. Two portions of the case study were conducted, one of which focused on the year 2030 and the other on the year 2040. Both halves explored a variety of different combinations of hybrid power producing systems and renewable energy systems. The acronym HOMER, which stands for Hybrid Optimisation of Simulated Using Multiple Energy Resources, was used by both parties in order to signify the several scenarios present. The demand was forecasted by the model for the subsequent twenty years by using information from the Malaysia Energy Information Handbook (MEIH) and growth characteristics that are accessible to the general public via the Malaysian Energy Commission. Reputable organisations such as the EIA and IRENA have proposed the use of renewable energy sources and the costs that are linked with them.

Keywords: Renewable Energy, Fossil Fuels, Malaysia Energy Information Handbook, Energy Commission.

INTRODUCTION

International Energy Agency projections show a 53% rise in global energy consumption by 2030, with emerging nations accounting for 70% of the growth. Malaysia has the second-highest GDP per capita among ASEAN member states when purchasing power parity is accounted for, behind only Singapore. A 4.6% increase was seen in the GDP in 2009. Experts project a 6% yearly increase in Malaysia's energy

usage if the country's GDP grows by 5% in 2005. The fast economic expansion of Malaysia from 2000 to 2005 led to a 5.6% rise in final energy consumption to 38.9 Mtoe in 2005. The world's energy consumption is projected to reach 98.7 Mtoe in 2030, which is almost three times more than the amount in 2002. The industrial sector is expected to see the fastest increase, with a growth rate of 4.3%. Industry used the most energy in 2007, accounting for 48% of total consumption. The current rate of oil use will deplete the resource in sixteen years, according to (Mekhilef et al., 2023) although the anticipated supply of natural gas is more than seventy years. When thinking about sustainability, Malaysia's power business mainly aims at ensuring a steady supply of electricity and diversifying energy sources. In order for development projects and the economy to go without a hitch, the researcher need to diversify the energy sources and find a solution to the problem of supply security and reliability. Like many other countries, Malaysia believes that green technology is the best solution to the energy and environmental concerns. The Malaysian government is returning to its roots by renewing its commitment to developing a "green economy." The administration is under increasing pressure to boost the country's income and strengthen its position in the global value chain in response to mounting concerns about the country's susceptibility to pollution and climate change. This research has so far concentrated on two main areas: the expansion of renewable energy sources in Malaysia and the many energy policies put in place by the government. Renewable Energy (RE) is gaining popularity as a means to combat climate change and the depletion of fossil resources. Furthermore, RE are plentiful, relatively unexplored, and environmentally benign. In 1999, the Four-Fuel Strategy was replaced with the Five-Fuel Diversification Strategy. The goal is to increase the overall energy mix by 5% by 2010. Energy from renewable sources was one of the goals of the eighth Malaysia Plan, which was in place from 2001 to 2005. The real estate market in Malaysia is still in its early phases, with its growth rate being quite slow. This section will discuss the current state of RE (Ember, 2023).

BACKGROUND OF THE STUDY

In May 2001, the Special Committee on Renewable Energy (SCORE) established the Small Renewable Energy Programme (SREP) to back the government's objective of encouraging the growth and use of RE as a source of fuel for producing power. Despite launching its fifth fuel plan a decade ago, the renewable energy hardly accounts for 1% of Malaysia’s total energy mix. Sustainable growth and the resolution of Malaysia's energy issue are the primary goals of the 9th Malaysian Plan (2006–2010), which focusses on energy efficiency programs. Following previous 2009 remarks by the Ministry of Energy, Communications and Multimedia on Malaysia's pursuit of a "clean and green" economy that valued sustainable solutions, a separate ministry was established to manage water, sustainable technologies, energy, and communications. In April 2009, the new strategy for eco-friendly technology was revealed by Datuk Seri Najib Tun Razak, the prime minister of Malaysia (Zainal Ariffin et al., 2022). This follows his statement. The National Green Technology Policy lays

