www.bircu-journal.com/index.php/birci
Budapest International Research and Critics Institute-Journal (BIRCI-Journal)
Humanities and Social Sciences
ISSN 2615-3076 Online)
ISSN 2615-1715 (Print)
Budapest Institute

Infrastructure and Network Development to Support the Energy Transition in Indonesia

Antony[1], Yifan Tang[2], Marlon Kansil[3]
[1,2,3]*Zhejiang University, China*
theironwill777@gmail.com, tangyifan@gotion.com.cn

Abstract

Development of the necessary infrastructure and networks to support the energy transition in Indonesia. The energy transition is an important step in facing the challenges of global climate change and the limitations of conventional energy resources. In the context of Indonesia, as a country with a large population and rapid economic growth, it is important to develop adequate energy infrastructure and networks to support the use of renewable energy and better energy efficiency. This study aims to identify the needs and propose the development of infrastructure and networks needed to support energy transition in Indonesia. The specific goal is to design an effective strategy to build infrastructure and networks that are able to accommodate optimal utilization of renewable energy sources. The research method used includes literature study and analysis of relevant qualitative data. This study explores infrastructure and network requirements covering the renewable energy sector, such as renewable power generation, transmission and distribution networks and electric vehicle charging. The results of the study found that energy infrastructure such as wind and solar power had been built but the electricity network was not significant to accommodate the load from this renewable energy. The development of sustainable energy infrastructure and networks must involve proper planning and strategy. This study also discusses the opportunities and challenges that may arise in the development of infrastructure and networks, thereby providing relevant policy recommendations to accelerate Indonesia's sustainable energy transition.

Keywords
infrastructure; network; energy transition

I. Introduction

The energy transition is one of the important agendas for Indonesia in facing the challenges of climate change and increasing energy sustainability. This effort is carried out by replacing the use of non-renewable fossil fuels with renewable energy sources that are more environmentally friendly. However, to succeed in this transition, it is necessary to develop sufficient infrastructure and networks to support the widespread use of renewable energy throughout the country.

As part of the national agenda, Indonesia is implementing an energy transition as a measure to maintain energy security and create a sustainable economy in the country. This energy transition reflects Indonesia's commitment to increasing accessibility to affordable and environmentally friendly technologies in order to promote a sustainable and more environmentally friendly economic recovery (Media ESDM, 2023).

The government has increased the target percentage of New Energy and Renewable Energy (EBET) in combined energy to 23% in 2025 and 31% in 2050. Indonesia has great potential to utilize EBET energy sources, such as the construction of the Green Industrial

Park in North Kalimantan which uses energy source from the Kayan River. The potential for hydro power on the Kayan River is estimated at 11-13 gigawatts. In addition, Indonesia also has other green energy sources in the form of geothermal energy. Geothermal potential in Indonesia is among the largest in the world, with hundreds of potential points spread throughout Indonesia.

The Ministry of Finance has created a funding program to improve energy transition infrastructure through ETM. The Energy Transition Mechanism (ETM) is a program that aims to increase the development of energy infrastructure and accelerate the energy transition towards net emissions (Net Zero Emissions/NZE) with the principle of equity and affordability in 2060 or accelerated (Ministry of Finance Fiscal, 2023).

The importance of ETM for Indonesia because Indonesia will have a projected economic growth that continues to increase and is targeted to become a developed country in 2045. Therefore, Indonesia needs a large enough energy source but must not have a negative impact on the environment.

The ETM scheme, namely the first Emission Reduction Facility Scheme: This scheme is used to replace coal-fired power plants (PLTU) in Indonesia with more environmentally friendly technologies. Second, the Clean Energy Facility Scheme: This scheme aims to develop and invest in the construction of clean energy facilities, such as renewable energy.

The transition process towards cleaner and environmentally friendly energy must be carried out without burdening state finances. The ETM will be financed through a blended finance approach involving multiple funding sources, including government agencies, development banks, commercial banks, climate change funds, equity investors, insurance companies, as well as local and international philanthropists.

To support the effective implementation of ETM, the government established the ETM Country Platform. This platform will provide a holistic framework for accelerating the national energy transition by mobilizing sustainable funding sources, both from the commercial and non-commercial sectors.

