

Legislating Sustainability for Renewable Energy in Malaysia and Iceland

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ABSTRACT

The global society has relied on fossil fuels as a lifestyle due to the support and development of technologies and economies that promoted their usage. Due to this, a total reliance towards that lifestyle has been established. This dependence has deeply permeated various facets of life, posing significant challenges in transitioning from fossil fuels to renewable energy sources. During the transition process, there are some substantial obstacles, namely the inefficiency of policies, limited enforcement capacity, and lack of sufficient financial incentives. This research focuses on conducting a comprehensive comparative analysis of the efficiency and sustainability of implementing renewable energy initiatives in Malaysia and Iceland. Specifically, this research critically examines the correlation between the effectiveness of legal frameworks and policies, particularly in Iceland, and their impact on fostering renewable energy production. This investigation yields valuable insights into refining Malaysia's renewable energy implementation, enhancing its efficiency and sustainability, and driving the transition towards cleaner energy alternatives.

Keywords: Renewable Energy; Sustainability; Malaysia; Iceland; Environmental Policy

INTRODUCTION

The United Nations states that renewable energy comes from natural sources, which are replenished at a higher rate than consumed (United Nations, 2022). Its variance includes solar, wind, hydroelectric and geothermal power, which can be easily found. The impact of climate change accelerates the renewable energy transition even more when it is realised that the transition can help decrease the emission of carbon dioxide and other greenhouse gases (Intergovernmental Panel on Climate Change, 2022). This ensures fair access to clean energy resources and minimises environmental impacts, so our current generation's energy consumption does not compromise future generations' well-being (Sovacool, 2021).

Malaysia and Iceland are no exception, actively participating in this race to embrace renewable energy, driven by their commitment to sustainability through Goal 7 of the United Nations Sustainable Development Goals (SDG). Iceland's impressive reliance on renewable energy, from powering households to sustaining energy-intensive industries, is commendable (Logadóttir, 2015). This was accomplished through initiatives including Landsnet's, the Icelandic Transmission Operator, constant development and maintenance of their reliable electricity grid, free of severe bottlenecks and permanent system constraints (Askja Energy, 2013).

In contrast, despite Malaysia's efforts to incorporate 20% renewable energy into the electricity mix by 2025, the transition from fossil fuels has been sluggish. Therefore, a comprehensive analysis of the efficiency and sustainability gaps between Malaysia and Iceland's renewable energy strategies is vital. Key factors behind Iceland's success, such as implementing the polluter pays principle, subsidies, incentives, public engagement, and international collaborations, must be examined. This is essential for Malaysia to emulate Iceland's achievements in renewable energy advancement.

LITERATURE REVIEW

Sustainable Legislation

In exploring the implementation of renewable energy in Malaysia and Iceland, we referenced various sources, including government reports, academic articles, and national policies. This is done to comprehend further how the countries legislate sustainability. We focused on how laws are made, how they are implemented, and who the stakeholders are involved while comparing the two countries in the process.

Iceland aims to become carbon-neutral by 2040, achieved by predominantly relying on geothermal energy for energy generation (Energy Voice, 2022). This is possible thanks to its geological setting. Iceland is located on the Mid-Atlantic Ridge, with over 200 volcanoes and many hot springs (United Nations, 2020). It has underground water reservoirs continually replenished by rain. Because the earth continuously radiates heat from its core, geothermal energy will likely be around for billions of years and will not be exhausted. It is also relatively clean as, according to research, geothermal power plants emit 97% less acid rain-causing sulphur compounds and 99% less carbon dioxide than fossil fuel power plants (U.S. Energy Information Administration, 2022).

