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Silica Sand as an Alternative Source of Renewable Energy within the Green Economy Concept: A Maqasid al-Shari'ah Perspective

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Abstract

The concept of the Green Economy emerges to address the negative impacts of pollution and environmental damage caused by increasing economic activities. One of the programs of the Green Economy is Renewable Energy, which sources its energy from nature. A potential source of Renewable Energy, especially in Indonesia, is silica sand. This research uses a qualitative method aimed at analyzing the challenges in integrating silica sand as the main raw material in the production of solar panels as an environmentally friendly alternative energy to fossil fuels. It also outlines the future prospects of the silica sand industry, including its impact on regulations, industrial development, and social aspects, with a review of maqashid sharia, using fiqh bi'ah (environmental jurisprudence). The results of this research are expected to serve as a basis for decision-makers, create jobs, and improve the quality of life for the community. Thus, the researcher can conclude the cohesion and correlation between Green Economy, renewable energy, the silica sand industry, and Maqashid Syariah. The results of this research are expected to serve as a basis for decision-makers, create job opportunities, and improve the quality of life for the community.

Keywords: Green Economy, Renewable Energy, Silica Sand, Maqashid Sharia

Abstrak

Konsep Green Economy hadir untuk mengatasi dampak negatif timbulnya pencemaran bahkan kerusakan lingkungan yang disebabkan oleh meningkatnya aktivitas ekonomi masyarakat. Salah satu program dari Green Economy adalah Energi Baru Terbarukan. Contoh sumber Energi Baru Terbarukan yang berpotensial di Indonesia adalah pasir silika. Penelitian ini menggunakan metode kualitatif yang bertujuan untuk menganalisis tantangan dalam mengintegrasikan pasir silika sebagai bahan baku utama dalam produksi sel panel Surya sebagai energi alternatif ramah lingkungan terhadap energi fosil, serta menguraikan prospek industri pasir silika di masa depan, termasuk dampaknya terhadap regulasi, perkembangan industri, aspek sosial, dengan tinjauan maqashid syariah, menggunakan fikih bi'ah (lingkungan). Dengan demikian, peneliti dapat menyimpulkan adanya kohesi dan korelasi antara Green Economy, energi terbarukan, industri pasir silika dan Maqashid Syari'ah. Hasil penelitian ini diharapkan dapat menjadi dasar bagi pengambil keputusan, menciptakan lapangan kerja dan meningkatkan kualitas hidup masyarakat.

***Kata kunci**: Green Economy, Energi Terbarukan, Pasir Silika, Maqashid Syariah*

A. INTRODUCTION

Electrical infrastructure serves as a doundational determinant of macroeconomic productivity and structural development, directly mediating the efficiency of udstrial output.. One way to assess a country's economic growth is by examining its level of electricity consumption, as electricity consumption serves as an indicator of ongoing economic activities (Basri, 2014). Global economic growth and rising per capita income in a country drive higher demand for electrical equipment across small, medium, and large-scale industries (Shengfeng et al., 2013). Thus, the electricity sector is considered a leading sector in supporting the economy and national development (Hasyim, 2020), given that electricity is inseparable from modern life. Consequently, electricity consumption or usage continues to increase each year. Therefore, to achieve sustainable economic growth, it is essential to integrate the concept of a Green Economy with efforts to increase electricity consumption. This conceptual integration ensures that accelerated macroeconomic activities optimize societal welfare while avoiding ecological degradation, leveraging sustainable resource allocation and low-carbon technological innovations, such as renewable energy, we can achieve inclusive and environmentally sustainable economic growth.

Official metric published by the Minister of Energy and Mineral Resources (ESDM), indicate that Indonesia's per capita electricity consumption in 2023 reached 1,285 kWh, increasing from 1,173 kWh per capita in 2022 and 1,109 kWh per capita in 2021. The government has set a target of 1,408 kWh per capita for 2024 (Ministry of ESDM Press Release, 2024). Although electricity consumption in Indonesia has shown an upward trend over the past few decades, the national level of electricity consumption remains relatively low compared to other ASEAN countries (Hasyim, 2020).