forth the following objectives: Ceaselessly reduce energy use while fostering economic growth. In order for the growth of environmentally friendly technology to contribute positively to the nation's economic progress. Among the objectives is enhancing Malaysia's capacity for innovation and making the country's green technology more competitive on a global scale. The first concern is ensuring that the environmental preservation initiatives are sustainable for the benefit of generations to come. Only by educating and outreaching to the public will environmentally friendly technology be adopted. By 2030, renewable energy sources such as wind, solar, biomass, biofuel, and geothermal heat are projected to have grown thrice, although they will still only provide about 5.9% of the world's energy needs. But for the time being, fossil fuels are anticipated to remain dominant. Here the researcher may find information on every single energy policy proposal: Petronas was established in 1974 and was formerly known as Petroleum Company Berhad. This is shown by the following policies in action: several national policies that were enacted from 1975 to 1981, including those pertaining to energy, petroleum, depletion, the four fuels, and diversification. From 1995 to 2005, the primary focus was on the variety of fuels used to produce electricity. Since its inception in 2000, the Fifth Fuel Policy has placed a premium on renewable energy sources. The energy sector was a primary emphasis of the Ninth Malaysia Plan (2006–2010), an initiative that expanded upon the Energy Efficiency (EE) program of the Eighth Malaysian Plan (2001–2005) (Chen & Bhaumik, 2024).

PURPOSE OF THE STUDY

The primary barriers to renewable energy adoption in Malaysia were investigated from three vantage points by the researchers: technical, economic, and sociological. Picking a solution that works with Malaysia's resources is critical from a technological perspective. An example of this would be making sure that the selected wind technology can withstand low-wind situations, given that Malaysia's wind resources are very minor in comparison to other countries. Because biogas and BESS are still in their infancy as solutions, research or pilot projects on a smaller scale are needed to determine their actual suitability for the Malaysian context. Despite encountering several challenges, the business sector ultimately prevailed. An exciting investment opportunity exists in renewable energy (RE) since it represents a novel energy source for Malaysia. Government incentives play a vital role in launching a deployment. Although the FiT method seems to be working in terms of implementation, some technologies may still not have sufficient rates when all other aspects are taken into account. Compensation payments to Aboriginal and other affected organisations, for example, can lead micro hydro projects to exceed budget. The present problem of managing municipal solid waste (MSW) and the need to prolong the life of the nation's landfills may be met by redesignating FiT for biogas generation from MSW or food waste.

LITERATURE REVIEW

In 2018, the unprecedented amount of energy use was easily observable. The world's energy demand skyrocketed due to fuel consumption rising at a rate almost double that of the preceding decade. Over 80% of the world's primary energy consumption is still derived from fossil fuels, even though renewable energy has surpassed all other energy-related measures since 2010. The United States Environmental Protection Agency states that energy use is the leading source of air pollution and global warming. Greenhouse gas emissions from fossil fuel combustion in power stations and other energy-intensive industries account for 25% of global emissions. Among all energy-related firms, 6% are buildings (including both external energy generation and internal combustion for heating and cooking), 14% are transportation, 10% are other energy-consuming sectors, and 21% are power plants. 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 (Gielen et al., 2019). With an estimated 4.0 Gtoe in the 2040s, China is expected to maintain its position as the world's top user, according to the Institute of Energy Economics Japan. Rising demand is anticipated as a result of the rapidly expanding middle classes and populations in Southeast Asia, the Indian subcontinent, and the Middle East and North Africa. On the other hand, lower energy use in the US and EU is expected. Rising energy consumption and housing demands are direct results of the world's expanding human population in recent decades. One of the leading worldwide energy consumers is the construction industry. In the United States and the European Union, 40% of all energy consumption is attributed to buildings, whether they are utilised for residential or commercial reasons. Accurate energy recommendations need research on building interfaces, architecture (including location), and tenant behaviour. Eighty percent of the EU's greenhouse gas emissions come from the energy sector. Roughly one-third of the European Union's overall carbon dioxide emissions and over 40% of its overall energy output originate from a single sector. Nonetheless, it has already shown levels below the 2020 goal. In 2006, consumption was 1.046 Mtoe, which is 9.1% more than the 2020 goal. Scientists in Madagascar examined the energy use of commercial and residential buildings to create a database detailing overall energy use and to determine the cooling energy needs of individual structures. The study found that commercial buildings used the most energy overall, although cooling energy consumption was rising fastest in residential structures (Klepacki et al., 2021).