This study aims to identify needs and propose the development of infrastructure and networks needed to support the energy transition in Indonesia. The specific objective is to design an effective strategy in building infrastructure and networks that can accommodate the optimal use of renewable energy sources.

This study has great significance in the context of sustainable development in Indonesia. By developing adequate infrastructure and networks, Indonesia can accelerate the energy transition and reduce dependence on fossil fuels. In addition, the wider use of renewable energy can also contribute to reducing greenhouse gas emissions and protecting the environment.

This study will focus on the identification and needs of infrastructure and networks needed to support the use of renewable energy in Indonesia. This includes aspects such as construction of electricity transmission and distribution networks, development of energy storage systems, as well as supporting infrastructure such as charging electric vehicles and construction of renewable energy generation facilities.

II. Review of Literature

The energy transition is an important issue in Indonesia because of the challenges in meeting sustainable and low-carbon energy needs. The aim of this research is to identify the role of infrastructure and networks in supporting Indonesia's energy transition, and to

look at the challenges and opportunities associated with this transition. This research has significance in providing insights into renewable energy policies and infrastructure development that can serve as a guide for other countries wishing to make a similar transition.

2.1 Energy Transition in Indonesia

The energy transition in Indonesia involves various challenges and opportunities that need to be understood. In facing these challenges, renewable energy policies play an important role in encouraging the use of clean energy sources and reducing dependence on fossil fuels.

According to Hidayah and Rizal (2019), the challenges of energy transition in Indonesia include issues of energy sustainability, accessibility, and energy disparities between regions. However, Rahadi (2020) stated that this challenge also provides opportunities to develop the renewable energy industry, create new jobs, and reduce greenhouse gas emissions.

Renewable energy policy in Indonesia is an important factor in achieving a successful energy transition. A study conducted by Susanto (2018) shows that Indonesian government policies have aimed at increasing the use of renewable energy, such as the development of solar and wind power plants.

2.2 The Role of Infrastructure and Networks in the Energy Transition

Infrastructure and networks play a very important role in supporting Indonesia's energy transition. The development of electricity infrastructure is a priority in overcoming energy sustainability issues.

Rahman (2020) states that the development of electricity infrastructure in Indonesia must pay attention to the rapid growth in energy demand, as well as incorporating renewable energy sources into the national electricity grid. Wibowo (2021) highlighted the importance of developing electricity infrastructure that can accommodate the use of renewable energy such as solar panels and wind turbines.

In addition, infrastructure for renewable energy must also be considered. Khairani and Raharja (2020) argue that the development of renewable energy infrastructure in Indonesia must consider factors such as the right location, availability of resources, and technological readiness.

To achieve a successful energy transition, it is important to develop an integrated power grid. Ardiansyah (2019) reveals that the development of an integrated power grid can optimize the use of renewable energy sources by connecting various energy sources such as solar, wind, and hydroelectric power into one connected grid. Saputra and Maulana (2021) emphasize the importance of developing an integrated electricity network to maximize the use of renewable energy in Indonesia.

2.3 Case Studies from Other Countries:

To gain further insight, case studies from other countries such as Germany and China can be used as a reference in developing infrastructure and networks to support the energy transition in Indonesia.

The experience of the German State in the Development of Renewable Energy Infrastructure has been researched by Gensinger and Jochem (2019). They provide a thorough overview of the development of renewable energy infrastructure in Germany,

including policy, implementation, costs and lessons learned. Kemfert (2019) also provides insight into the design, implementation, costs and lessons from the Energy Transition in Germany.

China also has valuable experience in building a unified network for renewable energy. Zhang, Zhao, and Li (2019) comprehensively discuss the integrated energy system in China, including the development of infrastructure and networks for the integration of renewable energy sources. Li, Li, and Ma (2021) also identify challenges and provide recommendations for the development and utilization of renewable energy in China.

In developing infrastructure and networks to support the energy transition in Indonesia, it is important to consider lessons learned from the experiences of other countries such as Germany and China. Through the research that has been conducted in these sources, valuable insights can be obtained to inform policies and strategies for the development of appropriate infrastructure and networks in supporting the energy transition in Indonesia.

III. Research Method

The research method to be used includes literature study and analysis of relevant qualitative data. This research will gather information on the development of renewable energy technology, the latest energy policies in Indonesia, as well as infrastructure and network requirements needed to support the energy transition. The data obtained will be analyzed systematically to produce recommendations based on a comprehensive understanding of the current situation and future needs. The research method for the development of transition energy infrastructure and networks will go through research stages such as data collection, data disaggregation, data and product analysis. The research results are then discussed further to obtain a more integrated perspective on energy transition infrastructure and networks.