The domestic power grid remains highly carbon-intensive, with fossil fuels (oil, coal, and natural gas), which account for approximately 61% of the energy mix (ESDM, 2023). This profound hydrocarbon dependency exposes the state to severe non-renewable resource depletion risks if extractive volumes continue unmitigated without strategic energy substitutions pathways. The extraction and combustion of fossil fuels cause various environmental problems, which are clearly inconsistent with the perspective of *maqāṣid al-sharī'ah* (the objectives of Islamic law), namely: *hifz al-nafs* (protection of life), *hifz al-'aql* (protection of intellect), *hifz al-māl* (protection of wealth),

hifz al-nasl (protection of progeny), and *hifz al-dīn* (protection of religion). Compounded by accelerating demographic growth projections, the looming supply-demand deficit threatens structural energy transitions, localized fuel crises and systemic shortage will become mathematically einveitable (Pramudiyanto & Suedy, 2020).

The growing scarcity of fossil fuels and the declining global supply of crude oil have drawn special attention to the search for alternative energy sources that do not harm the environment, such as renewable energy. As the use of fossil energy in household and industrial activities continues to rise alongside technological advancement, renewable energy is expected to reduce dependence on fossil fuels in the future. One of the renewable energy sources with the greatest potential is solar energy, which is obtained by harnessing sunlight. The mechanism involves converting solar radiation into electrical current with the assistance of semiconductor components. One of the most commonly used and widely available semiconductor components is silicon, which is produced by extracting it from silica sand.

Although Indonesia is rich in silica sand resources that can be found naturally, its utilization as a raw material for solar panels remains rare and limited. According to data from the Central Bureau of Statistics (BPS), silica sand in Indonesia has not yet been processed into silicon products, instead industrial utilization is restricted to low-value-added unit operations within glass manufacturing, chemical preservation and cement formulation. Consequently, the domestic extraction of silica sand must be optimized to accelerate the national solar energy transition. To address these structural gap, this study aims to: (1) Analyze the challenges faced in the implementation of renewable energy in Indonesia from the perspective of *maqāṣid al-sharīʻah*, (2) Examine the feasibility of utilizing silica sand as a raw material for the production of solar panel cells, along with its impact on economic growth and social welfare in Indonesia and (3) Elaborate on the future prospects of the silica sand industry, including its implications for regulation, industrial development, social aspects, and compliance with Sharia-compliant governance models.

B. RESEARCH METHODOLOGY

The research method employed in this study is a descriptive qualitative approach, which aims to describe and analyze targeted phenomena in depth. The investigation

relies primarily on a systematic, desk-based review of secondary data metrices, including institutional reports, peer-reviewed scientific literature, legislative documents, and official statistical datasets relevant to the research scope.. The collection of secondary data is conducted through a process of extraction, selection, and critical analysis of available literature from libraries, online databases, and archives of relevant institutions.

C. RESULT AND DISCUSSION

1. Issues in the Implementation of Renewable Energy (EBT) in Indonesia

Renewable energy integration has emerged as a cornerstone of multilateral climate discourse within prominent international forums such as the Conference of the Parties (COP28) and the G20 Summit. Indonesia is believed to have the capacity to drive the energy transition toward a sustainable green and clean economy. Indonesia possesses substantial structural capacity to catalyze this energy transition toward a sustainable, low-carbon economy. This paradigm shift is highly critical given that Indonesia as a developing nation with expansive renewable energy endowment, has formally committed to reducing greenhouse gas emissions in order to achieve net-zero emissions by 2060 (Nadhira, 2023). Therefore, Indonesia has received international support in meeting its emission reduction targets to accelerate the green energy transition. Renewable energy not only has positive environmental impacts but also contributes to economic growth. According to simulation modeling, the implementation of green economy principles could generate long-term economic benefits, such as an average GDP growth of 6.3% during the 2025–2045 period and the creation of 1.7 million new green jobs by 2045 (Egi Suarga et al., 2024).

The Ministry of Energy and Mineral Resources (ESDM) reported encouraging achievements in the renewable energy and energy conservation (EBTKE) subsector in 2023. These achievements demonstrate Indonesia's increasing commitment to realizing a sustainable energy transition. During a press conference on the 2023 performance of the EBT subsector, the Director General of EBTKE, Jisman P. Hutajulu, stated that the government remains committed to enhancing the utilization of renewable energy in order to achieve clean and sustainable energy. This effort represents a strategic move to reduce dependence on fossil fuels and preserve environmental sustainability (Directorate of EBTKE, 2023). This intervention constitutes a macro-level strategy

designed to decouple national development from volatile fossil fuel dependencies and preserve environmental homeostatic equilibrium. The implementation of renewable energy in Indonesia continues to be promoted by the government, given its significant potential to support human needs, particularly in providing electricity as a substitute for limited and non-renewable fossil energy sources.