RESEARCH QUESTION

How can efficiency improvements enhance the performance of Malaysia’s renewable energy sector?

METHODOLOGY

Measuring mathematical variables is the bedrock of quantitative research; further steps include using statistical models to deduce the relationships between variables

and the correlation coefficients between them. The purpose of quantitative research is to provide a fuller view of society. Researchers often use quantitative approaches when examining matters that impact humans. Visualisations of data derived from quantitative studies provide concrete proof. The collection and analysis of numerical data is the backbone of quantitative research. Averaging data, making predictions, investigating relationships, and extrapolating results to bigger populations are all potential applications.

SAMPLING

520 energy sector workers comprised the study's final sample, with 20 individuals from the energy industry in Malaysia taking part in the questionnaire's preliminary research. Surveys were sent out to those employed in the energy industry using a systematic random sampling technique. Only questionnaires with all requested information were utilised for this study; any questionnaires lacking information were promptly removed.

DATA AND MEASUREMENT

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STATISTICAL SOFTWARE

The statistical analysis was conducted using SPSS 24 and MS-Excel.

STATISTICAL TOOLS

Descriptive analysis was used so that the essential nature of the data could be understood. Validity was checked by researchers using factor analysis.

Keywords such as energy efficiency, greenhouse gas emissions, energy consumption, usage of geographic information systems, and limits are prevalent in this study. The researcher started by investigating the environmental effects of buildings' primary energy use, with a focus on Malaysia. This section will walk the researcher through the steps of using a GIS to measure energy efficiency and make predictions about future solar radiation. Renewable power and energy efficiency were brought up as potential substitutes for conventional energy sources to round up the discussion. For the overall plan of this study, see Figure 1.