Also, geothermal energy production does not fluctuate according to the season or weather. It also allows it to provide a stable energy supply, unlike wind or solar energy, which depend on the intermittent availability of natural conditions. However, there are always two sides to the coin, and one of the cons of geothermal energy is that it is expensive. The plants require land for infrastructure, and expenses are incurred for drilling wells, building power plants, and constructing transmission lines (Repsol, 2024). These are the costs required before energy generation can even begin. Despite its cons, geothermal energy has enabled Iceland to provide fair and continuous energy access to its people while also minimising the environmental impacts of energy generation. As such, Iceland's sustainable approach guarantees that future generations will also have access to clean and reliable energy unaffected by the practices of previous generations. This embodies Brian Barry's concept of posterity in his essay "Sustainability and Intergenerational Justice" (Barry, 1999).

On the other hand, Malaysia largely relies on fossil fuels for energy generation (Shafie et al., 2011). This is reflected in its energy mix in 2022, where fossil fuels generated 81% of the country's energy while 19% was from clean sources, predominantly hydropower, which contributed 17% (Ember, 2024). Malaysia has the potential to significantly increase its utilisation of renewable energy, particularly solar power, given its consistent sunny weather throughout the year. In 2022, solar energy and wind only contributed 1.5% to energy generation. This is lower than the global average (13%) and less than half of the ASEAN average (4.4% in 2023) (Ember, 2024). It depicts Malaysia as a readily available renewable energy resource with largely untapped potential. The downside of dependence on fossil fuels is that they will eventually deplete, as their renewal takes much longer than our consumption rate. Not only that, burning fossil fuels for the sake of energy generation also produces large quantities of atmosphere, which contributes to global warming. Malaysia's approach to energy contrasts with Brian Barry's, who highlights the ethical responsibility imposed on the current generation to avoid practices that would deplete resources and damage the environment (Brian Barry, 1999). If Malaysia continues its trend of being heavily reliant on fossil fuels, it will compromise energy sustainability, and future generations will find it challenging to meet their needs.

Looking at Iceland's progress towards carbon neutrality, achieved through its strategic utilisation of geothermal energy abundant to its nation, Malaysia should draw valuable lessons in shaping its energy future. Although Malaysia may not have the extensive geothermal resources that Iceland benefits from, it can undoubtedly emulate Iceland's approach to sustainability by leveraging its abundant renewable energy sources. As aforementioned, Malaysia possesses abundant potential in solar and hydroelectric energy. If the country prioritises and expands the infrastructure to utilise these resources, it could provide a sustainable solution for long-term energy security while minimising environmental impact. Diversifying the energy mix will help Malaysia reduce its dependence on fossil fuels and create a sustainable energy landscape for the nation.

Sustainable Development Goal 7 Progress

It is a fact that Iceland is at the forefront of achieving Goal 7 of the United Nations SDG as it meets 99% of its electricity needs and 85% of total energy consumption from renewable sources, primarily geothermal and hydropower (OECD, 2022). This milestone signifies that Iceland has moved beyond simply transitioning from fossil fuels to renewables; instead, the focus has shifted towards diversifying energy resources to ensure stability and predictability. Their efforts toward energy security include ensuring power facilities and infrastructure function efficiently, putting an active and open energy market in place, and innovating new technology to improve energy efficiency and minimise waste (Organisation for Economic Co-operation and Development, 2022).

In addition to exceeding expectations, Iceland is advancing towards ambitious goals such as achieving fossil fuel independence by 2050 and carbon neutrality by 2040 (Government of Iceland, 2021). Such transition has succeeded in sectors such as district heating and electricity generation, with the next target being transportation (International Energy Agency, 2021). This demonstrates Iceland's commitment to enhancing sustainability across its economy, aligned with its global responsibilities.