With Indonesia's abundant renewable energy potential, the utilization of solar energy through solar power plants (PLTS) has grown rapidly. Solar energy is the fastest-growing renewable energy source (IRENA, 2021). The development of solar power plants in remote areas with limited electricity access, combined with community empowerment to generate electricity from sunlight, offers substantial advantages. These benefits have made solar energy an attractive alternative energy source for many countries worldwide, including the United States. In addition, other efforts to achieve renewable energy targets include the co-firing program. Biomass co-firing is considered a relatively quick and practical method to increase the share of renewable energy in the national energy mix. As of 2024, the co-firing program has been implemented in 52 coal-fired steam power plants (PLTU) (Denis, 2020). This program involves mixing biomass materials such as sawdust, palm kernel shells, and waste with coal as fuel for power plants. The President Director of PLN, Darmawan Prasodjo, explained that co-firing technology represents a breakthrough in Indonesia's energy transition, as it supports the provision of reliable and affordable electricity while also stimulating local economic development through biomass production (PLN, 2023).

Renewable energy not only offers breakthroughs in technology but also brings innovation to the Islamic economic sector. The implementation of collaborative waqf (Islamic endowment) is one of the new initiatives first practiced in Indonesia. Several start-ups and foundations have begun to implement energy waqf schemes. One example is a shared-electricity start-up operating under the Yayasan Wakaf Energi Nusantara, which aims to provide assistance and support to regions in Indonesia that still lack adequate access to electricity through solar power plant (PLTS) waqf schemes and productive waqf models (Yasmin, 2021).

In addition, the Masjid Istiqlal has also implemented an energy waqf initiative to meet its operational electricity needs. The collected waqf funds are allocated to finance solar panels used to supply electricity for the mosque's operations. Essentially, energy

waqf is part of productive waqf, aimed at supporting renewable energy development in alignment with the Sustainable Development Goals (SDGs) to mitigate the adverse impacts of climate change (Anam & Fauzi, 2021).

Despite the numerous positive benefits of renewable energy, its utilization is not without shortcomings and challenges. The implementation of renewable energy in Indonesia faces several challenges that can be examined from the perspective of *Maqasid al-Shariah*:

Table 1: Challenges and Implementation of Renewable Energy (EBT) from the Perspective of *Maqasid al-Shariah*

Number	**Challenge**	**Renewable Energy (EBT) as a Solution from a Maqasid Sharia Perspective**
1	Fossil fuel energy pollution remains dominant, resulting in negative impacts on public health	Renewable energy can reduce pollution and improve air quality, in line with *Maqasid Sharia* in preserving human health and safety (*hifz al-nafs*).
2	Lack of public awareness and support for renewable energy (EBT).	Renewable energy can help maintain environmental sustainability, in accordance with the principles of *Maqasid Sharia* in preserving ecological balance (*hifz al-bi'ah*).
3	High initial costs for renewable energy infrastructure.	Investment in renewable energy can reduce dependence on expensive and non-renewable fossil fuels, while supporting long-term economic stability, in line with *Maqasid Sharia* in protecting wealth (*hifz al-mal*).

2. Feasibility of Implementing Renewable Energy Using Silica Sand in Indonesia

The Government of Indonesia has committed to addressing climate change by maximizing electricity generation through renewable energy, particularly solar power. As a tropical country located along the equator, Indonesia has abundant solar energy potential. Most regions receive relatively stable and intense solar radiation, with an average daily radiation value of approximately 4 kWh/m^2 (Ab Kadir & Rafeeu, 2010). In solar energy systems, solar radiation is converted into electrical current using solar

panels made from semiconductor materials. One of the most commonly used and readily available semiconductor materials is silicon. However, silicon is rarely found in nature in its free form; rather, it is commonly present in the form of silica compounds (SiO_2) within quartz minerals (Tanggara & Kristiana, 2023).