IV. Results and Discussion

4.1 Development of Energy Infrastructure in Indonesia

Research shows that Indonesia has made significant progress in developing energy infrastructure. According to Dewi et al. (2020), there has been an increase in the construction of solar and wind power plants in various parts of Indonesia. However, there are still challenges in building renewable energy infrastructure which includes aspects of financing, regulation and accessibility (Marwan et al., 2020).

4.2 Evaluation of Existing Electrical Networks

It is important to evaluate the existing power grid to support Indonesia's energy transition. Based on Grace et al. (2021), this evaluation includes network capacity, supply reliability, and the ability to integrate renewable energy sources. This study highlights the need for the development and improvement of the electricity network to overcome the increasing burden due to the use of renewable energy.

4.3 Infrastructure and Network Development Potential for Energy Transition

Research has identified the potential for developing infrastructure and networks that can support Indonesia's energy transition. Wiratama et al. (2019) explained that there is great potential in the development of solar power plants in Indonesia, especially in remote areas. Infrastructure for the distribution of renewable energy also needs attention, such as

building an efficient transmission network and improving the distribution network (Perdana et al., 2020).

Another study from Pramono et al. (2021) highlighted the potential for developing smart grids as part of energy infrastructure in Indonesia. Smart grids enable better integration between energy providers, users and distribution systems to maximize the use of renewable energy.

In addition, there is research that discusses increasing the efficiency of the electricity network. Maulana et al. (2020) proposed the use of artificial intelligence (AI) technology in the management of power grids which can optimize energy use and increase efficiency.

In the context of the energy transition, it is important to combine infrastructure and network development with supportive policies. Suryadi et al. (2019) present an analysis of renewable energy policy in Indonesia and suggest the need for stronger policy impetus to encourage the development of infrastructure and networks that support the energy transition. This includes providing financial incentives, developing enabling regulations, and collaboration between government, the private sector, and civil society.

In addition, the implementation of innovative business models can also accelerate the development of infrastructure and networks for the energy transition. Sari et al. (2021) propose adopting a partnership-based business model between the government, the private sector, and local communities in the development of renewable energy infrastructure. This can increase accessibility, efficiency and sustainability of energy infrastructure development in Indonesia.

However, the challenges that need to be overcome in developing infrastructure and networks to support the energy transition must also be considered. Herman et al. (2021 highlights several challenges, including land availability, immature technology, and the sustainability of renewable energy policies. Comprehensive efforts, including increasing investment, research and development, and public awareness of the importance of the energy transition, will be key in addressing these challenges.

In the context of infrastructure and network development for the energy transition in Indonesia, learning from the experiences of other countries is also very valuable. Oumer et al. (2019) describe Norway's experience in the successful development of renewable energy infrastructure, with an emphasis on the development of transmission and distribution networks. Lu et al. (2021) presents research on Taiwan's experience in building a unified network and integrating renewable energy sources, with a focus on sustainability and efficiency.

Through collaboration and knowledge exchange with other countries, Indonesia can gain valuable insights in developing infrastructure and networks to support the energy transition. Thus, implementing the right policies, innovative business models, and learning from other countries' experiences will be important steps in achieving the goal of a sustainable and low-carbon energy transition in Indonesia.

4.4 Discussion

By integrating the results and discussion above, this explanation needs to provide a comprehensive understanding of infrastructure and network development to support the energy transition in Indonesia with in-depth discussion.

a. Implications of Research Results

In order to support the energy transition in Indonesia, research results from several secondary sources show several important implications. First, research (Dewi et al., 2020) shows that the development of renewable energy infrastructure has made significant

progress in Indonesia, but there are still challenges in terms of financing, regulation and accessibility. Therefore, there needs to be concrete steps to increase the sustainability of renewable energy infrastructure development.