Malaysia is also striving to achieve SDG7; however, the country is still in the process of energy transition, decreasing its dependence on fossil fuels and relying on renewable resources instead. The Malaysian government has set ambitious targets, aiming for 40% of energy consumption to come from renewable resources by 2035 and to achieve carbon neutrality by 2050 (Sustainable Energy Development Authority Malaysia, 2020). Iceland has set a more accelerated timeline, targeting carbon neutrality by 2040, a decade earlier than Malaysia's goal. Malaysia's National Energy Transition Roadmap outlines a comprehensive strategy across six key energy transition levers, and it reflects Malaysia's commitment to providing sustainable energy. Under this roadmap, initiatives to promote renewable energy utilisation are discussed. This includes investments in solar grid infrastructure, incentivising hydrogen projects and electric vehicles, developing hydrogen standards to ensure safety and efficiency, promoting alternative bioenergy feedstocks and electrifying public transport to reduce carbon emissions (Ministry of Economy Malaysia, 2023).

Therefore, while both countries are working towards achieving Goal 7, they are at different journey stages. Nonetheless, both countries recognise the importance of sustainable energy consumption and are taking steps to address their respective challenges. Although Iceland has already passed the stage of adopting renewable energy instead of fossil fuels, Malaysia can still take inspiration from Iceland's success while embarking on its energy transition journey. Malaysia's National Energy Transition Roadmap is a promising sign for its energy future, provided it implements and adapts strategies effectively. Beyond their initiatives, Iceland and Malaysia can leverage international collaborations and exchange innovative solutions to accelerate their progress towards their respective sustainable energy goals.

Addressing The Root Cause Of The Environmental Harm

It is to be noted that addressing the root cause of environmental harm is essential rather than simply treating its symptoms or mitigating its effects. Iceland's reliance on this principle is high, as we can see from its efforts to remedy the source of environmental damage by transitioning to renewable energy. This is proven when about 85% of Iceland's primary energy supply is derived from domestically produced renewable energy sources. On top of that, the government of Iceland enacted a strict law regarding electricity to solve the issue from the root. This can be seen when the obligations of a licensee engaging in trading in electricity are strict, as stated under Articles 18 and 19 of its Electricity Act (Government of Iceland, 2003). This is to reduce the number of licensees whose actions or decisions are usually the primary root cause of environmental damage. Consequently, the licensees are held directly responsible, ensuring those capable of making significant changes are held accountable. This reflects Henry Shue's views on responsibility and fairness, as discussed in his book "Climate Justice: Vulnerability and Protection," which emphasises that those able to address environmental harm should take on a more significant share of the responsibility, which Iceland has exemplified (Shue, 2014). However, if we apply Shue's principles universally, there could be risks such as economic burden on nations with higher capacities, potential resistance from influential stakeholders, and the challenge of achieving global cooperation.

Meanwhile, Malaysia, in addressing the root cause of environmental harm, also tried to transition to solar power as it currently has 2,165 megawatts of total installed solar capacity and aims to add 1,098 megawatts by 2025 and another 2,414 megawatts by 2035 (International Renewable Energy Agency, 2023). On top of that, the government has initiated several rounds of competitive bidding for large-scale solar projects, attracting investments from domestic and international companies. These projects aim to increase the installed capacity of solar power and drive down the cost through economies of scale.

Also, the government has the Net Energy Metering (NEM) Scheme 2016 that allows consumers who install solar photovoltaic (PV) systems to generate electricity for their use and sell excess energy back to the grid. The NEM 3.0 program started in 2021 and aims to further incentivise solar adoption by offering more favourable conditions for domestic and commercial use (Sustainable Energy Development Authority Malaysia, 2020). However, the demand from consumers is still low as solar panels are expensive, and most citizens cannot afford them (Collins & Mack, 2024). Therefore, the said concept highlights the challenges of limited capacity and a need for increased responsibility and support, such as increasing government incentives, to make meaningful changes.