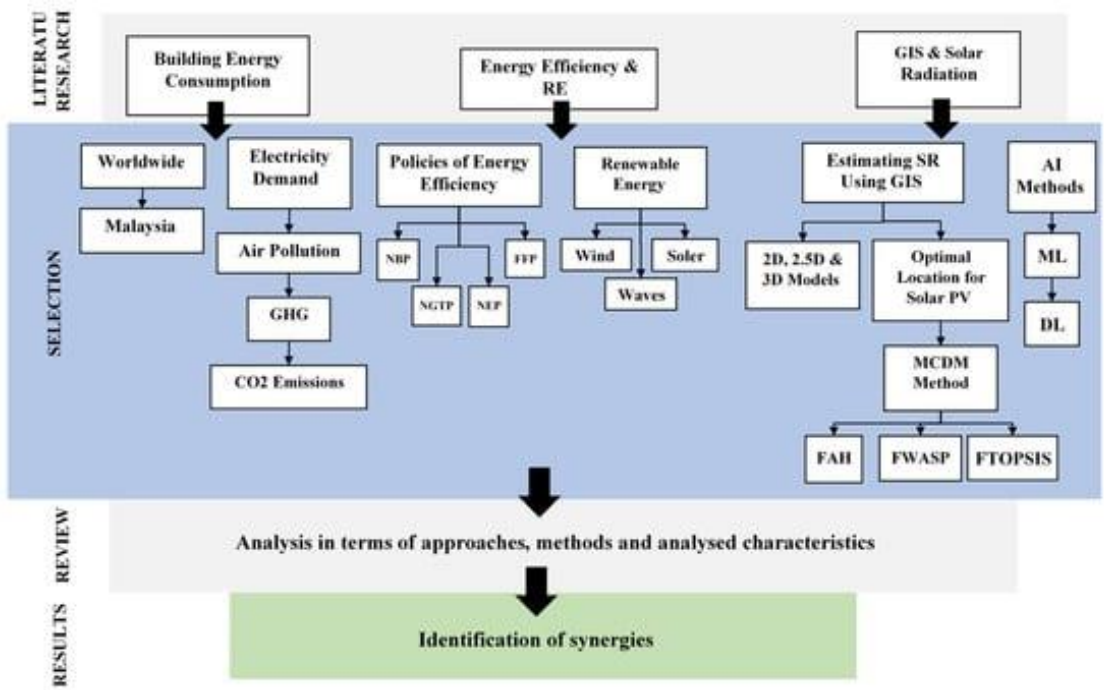
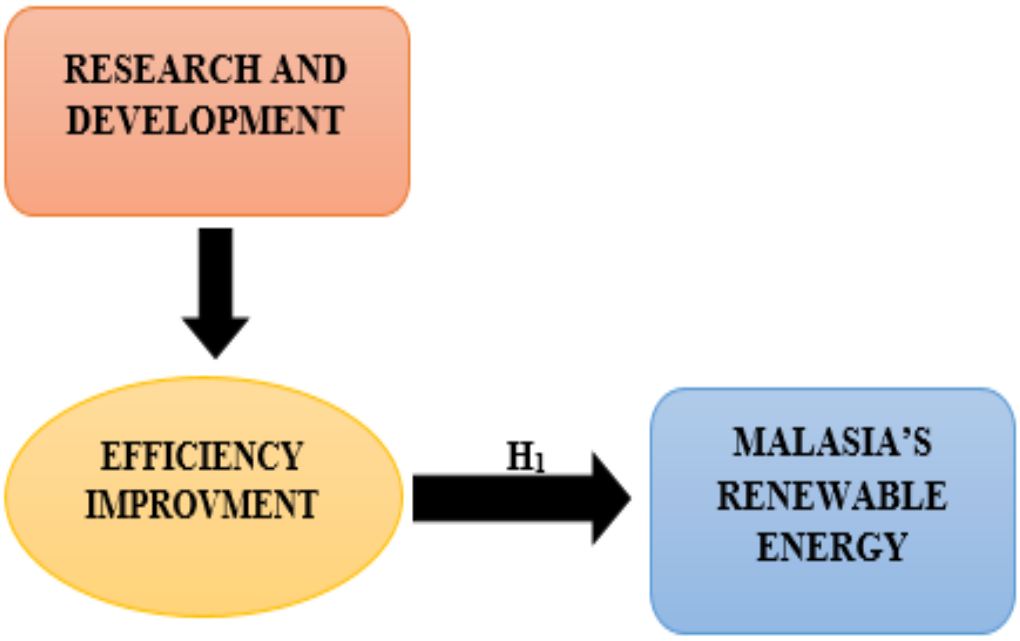


Figure 1: Identification of synergies.

The Southeast Asian nation of Malaysia is approximately located between 2°30′ N and 112°30′ E, and its total size is 329,750 square kilometres. Yearly rainfall averages 250 cm and temperatures hover around 27 °C, making for consistently humid and muggy weather. Malaysia is a massive nation that covers an area of 329,847 square kilometres. Among Southeast Asian countries, Malaysia produced more natural gas and oil than any other in 2019, and it ranked sixth globally for liquefied natural gas exports.