Indonesia possesses abundant quartz sand resources. Based on the 2020 Balance Sheet of Mineral, Coal, and Geothermal Resources and Reserves issued by the Ministry of Energy and Mineral Resources, Indonesia has total quartz sand resources amounting to 2.1 billion tons and total reserves of 332 million tons (Ministry of ESDM, 2020). However, silica used as a raw material for solar panel production must have a purity level of 99.99%, which is only found in certain regions of Indonesia. Therefore, it can be concluded that the development of renewable energy using silica sand in Indonesia is feasible. Nevertheless, not all silica sand deposits in Indonesia are suitable for semiconductor energy materials due to variations in their characteristics (Tanggara & Kristiana, 2023).

In addition, the strategic drive toward establishing a domestic silica sand processing industry necessitates rigorous structural interventions, including the formulation of an industrial roadmap and value chain structure. Environmental sustainability must also be carefully considered, as environmental exploitation can harm local communities, especially future generations. Protecting the environment falls under *hifz al-nasl* (protection of progeny), which is part of *maqasid al-shariah*. This principle aligns with the legal maxim *La Dharar wa La Dhirar* (there should be neither harm nor reciprocating harm), which plays a significant role in Islamic legal development, particularly in preventing various forms of harm within society.

3. The Impact of Silica Sand Utilization on Economic Growth and Indonesian Society

Badan Pengkajian dan Penerapan Teknologi (BPPT) states that Indonesia possesses approximately 17 billion tons of silica sand potential. With reserves of this magnitude, Indonesia has the opportunity to become energy self-sufficient by developing a photovoltaic (PV) module industry, where the primary raw material—silica sand—is processed into silicon wafers. However, to date, there is no domestic industry in Indonesia capable of processing silica into solar-grade silicon wafers (Warsito, 2023). Most silica sand mining products are exported abroad, particularly to China. In 2023,

silica sand exports to China reached 2,007,560,000 kilograms, positioning Indonesia as one of the largest silica exporters in the world (World Integrated Trade Solution, 2023).

From an economic perspective, support for utility-scale PV development in Indonesia is becoming stronger. The declining prices of production equipment have reduced the Levelized Cost of Electricity (LCOE) for solar power plants (PLTS). Currently, the abundance of inexpensive domestic coal makes coal-fired power plants the most cost-effective option for large-scale electricity generation in Indonesia, with a cost of approximately $64/MWh. However, solar power is projected to become cheaper than coal in the near future (Institute for Essential Services Reform, 2021). The LCOE associated with newly built coal-fired power plants is expected to rise due to increasing financing costs. Meanwhile, the LCOE for utility-scale solar power in Indonesia currently ranges from $65–$137/MWh (in real 2020 dollars) and is projected to decline to $27–$48/MWh by 2030 due to cheaper equipment, lower development costs, and more attractive financing terms (Keyser, 2020).

The socio-economic impacts of utilizing silica sand for the PV industry are summarized in the following table:

Table 2: Socio Economic Impact of Silica Sand Industry

Number	Impact	Positive	Negative
1	Land use	- Reduces land usage compared to conventional energy industries. - Reutilizes degraded or damaged land.	- Decreasing land availability due to competition with the agricultural sector. - Vegetation degradation and soil erosion. - The development of the PV (photovoltaic) industry requires very high capital investment
2	Infrastructure	- Reduces electricity transmission network requirements. - Provides energy supply for off-grid areas (generally remote, frontier, and	Requires large-scale energy storage systems to ensure stable energy supply

		underdeveloped regions/3T areas) through decentralized systems, making PV suitable for developing countries such as Indonesia	
3	Politics	- Strengthens national energy independence from imports. - Reduces military spending by minimizing involvement in conflicts with oil-producing countries.	Requires the government to subsidize electricity generated from solar power plants (PLTS) and independent rooftop solar panel installations.
4	Energy Market	- Energy diversification. - Deregulation of the energy sector. - Reduces the national budget burden for solar technology imports.	Intermittency issues (interrupted or unstable energy supply).
5	Industry and research	- Creates significant employment opportunities. - Encourages research and studies in renewable energy fields. - Fosters collaboration with local SMEs around factory areas. Generally, PV factories in various countries source raw materials besides silica such as copper, aluminum, and glass from traditional mining and manufacturing	Health hazards and occupational risks during the production process.

		sectors (Dubey et al., 2023).	
6	Public and Marketing	- Builds awareness of environmental sustainability. - Enhances a positive public image. - Increases demand for rooftop solar installations in households and industries due to improved efficiency and lower prices when produced domestically.	High Market Education Costs