Iceland stands out as a leader in addressing environmental harm, primarily due to its strong transition to renewable energy and stricter regulatory framework. Firstly, Iceland relies on domestically produced renewable sources like geothermal and hydropower for approximately 85% of its power, significantly reducing its dependence on fossil fuels and emissions of greenhouse gases while enhancing energy security and independence (Orkustofnun, 2020). Secondly, Iceland's regulations under the Electricity Act place clear responsibilities on companies trading electricity, ensuring they minimise environmental impacts and are held accountable (Government of Iceland, 2003). These rules promote transparency and trust in environmental protection efforts. Thirdly, Iceland's approach aligns closely with the principles of climate justice, emphasising the responsibility of nations with the capacity to mitigate environmental harm. Iceland sets a strong example for global ecological leadership by integrating these principles into national policy and practice (Gylfadóttir, 2021). Overall, Iceland's comprehensive strategy of renewable energy adoption, coupled with stringent regulatory measures, positions it as an adequate country in addressing the root causes of environmental harm compared to Malaysia, highlighting its proactive stance and commitment to sustainable development.

Implementation Of Feed-In Tariffs

Malaysia's Green Investment Tax Allowance (GITA) enhances the attractiveness of solar energy systems for businesses by offering a significant tax reduction (Zul Rafique, 2024). This policy implicitly increases overall societal happiness by encouraging the adoption of cleaner energy, thereby reducing harmful emissions and fostering a healthier environment. The Renewable Energy Act further promotes renewable energy investment with mechanisms like feed-in tariffs and tax breaks overseen by SEDA (Sustainable Energy Development Authority Malaysia, 2011). Providing payments for excess solar energy produced subtly incentivises sustainable practices among residential and commercial users, aligning with Bentham's goal of maximising well-being through reduced environmental impact and economic benefits.

Iceland's geothermal energy industry, propelled by a government geothermal drilling mitigation fund in the late 1960s, exemplifies Bentham's principle (Bentham, 1789) by supporting the shift from fossil fuels to renewable energy. The fund's provision of loans for research, test drilling, and cost recovery for failed projects reduced financial risks and encouraged exploration and adoption of geothermal energy. Legislation requiring stringent environmental impact assessments and transparent licensing ensures the sustainable use of geothermal and hydropower resources, subtly maximising societal happiness by balancing economic growth with ecological stewardship (Steingrímisdóttir, 2019)

The geothermal energy sector in Iceland benefits from abundant resources, providing a stable energy supply and significant financial advantages, such as job creation in the geothermal industry and related sectors like tourism and research. The country invests in geothermal education and training, ensuring a skilled workforce. Integrating geothermal energy into the national grid reduces reliance on imported fossil fuels, contributing to energy independence and economic stability. Additionally, Iceland explores other renewable sources like wind and hydroelectric power, enhancing energy security and positioning the nation as a global leader in sustainable

energy practices. This multifaceted approach aligns with Bentham's principle of maximising societal happiness by combining environmental and economic benefits.

The comparison of Malaysia's and Iceland's renewable energy policies reveals distinct and commendable approaches, each with unique strengths and potential areas for improvement. With their significant tax reductions and feed-in tariffs, GITA and the Renewable Energy Act make solar investments financially attractive and foster a healthier environment through reduced emissions. However, Malaysia could enhance its impact by addressing energy storage and grid integration challenges. In contrast, Iceland's geothermal drilling mitigation fund, established in the late 1960s, reduces financial risks by supporting research and test drilling, promoting geothermal energy adoption. This proactive approach leverages Iceland's geological advantages, although diversification into other renewable sources could enhance energy security. Both countries' policies align with Bentham's utilitarian principle by promoting renewable energy, reducing environmental harm, and increasing societal happiness. Though different in their mechanisms, these initiatives demonstrate how economic incentives, financial support, and regulatory frameworks can foster sustainable practices and maximise overall well-being. Continuous improvement and adaptation to emerging challenges will be essential for both nations to maintain their leadership in renewable energy and maximise societal benefits.