CONCEPTUAL FRAMEWORK



RESULTs

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.520

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 0.550. 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.		.550
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 0.550. 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: In both the private and governmental sectors, innovation is often associated with R&D. Research and development (R&D) spending may help businesses remain competitive. An organization's ability to innovate is defined by its research and development (R&D) program. Without it, the company runs the danger of collapsing and may have to resort to less desirable strategies like M&A or partnerships. By allocating resources to research and development, businesses have a higher chance of creating innovative and upgraded items. There is complete separation between the R&D division and the rest of the business. The goal of most R&D projects is not to make a profit. Most people think it will be good for a company's bottom line in the long run. R&D is the reason why many businesses receive copyrights, trademarks, patents, and patents for their ideas and goods. Companies need to put a lot of money into starting and maintaining their research and development departments. After accounting for risk, determining ROI always involves capital risk. This is due to the fact that both the payment and the return on investment (ROI) are not immediately apparent. The capital risk grows in proportion to the amount of money invested in R&D. For reasons like size and cost, other businesses may choose to outsource their research and development to other enterprises (Bakos & Khademi-Vidra, 2021).

More over half of peninsular Malaysia's power is now generated by natural gas, hence the NGG scenario was chosen as the baseline. With an annual capacity gap of less than 0.1%, it was concluded that the 10 GWh NGG plant could provide the necessary demand. Since the system is interconnected with the electrical grid, it can smooth out any unexpected surges, and the peak unmet power demand for 2030 is just 60 kW more than the capacity, so there shouldn't be any cause for concern.

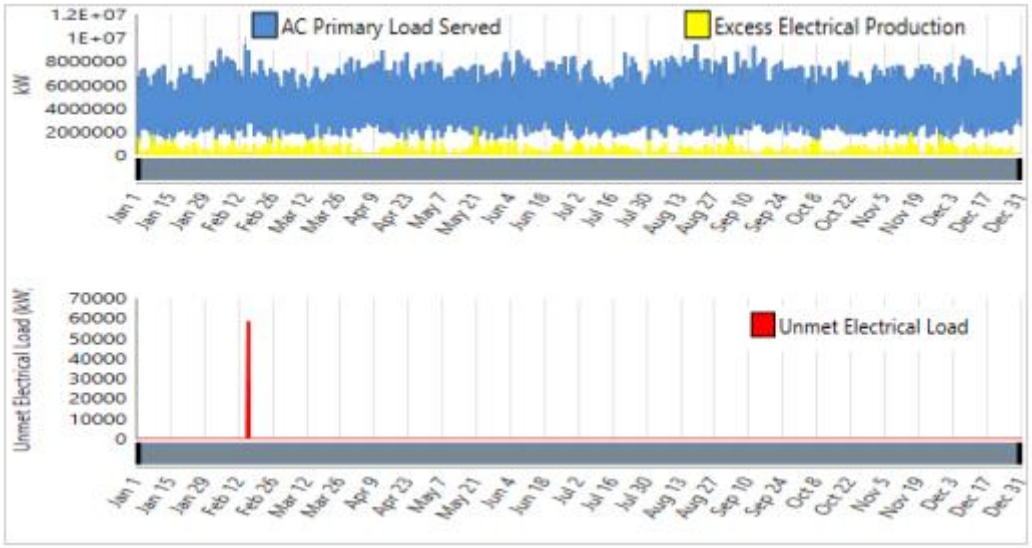


Figure 2: Unmet Electrical Load.

The dispatchability of NGG allows it to adapt its power output to fluctuations in demand. This allows for a yearly decrease of 0.74 percent in surplus power and a decrease of 0.07 percent in unmet energy needs. There was little need to invest in infrastructure, since peninsular Malaysia already has a well-established gas network, and the initial expenditure of USD 11.7 billion for this system is fair. Nevertheless, since it runs on natural gas, this power plant adds a lot of carbon dioxide to the air. In this instance, the NGG facility is indicated to emit 29.18 billion kg of CO_2 per year. Due to the extensive environmental impact assessments and mitigation strategies that would be required to begin the project in light of such a massive emission, it would be financially impossible to do so. Additionally, this process was impacting long-term global warming (Garcilazo, 2022).