Next, evaluate the existing power grid according to Rahmat et al. (2021) and Wiratama et al (2019) point out the need to increase network capacity, supply reliability, and the ability to integrate renewable energy sources. This indicates that there is a need to update and expand existing grid infrastructure to accommodate changes in energy patterns.

b. Challenges and Obstacles in Infrastructure and Network Development

In the process of developing infrastructure and networks to support the energy transition in Indonesia, there are challenges and obstacles that need to be overcome. One of the main challenges is the availability of sufficient land to build renewable energy infrastructure (Hermawan et al., 2021). In addition, immature technology and the sustainability of renewable energy policies are also obstacles in infrastructure development according to Sari et al. (2021).

c. Strategies to Overcome Challenges and Improve Infrastructure Development:

To overcome challenges and obstacles in infrastructure and network development, several strategies can be implemented. First, supporting policies and financial incentives are needed to encourage the development of renewable energy infrastructure (Suryadi et al., 2019). Furthermore, collaboration between the government, the private sector, and civil society is also important in overcoming these obstacles (Omer et al., 2019).

In addition, innovative business models such as partnerships between government, private sector and local communities can be applied to accelerate the development of renewable energy infrastructure according to Liu et al. (2021). Increasing investment, research and development, and increasing public awareness of the importance of the energy transition (Pramono et al., 2021) are also necessary strategies to increase infrastructure development (Perdana et al., 2019).

By implementing this strategy, it is expected that infrastructure and network development to support the energy transition in Indonesia can run more smoothly and effectively. However, it still requires commitment and cooperation from various parties to achieve this goal.

d. Road Map

Infrastructure and Network Development Roadmap to Support the Energy Transition in Indonesia

1. Current Situation Analysis:
    - Undertake a thorough evaluation of the current status of energy infrastructure and networks in Indonesia, including power generation, transmission and distribution networks, and electric vehicle charging infrastructure.
    - Identify weaknesses, deficiencies, and obstacles that need to be overcome in supporting the energy transition.
2. Setting Goals and Targets:
    - Set specific and measurable short, medium and long term goals and targets for the development of energy infrastructure and networks that support the energy transition in Indonesia.
    - Taking into account factors such as national energy needs, renewable energy potential, and the need for energy accessibility in remote areas.
3. Policy and Regulation Development:

- Develop policies and regulations that support the development of energy infrastructure and networks, including incentive policies, technical standards, and funding mechanisms.
- Strengthen the legal framework that facilitates public and private sector investment and collaboration in the development of energy infrastructure.

4. Infrastructure Development Plan:
    - Designing a comprehensive and integrated infrastructure development plan, including the construction of renewable power plants, expansion of transmission and distribution networks, and improvement of electric vehicle charging infrastructure.
    - Paying attention to regional needs, mapping of renewable energy resources, and potential for collaboration with neighboring countries.
5. Capacity Strengthening:
    - Identify training needs and increase human resource capacity in the field of renewable energy infrastructure and networks.
    - Develop relevant education and training programs to meet those needs.
6. Financing and Investment:
    - Determine sustainable financing and investment strategies for the development of energy infrastructure and networks.
    - Identify potential sources of financing, including government funds, international loans, private investment, and sustainable financing schemes.
7. Implementation and Supervision:
    - Carry out the implementation of the infrastructure development plan in stages, taking into account the priorities and availability of resources.
    - Monitor and evaluate implementation progress, make strategic adjustments if necessary, and ensure compliance with established standards and regulations.
8. Continuous Evaluation and Improvement (continued):
    - Conduct periodic evaluations of the results and impacts of the development of energy infrastructure and networks.
    - Analyze the success in achieving the goals and targets that have been set, as well as measure the efficiency and effectiveness of the infrastructure built.
    - Identify challenges and obstacles that arise during implementation, and take corrective steps as needed.
9. Information Dissemination and Public Awareness:
    - Communicating progress, benefits, and challenges in the development of energy infrastructure and networks to the general public.
    - Gather public support and raise awareness about the importance of the energy transition and the role of sustainable infrastructure.
10. Collaboration and Partnership:

- Promote collaboration and partnerships between government, private sector, academic institutions and civil society in the development of energy infrastructure and networks.
- Establish dialogue forums and collaboration platforms to share knowledge, experience and resources in supporting a sustainable energy transition.

11. Environmental Monitoring and Sustainability:

- Monitor the environmental impact of the development of energy infrastructure and networks, and ensure compliance with sustainability standards.
- Implement friendly and sustainable environmental management practices in every stage of infrastructure development.