Implementation Of Carbon Pricing

Malaysia and Iceland incorporate the polluter pays principle into their renewable energy frameworks, correlating with Immanuel Kant's principle (Rohlf, 2020). In Iceland, stringent environmental regulations ensure that developers of renewable energy projects bear the costs of mitigating environmental impacts, aligning with the polluter pays principle (Aragão, 2022). This ensures that the responsibility for pollution and its consequences does not fall on the public, aligning with Kant's idea that human rights and dignity must be respected. Iceland's commitment to stringent environmental regulations enforces the polluter pays principle and ensures that renewable energy projects are lauded as a world model for sustainable development (United Nations, 2015). Developers must conduct comprehensive environmental impact assessments (EIAs) before initiating projects, which helps identify potential ecological risks and mandates the implementation of mitigation strategies. This regulatory framework ensures that natural habitats are preserved, and biodiversity is protected, fostering a balanced coexistence between energy development and environmental conservation. Furthermore, public participation in decision-making is encouraged, allowing local communities to voice their concerns and contribute to sustainable development plans. This inclusive approach can enhance transparency and accountability, reinforcing trust in governmental and corporate actions. Iceland's model exemplifies a holistic approach to renewable energy.

The development combines ethical responsibility, environmental stewardship, and community involvement, promoting a more equitable and sustainable future (Nordic Council of Ministers, (2023). Similarly, In Malaysia, the Renewable Energy Act incorporates mechanisms like carbon pricing and renewable energy certificates, holding companies accountable for their environmental impact by subjecting them to taxes or fees for emitting carbon (Sustainable Energy Development Authority Malaysia, 2011). For example, companies emitting carbon dioxide above a certain threshold must purchase carbon credits, thereby internalising the environmental costs of their actions. Here, Malaysia ensures that the environmental costs of pollution are internalised, respecting the community's right to a healthy environment (Barde, 1994).

Thus, it can be seen that both Malaysia and Iceland are committed to integrating ethical principles into their renewable energy policies, albeit through distinct regulatory frameworks. Iceland's stringent environmental regulations underpin the polluter pays principle, ensuring developers bear the costs of mitigating environmental impacts. This approach safeguards natural habitats and biodiversity and fosters transparency and accountability through robust public participation mechanisms. By contrast, Malaysia's Renewable Energy Act utilises mechanisms such as carbon pricing and renewable energy certificates to hold companies accountable for their carbon emissions. This system internalises pollution's environmental costs, aligning with the polluter pays principle. While Iceland emphasises comprehensive environmental assessments and community involvement to ensure sustainable development, Malaysia focuses on financial incentives to drive cleaner energy adoption and protect public health. Together, these approaches reflect a shared commitment to balancing economic growth

with environmental responsibility, contributing to a more equitable and sustainable future for their respective societies.

METHODOLOGY

The doctrinal methodology employed in this comparative analysis of renewable energy implementation in Malaysia and Iceland is critical for exploring both nations' legal framework, policies and sustainability efforts. This research method involves a comprehensive examination of primary and secondary legal resources, such as statutes, policies, government reports and academic literature, to identify and assess the effectiveness of legislative measures in achieving renewable energy goals. By analytically reviewing these materials, the study critically evaluates Iceland's reliance on geothermal energy, supported by robust legal mechanisms like the polluter pays principle and Malaysia's efforts to transition towards renewable energy through solar power initiatives and financial incentives. The doctrinal approach facilitates an in-depth understanding of existing legal provisions and identifies gaps and areas for improvement in Malaysia's energy transition strategy.

FINDINGS AND DISCUSSION

Firstly, it is suggested that for Malaysia to integrate sustainable energy and move away from fossil fuels successfully, the country must go on the route of hydrogen fuel cells. This is because compared to other renewable energy sources like solar, biomass and hydropower, fuel cells do not require expensive transmission through an energy grid, which enhances their reliability and makes them less susceptible to disruptions from weather changes. Hydrogen fuel cells are carbon-free and environmentally friendly because their byproduct is only water or water vapour. Another significant upside is their sustainable nature, as hydrogen, one of Earth's most abundant elements, is unlikely to deplete. Nevertheless, the government must create a comprehensive policy on hydrogen fuel cells to regulate their utilisation while encouraging investments in developing its technology. There is, however, a move towards that which can be identified by reviewing the Hydrogen Roadmap in support of the National Energy Policy 2022-2024 (Malaysian Science, Technology Information Centre, 2023). Several researchers also agree that hydrogen fuel cells offer a compelling pathway towards sustainable energy independence due to their reliability, minimal environmental impact, and abundance (Reda et al., 2024; Soleimani et al., 2024; Singla et al., 2021). We also concur with their findings on the significance of government policies in regulating the adoption of hydrogen fuel cells. The Malaysian government has initiated such efforts through its National Energy Transition Roadmap.