FACTOR

Efficiency Improvement: Improving the efficiency of a system, process, or technology implies making it more effective by reducing the amount of waste it generates, making more efficient use of the resources it has, and generating more with less work. The advancement of technology, the optimisation of processes, the automation of tasks, and the improvement of management approaches might reach this goal. In a range of sectors, such as manufacturing, energy, and corporate operations, increasing efficiency leads to increased sustainability and competitiveness. This is because increasing efficiency results in a number of benefits, including the reduction of environmental impact, the improvement of overall performance, and the saving of money (Rokicki et al., 2020).

DEPENDENT VARIABLE

Malaysia's renewable energy: As a result of its fast economic development, emerging Malaysia's energy consumption has increased in comparison to developed

nations. Producing enormous quantities of carbon emissions and triggering an energy crisis will ultimately lead to the demise of sustainability. Fossil fuels are still the backbone of Malaysia's power sector's power generation strategy. The rapid depletion of fossil fuel reserves and the subsequent negative effects on the environment rendered their use environmentally unsustainable. The increasing energy needs of Malaysia's population and industry necessitate the exploration of alternative energy sources. In Malaysia, 10% of the total energy consumption comes from renewable and alternative sources. Currently, hydropower and solar electricity are the two main renewable energy sources used by Malaysia (Herman et al., 2021).

Relationship between Efficiency Improvement and Malaysia's Renewable Energy: Improving the efficiency of energy production, storage, and distribution is crucial for Malaysia's renewable energy industry to develop and be successful faster. Improving the efficiency of renewable energy systems helps maximise production while minimising waste and expenses, which is crucial as Malaysia strives towards its goals of net-zero carbon emissions by 2050 and the Renewable Energy Transition Roadmap (RETR) 2030. For instance, solar power has seen improvements in efficiency thanks to developments in photovoltaic (PV) panels, smart grid integration, and improved inverters, which have led to higher conversion rates and lower transmission losses. Similarly, advancements in energy management systems and turbine design lead to increased power output and decreased operating costs in hydropower and wind power. To further improve efficiency, it is essential to use enhanced energy storage technologies such pumped hydro storage and high-capacity batteries to decrease energy losses and provide a consistent power supply. Digital advances such as the Internet of Things (IoT) and artificial intelligence (AI) allow for demand forecasting, predictive maintenance, and real-time monitoring, which in turn increase efficiency, resource utilisation, and grid stability. Businesses and consumers in Malaysia are incentivised by government regulations and incentives to embrace energy-efficient technology, which in turn decreases carbon emissions and dependence on fossil fuels. Malaysia can strengthen its energy security, boost its economy, and build a more robust energy system by focussing on renewable energy efficiency improvements. Ultimately, improving the efficiency of renewable energy production and utilisation reaffirms Malaysia's commitment to a future energy that is cleaner, more environmentally friendly, and cost-effective (Gielen et al., 2019).

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

H_1: There is a significant Relationship between efficiency improvement and Malaysia's renewable energy.

H_{01}: There is no significant Relationship between efficiency improvement and Malaysia's renewable energy.

Table 2: H1 ANOVA Test.

ANOVA					
Sum					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	39588.620	163	5665.517	1061.7535	.000
Within Groups	492.770	356	5.336		
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 5665.517, approaches significance. Thus, it follows that **H_1: "There is a significant Relationship between efficiency improvement and Malaysia's renewable energy."** is accepted and the null hypothesis is rejected.