12. Research and Innovation:
- Encouraging research and innovation in the field of energy infrastructure and network development, including the use of the latest technology and the development of energy efficient solutions.
- Facilitate knowledge exchange and technology transfer with other countries that have been successful in energy transitions.

13. Reevaluate and Update:
- Periodically re-evaluate this roadmap, taking into account developments in technology, policies and energy needs in Indonesia.
- Updating the strategies and measures necessary to address changing circumstances and achieve the goal of a sustainable energy transition.

This roadmap can serve as a guide to direct and guide the development of energy infrastructure and networks that support the energy transition in Indonesia. Implementation of this roadmap requires the collaboration and involvement of all relevant stakeholders to achieve a more sustainable energy goal.

V. Conclusion

5.1 Summary of Findings

It can be concluded several important findings related to the development of infrastructure and networks to support the energy transition in Indonesia. First, the development of renewable energy infrastructure in Indonesia has progressed, but there are still challenges in terms of financing, regulation and accessibility. Evaluation of the existing power grid indicates the need for increased capacity, reliability and ability to integrate renewable energy sources. In addition, the potential for infrastructure development and renewable energy networks in Indonesia is still very large.

5.2 Recommendations for the Development of Energy Infrastructure and Networks in Indonesia

Based on these findings, several recommendations can be given for the development of energy infrastructure and networks in Indonesia. First, supporting policies and financial incentives are needed to encourage the development of renewable energy infrastructure. Second, collaboration between the government, the private sector and civil society is key in overcoming obstacles and encouraging infrastructure development. Third, the use of smart technology and artificial intelligence can also increase the efficiency and reliability of energy networks.

5.3 Writing Contribution

Writing this article can make an important contribution to understanding the development of infrastructure and networks to support the energy transition in Indonesia. In summary of the findings, the sources studied provide a deeper understanding of the challenges, opportunities and strategic recommendations in the development of renewable energy infrastructure and integrated electricity grids in Indonesia. With the recommendations presented, it is hoped that this research can become a reference for stakeholders in designing policies and taking concrete steps to accelerate the energy transition in Indonesia.

References

Ardiansyah, A. (2019). Pengembangan Jaringan Listrik Terintegrasi di Indonesia. Jurnal Teknik Elektro, 11(1), 24-33.

Budiman, A., & Yatmo, Y. A. (2021). Kebijakan Energi Terbarukan di Indonesia: Tinjauan Implementasi dan Tantangan. Jurnal Riset Manajemen Sains Indonesia, 12(1), 105-120.

Dewi, A. K., Rostiana, N., Indrawati, A., & Lusyana, M. (2020). The Development of Renewable Energy Infrastructure in Indonesia: A Review. Journal of Physics: Conference Series, 1462(1), 012029.

ESDM (2023 Maret, 7). Pemerintah Terus Mendorong Percepatan Transisi Energi di Dalam Negeri Guna Mencapai Target Net Zero Emission pada 2060 (Halaman Web). Diakses dari https://www.ekon.go.id/publikasi/detail/4996/pemerintah-terus-mendorong-percepatan-transisi-energi-di-dalam-negeri-guna-mencapai-target-net-zero-emission-pada-2060

Fiskal Kemenkeu (2023). Energi Transistion Mechanisme. Diakses dari https://fiskal.kemenkeu.go.id/fiskalpedia/2022/11/10/21-energy-transition-mechanism

Gensinger, A., & Jochem, P. (2019). Renewable Energy Infrastructure Development in Germany: Lessons Learned and Future

Hermawan, R., Syarifuddin, F., & Rustam, D. (2021). Challenges in Renewable Energy Infrastructure Development in Indonesia: A Review. Journal of Sustainable Energy Conversion and Storage, 3(2), 41-46.

Hidayah, N., & Rizal, M. (2019). Tantangan dan Peluang Transisi Energi di Indonesia. Jurnal Manajemen Energi, 5(2), 101-110.

Kemfert, C. (2019). The German Energy Transition: Design, Implementation, Cost, and Lessons. Energy Economics, 74, 789-801.

Khairani, F., & Raharja, S. (2020). Pembangunan Infrastruktur Energi Terbarukan di Indonesia: Perspektif dan Tantangan. Jurnal Rekayasa Sistem Industri, 8(2), 67-76.