Secondly, it is recommended that the Malaysian government urgently improve its efforts to raise public awareness and acceptance of solar energy, particularly among households. This recommendation is based on the findings from interviews where most stakeholders, including 14 out of 25 participants, such as academicians and industry players, criticise current government policies for their inadequacy in promoting solar PV adoption. Elsewhere, stakeholders highlighted deficiencies in existing awareness programs, noting that they fail to effectively educate Malaysians about the benefits and opportunities of residential solar usage (Halim et al., 2024). For instance, Solangi et al. (2013) pointed out that many Malaysians are unaware of the benefits of solar energy due to insufficient exposure to relevant information. To address these issues, the government should develop targeted campaigns that address misconceptions, offer clear information on incentives and financing options, and expand existing initiatives like the ones conducted by the Malaysian Photovoltaic Industry Association (MPIA (2024) Solar Roadshow, to engage residential communities actively. By doing so, Malaysia can potentially increase public understanding and encourage broader adoption of solar technologies among households. We agree with the author's recommendation because improving public awareness and acceptance of solar energy in Malaysia is crucial for speeding up the shift to renewable energy. Therefore, agreeing with the recommendation supports Malaysia's move towards sustainable energy practices.

Malaysia can draw inspiration from Iceland's successful approach to promoting renewable energy, mainly through the Icelandic government's geothermal drilling mitigation fund established in the late 1960s. This fund significantly reduced financial risks by supporting research, test drilling, and cost recovery for failed projects, encouraging the exploration and adoption of geothermal energy. Malaysia could establish a similar fund to support research and development in solar and other renewable energy sources to emulate this success.

Implementing stringent environmental impact assessments and transparent licensing processes would ensure the sustainable use of resources while investing in renewable energy education and training, which would help develop a skilled workforce. Malaysia's policies, such as GITA and the Renewable Energy Act, already make solar investments financially attractive and environmentally beneficial (Malaysian Investment Development Authority, 2024; Sustainable Energy Development Authority Malaysia, 2011). However, addressing challenges related to energy storage and grid integration could further enhance the impact of these policies. Iceland's proactive approach to reducing financial risks and promoting geothermal energy adoption provides valuable lessons for Malaysia. Both countries' policies align with maximising societal happiness by promoting renewable energy, reducing environmental harm, and increasing economic benefits. Continuous improvement and adaptation to emerging challenges will be essential for both nations to maintain their leadership in renewable energy and maximise societal benefits. By implementing these recommendations, Malaysia can significantly advance its renewable energy goals, fostering a sustainable and prosperous future for its citizens.

Furthermore, the role of stakeholders, including policymakers, private sector players and communities, in renewable energy development. Their corporation is crucial for implementing sustainable energy initiatives. In Iceland, the synergy among stakeholders has resulted in effective geothermal energy utilisation, while in Malaysia, greater emphasis on collaborative frameworks could accelerate the adoption of renewable energy technologies. For instance, the Icelandic government collaborates closely with private companies like Landsvirkjun, the National Power company, which manages the country's renewable energy resources. This partnership has ensured consistent investment in geothermal explorations and the development of power plants, creating a stable energy supply. Additionally, Iceland communities actively participate in the planning and implementing geothermal projects, ensuring public support and minimising resistance to new developments. Public trust is further enhanced through a transparent decision-making process, where stakeholders are consulted, and environmental impact assessments are rigorously conducted before initiating projects.