4. Future Direction and Contribution of Silica Sand

Silica sand (quartz) is projected to become a leading commodity in Indonesia. Many companies, including firms from China, have expressed interest in mining silica sand. According to data from the Ministry of Energy and Mineral Resources (ESDM), there are currently 328 corporate entities holding silica sand mining concessions in Indonesia. In the industrial sector, the share of silica sand utilization is already quite significant (Ministry of Industry, 2023). The Kementerian Perindustrian (Ministry of Industry) has stated that this commodity holds substantial potential to be developed as a raw material for semiconductor and solar cell industries, as the silica sand industry can increase added value and strengthen industrial self-reliance. The Ministry has confirmed that the downstream roadmap for silica sand has been completed and is currently being offered to investors. In a 2023 press conference, the Ministry also emphasized that silica is one of the oxide commodities with a crucial function in building the semiconductor industry. The domestic silica-based semiconductor industry has begun development and is progressing, with several potential sites under evaluation in Kalimantan (Afifah, 2023).

However, the development of the domestic semiconductor value chains remains severely constrained by structural deficits, primarily because Indonesia does not yet have an industry capable of processing silica into solar-grade silicon wafers. Establishing such

facilities is essential to promote and support national semiconductor industry independence. An expert staff member in the field of strengthening domestic industrial capacity emphasized that Indonesia needs to accelerate the development of intermediate industries through the downstream processing of silica into silicon wafers based on Solar Grade Silicon (SGS), which serves as the fundamental building block for semiconductor and solar cell industries. At present, no domestic industry processes silica into solar-grade silicon wafers (Media Indonesia, 2023).

The Silica/Quartz Downstream Policy Action Plan began this year with the drafting of the Roadmap for Silica Downstreaming into Silicon Wafers 2025–2035, aimed at achieving semiconductor industry self-sufficiency. In the coming year, the Kementerian Perindustrian will finalize the roadmap and subsequently issue a Ministerial Regulation concerning its implementation (Ministry of Industry, 2023). From the business perspective, the Chairman of the Indonesian Quartz Miners Association (HIPKI) noted that industry stakeholders have only been involved once in the roadmap drafting process through a focus group discussion facilitated by the Ministry of Investment/BKPM. Currently, the development direction remains at the stage of data and information gathering (Pro Indonesia, 2023).

To maximize macroeconomic and industrial value-added, Indonesia's silica sand industry is being directed toward downstream processing transforming raw materials into high-value products. The government encourages the development of silica into silicon wafers based on Solar Grade Silicon (SGS) and Electronic Grade Silicon (EGS). These silicon wafers are essential for semiconductor manufacturing and photovoltaic (PV) modules used in solar panels.

Beyond conventional economic paradigm, the silica sand industry intersects directly with Islamic economics, which is founded on principles of justice, shared prosperity, and sustainability. This can be achieved by ensuring that mining and processing activities do not harm the environment and provide equitable benefits to all stakeholders. Furthermore, investment in this sector can be conducted through Sharia-compliant financing schemes that avoid riba (interest) and excessive speculation, while ensuring fair profit-sharing based on each party's contribution. For example, under a *mudharabah* (profit-sharing) scheme, the investor (capital provider) supplies the capital, while the manager (*mudharib*) operates the silica sand mining business. Profits are

distributed according to a pre-agreed ratio. In the event of losses, the investor bears the financial loss unless it results from the manager's negligence or misconduct. Alternatively, a *musyarakah* (partnership) scheme may be applied, in which two or more parties contribute capital to the mining venture, and profits and losses are shared proportionally according to their respective capital contributions.

With an appropriate strategic approach, Indonesia's silica sand industry has strong potential to grow rapidly and generate significant economic benefits, both within the framework of the conventional economy and Islamic economics.

5. Implications in Terms of Regulation, Industry, Social Aspects, and Sharia Compliance

Indonesia must gradually reduce its dependence on fossil energy and accelerate the adoption of new and renewable energy alternatives. The Government's Energy Transition agenda toward achieving Net-Zero Emission by 2060 places particular emphasis on solar energy. However, the current installed capacity of Solar Power Plants (PLTS) in Indonesia has only reached approximately 450 MegaWatt (MW), a metric significantly lagging behing the 2025 target of around 6,500 MW. Therefore, coordinated cross-stakeholder policies are required to ensure that the vast solar potential of this tropical country can be optimally utilized, including strong industrial support (Forestinsight, 2024).