DISCUSSION

Investing in R&D has a major impact on the growth of Malaysia's renewable energy industry since it leads to better technology, lower costs, and more efficiency in the sector as a whole. Research and development (R&D) has a direct effect on renewable energy in Malaysia (the dependent variable) since it promotes improvements in clean energy infrastructure, technology, and policy. Efficiency Improvement is a critical component that connects renewable energy growth to research and development. It improves energy production, storage, and delivery. Maximising production while minimising resource loss is the goal of increasing efficiency in renewable energy sources including solar, wind, and hydropower. As an example, solar energy benefits from research and development in the form of improved inverters, tracking systems, and high-efficiency photovoltaic (PV) panels. Turbine design and grid integration efficiency improvements increase energy production and decrease operating costs in hydropower and wind generation. To further reduce transmission losses and stabilise the energy supply, research and development also leads to smart grids and high-capacity batteries, two forms of improved energy storage. New digital technologies, such as the Internet of Things (IoT) and artificial intelligence (AI), allow for demand forecasting, real-time monitoring, and predictive maintenance, all of which increase efficiency. Efficiency gains are accelerated even further with the help of government initiatives, financing, and partnerships between academic institutions and business entities. Malaysia can accomplish its goals set forth in the Renewable Energy Transition Roadmap (RETR) 2030 and reach net-zero emissions by putting an emphasis on efficiency improvements driven by research and development. This would also help the country become less reliant on fossil fuels. Research and development must prioritise efficiency improvements for Malaysia to have an energy future that is sustainable, robust, and cost-effective.

CONCLUSION

The renewable energy industry in Malaysia is seeing rapid expansion, and this can only be achieved via investments in R&D that aim to increase efficiency in power production, storage, and distribution. Research and development improve energy production, lowers costs, and maximises resource utilisation via innovations in hydropower, solar, and wind power. Renewable energy integration is further stabilised by efficient energy storage and smart grid technology. Research and development (R&D) acceleration is greatly influenced by government policy, financing, and partnerships with business. To reduce its dependency on fossil fuels and reach its net-zero ambitions, Malaysia should prioritise efficiency-driven technologies. This would help it accomplish its Renewable Energy Transition Roadmap (RETR) 2030. In the end, funding efficiency gains driven by research and development helps Malaysia move towards a cleaner, more resilient energy future, increases sustainability, and fortifies energy security.

REFERENCES

1. Bakos, I.M., & Khademi-Vidra, A. (2021), Empirical experiences of the Hungarian alternative food buying communities. Eur. J. Tour. Reg. Dev., 11, 55–73.
2. Chen, G., & Bhaumik, A. (2024). A Study to Explore the Research and Development. ² Process of Malaysia's Renewable Energy Industry. Frontiers in Health Informatics, 3(2), 1-12.
3. Ember. (2023). Solar and grid flexibility critical for Malaysia's future electricity system.
4. Garcilazo, E.J. (2022), Megatrends and Implications for Rural Development Policy. In Investing in Rural Prosperity; Federal Reserve Bank of St. Louise and the Board of Governors of the Federal Reserve System, Volume 1, pp. 17–27.
5. Gielen, D., Boshell, F., Saygin, D., Bazilian, M. D., Wagner, N., & Gorini, R. (2019). The role of renewable energy in the global energy transformation. Energy Strategy Reviews, 26, 100379.
6. Herman, L.E.; Udayana, I.B.N.; Farida, N. (2021) Young generation and environmentally friendly awareness: Does it the impact of green advertising? Bus. Theory Pract., 22, 159–166.
7. Klepacki, B.; Kusto, B.; Bórawski, P.; Bełdycka-Bórawska, A.; Michalski, K.; Perkowska, A.; Rokicki, T. (2021), Investments in Renewable Energy Sources in Basic Units of Local Government in Rural Areas. Energies, 14, 3170.
8. Mekhilef, S., Saidur, R., & Safari, A. (2023). Development of Renewable Energy in Malaysia-Strategic Initiatives and Challenges. Renewable and Sustainable Energy Reviews, 16(1), 1–10.
9. Rokicki, T.; Perkowska, A.; Klepacki, B.; Szczepaniuk, H.; Szczepaniuk, E.K.; Bereziński, S.; Ziółkowska, P. (2020), The Importance of Higher Education in the EU Countries in Achieving the Objectives of the Circular Economy in the Energy Sector. Energies, 13, 4407.

10. Zainal Ariffin, Z., Isa, N., Lokman, M. Q., Ludin, N. A., Jusoh, S., & Ibrahim, M. A. (2022). Consumer Acceptance of Renewable Energy in Peninsular Malaysia. Sustainability, 14(21), 14627.