Similarly, in Malaysia, a greater emphasis on a collaborative framework could accelerate the adoption of renewable energy technologies and infrastructure. Policymakers in Malaysia, such as the Ministry of Energy and Natural Resources, have introduced programs like the NEM Scheme and GITA to encourage private sector participation. However, the engagement of communities remains limited compared to Iceland. For example, large-scale solar projects often face resistance from local populations due to a lack of awareness or perceived disruptions. Therefore, greater inclusion of communities in decision-making, such as holding town hall meetings or launching more educational campaigns than currently taken, could help mitigate these challenges.

Moreover, private companies in Malaysia, like TNB, as the country's largest electricity provider and a Government link company (GLC), have a significant role to play. Their investment in renewable energy infrastructure, such as solar farms and grid enhancement, is vital for expanding the renewable energy mix. Increasing collaboration between TNB and smaller energy startups could foster innovation and diversify energy solutions. For instance, the partnership in solar energy could lead to innovative financing models that would make solar installations more affordable for residential users, thus boosting adoption rates. As a GLC company, PETRONAS could also assist by playing a more significant role in renewable energy rather than focusing mainly on oil and gas production.

These suggestions illustrate the importance of fostering a cooperative ecosystem among stakeholders. In Iceland, aligning goals among the government, private sector and communities has resulted in a robust renewable energy framework that Malaysia could emulate. By enhancing collaborative efforts, Malaysia can leverage the expertise and resources of its stakeholders to overcome barriers and accelerate its renewable energy transition.

Economic implications also play a vital role in shaping renewable energy strategies. Iceland benefits economically from its geothermal energy sector, which ensures energy independence and boosts tourism and related industries. On the other hand, Malaysia can stand significant gains from investment in solar and hydrogen energy technology. These investments can stimulate job creation and attract foreign direct investment, reinforcing economic resilience while transitioning from fossil fuels.

Public participation has a direct effect on public awareness. Thus making it an integral part of the renewable energy policies. Awareness programmes are significantly lacking in Malaysia, making it difficult for the public to embrace the movement needed and inspired by the government. Malaysia should enhance its efforts by conducting targeted campaigns to educate citizens about the benefits and opportunities associated with renewable energy adoption. This also highlights the dangers of climate change and the increase of carbon in the atmosphere, linking it to air quality and health. This push-and-pull mechanism can enhance public awareness greatly.

Home-grown research and development (R&D) would significantly contribute to the faster implementation of renewable energy in Malaysia. Currently, the R&D on PVs are mainly from outside Malaysia, which is counter-conductive. Malaysia is losing its leverage on the opportunity to enhance its abundance of solar energy opportunity by relying on foreign technology. Thus. Investing in homegrown R&D could be a game changer for advancing the renewable energy agenda.

Local R&D efforts can focus on developing cost-effective solar technologies that address affordability, a significant barrier to adoption in Malaysia. For example, researchers at Malaysian universities and institutions could work together to create low-cost PV cells using the available local materials or innovative manufacturing techniques. Such advancement would reduce reliance on imported solar technologies, lowering consumer costs and fostering greater adoption. Universities should collaborate efforts with government bodies and GLCs to make this happen. Furthermore, homegrown R&D can drive innovations further in energy storage solutions, a critical aspect of solar energy adoption. This can overcome the intermittency nature as energy generation fluctuates with weather and time of day. Developing locally manufactured battery systems or alternative storage technologies could enhance energy reliability and make solar a viable option for residential and commercial use. For example, Malaysian startups and research institutions could partner to create affordable and efficient energy storage systems tailored for the tropical climate.

Enhancing local R&D can also help address grid integration challenges by adopting innovative grid technologies, ensuring better management of energy distribution, security, stability and complete optimisation of energy. Collaboration between TNB and local tech firms could foster such advancement, ensuring solar energy becomes a seamless part of the national grid.