Li, H., Li, Z., & Ma, C. (2021). China's Renewable Energy Development and Utilization: Challenges and Recommendations. Energy Strategy Reviews, 33, 100616.

Lu, P., Lin, J., Cheng, W., & Chen, C. (2021). Sustainable and Efficient Energy Transition: Lessons from Taiwan's Experience in Renewable Energy Infrastructure and Integration. Energies, 14(4), 917.

Maulana, R., Pratama, R. A., Iqbal, M., & Huda, F. N. (2020). Artificial Intelligence for Smart Grid: Enhancing Energy Efficiency in the Power Distribution System. Journal of Sustainable Energy Conversion and Storage, 2(1), 14-19.

Marwan, M., Santoso, H., Rimbawan, R., Pratomo, B. A., & Tjahyono, H. (2020). Challenges and Opportunities in Developing Renewable Energy Infrastructure in Indonesia. Journal of Renewable Energy and Sustainable Development, 6(1), 23-30.

Oumer, A. N., Gagnon, Y., & Araujo, M. (2019). Renewable Energy Infrastructure Development in Norway: Lessons Learned for Developing Countries. Energy Policy, 125, 332-342.

Perdana, A. S., Ratri, P. N., & Prasetya, E. (2020). Infrastructure Development of Renewable Energy Distribution in Indonesia: Challenges and Opportunities. IOP Conference Series: Earth and Environmental Science, 423(1), 012011.

Pramono, B., Permana, D., & Anurogo, D. (2021). Smart Grid Development for Energy Transition in Indonesia. Journal of Renewable Energy and Sustainable Development, 7(3), 189-194.

Rahmat, R. F., Aulia, M. F., & Maulana, R. (2021). Evaluation of Existing Power Grid for Renewable Energy Integration in Indonesia. Journal of Renewable Energy and Sustainable Development, 7(2), 101-107.

Suryadi, M. T., Nugraha, P. H., & Sidabutar, D. P. (2019). Policy Analysis for Renewable Energy Development in Indonesia. Journal of Renewable Energy and Sustainable Development, 5(1), 11-16.

Sari, V. P., Arisandi, D., & Nugroho, G. (2021). Partnership-Based Business Model for Renewable Energy Infrastructure Development in Indonesia. Journal of Sustainable Development, 9(2), 122-129.

Rahadi, R. A. (2020). Transisi Energi di Indonesia: Tantangan dan Peluang. Jurnal Energi dan Lingkungan, 7(1), 1-14.

Rahman, F. (2020). Pengembangan Infrastruktur Listrik di Indonesia: Tantangan dan Strategi. Jurnal Teknik Elektro dan Komputer, 9(1), 17-26.

Sari, V. P., Arisandi, D., & Nugroho, G. (2021). Partnership-Based Business Model for Renewable Energy Infrastructure Development in Indonesia. Journal of Sustainable Development, 9(2), 122-129.

Saputra, A. B., & Maulana, M. F. (2021). Pengembangan Jaringan Listrik Terintegrasi untuk Mendukung Energi Terbarukan. Jurnal Teknik Elektro dan Komputer, 10(2), 45-54.

Susanto, H. (2018). Kebijakan Energi Terbarukan di Indonesia: Tinjauan Kebijakan dan Perkembangan Terkini. Jurnal Perencanaan Wilayah dan Kota, 29(1), 23-36.

Suryadi, M. T., Nugraha, P. H., & Sidabutar, D. P. (2019). Policy Analysis for Renewable Energy Development in Indonesia. Journal of Renewable Energy and Sustainable Development, 5(1), 11-16.

Tannady, E. S. (2022). Peran Infrastruktur untuk Pengembangan Energi Terbarukan di Indonesia. Jurnal Infrastruktur, 6(1), 32-43.

Wibowo, A. (2021). Pengembangan Infrastruktur Kelistrikan di Indonesia Menuju Energi Terbarukan. Jurnal Informatika dan Teknik Elektro, 5(1), 1-10

Wiratama, H., Noor, I. M., & Rizal, M. (2019). Potential Analysis of Solar Power Plant Development in Remote Areas of Indonesia. Journal of Sustainable Development, 7(6), 1-8.

Zhang, X., Zhao, J., & Li, J. (2019). Integrated Energy Systems in China: A Comprehensive Review. Renewable and Sustainable Energy Reviews, 107, 166-180