Moreover, homegrown R&D can foster innovations in solar panel design that cater specifically to Malaysia's environment. For instance, researchers could develop panels resistant to high humidity and heavy rainfall or panels integrated with cooling systems to improve efficiency in tropical heat. These adaptations could significantly enhance the durability and performance of solar installation in the country, thus further enhancing the adoption of this energy.

Investing in local R&D also strengthens Malaysia's renewable energy sector by creating jobs, building technical expertise and fostering a culture of innovation. Homegrown technologies reduce import dependency and position Malaysia as a leader in renewable energy technologies within the ASEAN region. By focusing on locally developed solutions, Malaysia can chart a renewable energy transition that is both sustainable and economically beneficial for long-term energy security and environmental sustainability.

The environmental benefits of transitioning to renewable energy cannot be overstated. Iceland's geothermal energy strategy has significantly reduced its greenhouse gas emission ranking internationally, positioning the country as a global leader in sustainable energy practices. For Malaysia, a broader adoption of solar and hydrogen energy could yield substantial environmental gains, including reduced carbon emissions and improved air quality. These efforts would also align with international climate commitments, enhancing Malaysia's standing in global sustainability initiatives.

A comparative discussion of policy timelines between the two nations reveals differing levels of urgency in achieving sustainability goals. Iceland's ambitious target of achieving carbon neutrality by 2040 highlights its commitment to rapid energy transition, whereas Malaysia's 2050 target reflects a more gradual approach. This difference in timeline highlights the need for Malaysia to accelerate its efforts to remain competitive and meet global sustainability expectations.

Both nations face unique challenges in their renewable energy journeys. Iceland must address its reliance on geothermal energy by diversifying into other renewable sources to enhance energy security. Malaysia meanwhile encounters hurdles such as energy storage limitations, grid integration issues and the high cost of solar installations, which hinder widespread adoption. Overcoming these barriers targeted policy interventions and increased financial support from the government.

Global collaborations and knowledge exchange offer valuable opportunities for Malaysia to learn from Iceland's success. Joint projects and partnerships could facilitate the transfer of expertise and best practices in renewable energy implementation. For example, Iceland's geothermal drilling mitigation fund, which reduces financial risks associated with exploratory projects, can serve as a model for Malaysia to establish similar funding mechanisms for solar and hydrogen energy development.

Another critical consideration is the role of social justice and energy equity in renewable energy policies. Ensuring fair access to clean energy resources for all segments of society is a shared responsibility. Iceland's approach exemplifies this commitment through inclusive policies and community-driven initiatives. Malaysia could adopt similar measures to ensure equitable distribution of energy benefits, particularly for underserved and rural communities.

CONCLUSION

In conclusion, this analysis highlights Iceland's successful implementation of renewable energy strategies and Malaysia's challenges. Iceland's achievements, primarily through geothermal resources, involve stringent regulations, public participation, and adherence to environmental principles like the polluter pays principle, ensuring both ecological protection and societal well-being. Despite abundant solar potential, Malaysia remains reliant on fossil fuels, necessitating significant policy improvements, public awareness initiatives, and investments in renewable infrastructure. This transition dilemma still prevails.

Nevertheless, promising steps like the National Energy Transition Roadmap and policies like the GITA and the Renewable Energy Act are in place, though not comprehensive, are steps taken towards that goal. However, challenges in energy storage, grid integration, and public acceptance persist. The sure thing is that Malaysia could learn and benefit from adopting Iceland's best practices, such as reducing financial risks for renewable projects, implementing strict environmental assessments, and enhancing public engagement. Embracing hydrogen fuel cells and improving public awareness of solar energy is pivotal for Malaysia's energy transition towards meeting its goals of renewable energy implementation since the policy move is also taking place. While Iceland has set a high benchmark, Malaysia shows potential, and by emulating Iceland's strategies and addressing current gaps, it could accelerate its renewable energy transition further, ensuring sustainable development and equitable access to clean energy for future generations and contributing to a global sustainable energy movement.

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