The first stage that must be addressed concerns supportive regulation to ensure that investment in solar power development is financially viable. However, the regulations governing PLTS appear to remain fragmented and insufficiently integrated to benefit all stakeholders. For instance, regulations on rooftop solar systems have changed three times between 2018 and 2024. The government shifted its focus for rooftop solar (PLTS Atap) development from the household sector to the industrial sector through a new regulation (Ministerial Regulation of ESDM No. 2/2024). This policy recalibration wasprimarily driven by assessments identifying the previous net-metering scheme was considered uneconomical and burdensome to state finances. One of the impacts of the new regulation is the potential loss of customers in the residential sector. Consequently, this new rooftop solar regulation requires attention from Commission VII of the House of Representatives (DPR RI). In its supervisory role, Commission VII should encourage the government to ensure that the new regulation attracts consumer interest and supports

the achievement of the renewable energy mix target of 23% by 2025. It should also advocate for transparent quota allocation and sufficient capacity to meet the national rooftop solar target of 3.6 GW by 2025 (Hilma Meilani, 2024).

The second critical stage concerns the upstream–downstream industrial development of the solar power sector. Development begins in downstream Engineering, Procurement, and Construction (EPC) operations with the capability to construct solar power plants, followed by upstream development such as the manufacturing of solar modules and panels. However, more upstream industrial stagessuch as crystalline silicon solar cell manufacturing, silicon crystal ingot production, silicon wafer fabrication, and silicon purification industries are not yet fully mastered by Indonesia. This is paradoxical, considering that silica sand (SiO_2), the raw material for silicon, is abundantly available in Indonesia (Forestinsight, 2024).

The third stage involves socio-economics and sub-national fiscal dynamics. Silica sand is a mining commodity that contributes to regional revenue (PAD), as its taxation authority falls under regional governments based on Law No. 28 of 2009 concerning Regional Taxes and Levies. Therefore, the development of solar modules and panels must be carried out systematically and with strict regulatory planning to avoid business uncertainty for entrepreneurs and local communities, which could otherwise hinder regional development trajectory (Julian, 2023).

The fourth stage relates to Sharia compliance. Progress toward advancement inevitably generates new challenges, particularly in the field of renewable energy economics. Yusuf al-Qaradawi stated that “Societal conditions continuously change and evolve, and Islamic law remains applicable at all times and places in determining rulings for human affairs; especially in modern times, *ijtihad* (independent legal reasoning) is more needed than in previous eras.” Therefore, to address emerging issues, one of the principles of *usul al-fiqh* (principles of Islamic jurisprudence) can be applied, namely *al-maslahah al-mursalah* (consideration of unrestricted public interest), which serves as a means to establish rulings related to human welfare based on the principle of attaining benefits and preventing harm (Misran, 2020). Within this hierarchy, the concept of *maslahah al-daruriyah* (essential public interest) dictates that industrial policies must protect fundamental human needs such as the creation of employment opportunities for local communities, enabling them to meet their basic needs and prevent hunger.

6. Recommendations for the Government, Industry, and Society

The largest customers of photovoltaic (PV) installations in Indonesia are still dominated by middle- to upper-income households with electricity capacities above 2,200 VA. This is mainly due to the high installation costs of solar power systems, which are generally affordable only to a limited segment of society. It can therefore be concluded that the implementation of solar power plants (PLTS) in Indonesia has not yet been evenly distributed. In fact, solar power development should prioritize the 3T regions (frontier, outermost, and underdeveloped areas), where electrification ratios remain the lowest, such as Highland Papua (93.70%), Central Papua (94.14%), and East Nusa Tenggara (94.89%), by implementing off-grid PLTS systems (ESDM, 2023).

One of the main obstacles to the equitable implementation of PLTS in Indonesia is the high production and installation costs of solar panels, which are typically paid upfront. These high costs are not only due to Indonesia's lack of self-sufficiency in producing PV modules, solar cells, and other components, but also because the silica sand purification process requires specialized and advanced technology (Hanawindy, 2023).

The following are the components of a solar power system (PLTS) and their characteristics to assess Indonesia's readiness in developing an independent solar panel industry:

Table 3: Indonesia's Readiness in Developing Solar Panel Industry

Component	Function	source
Solar Module	Converts sunlight into direct current (DC) electricity.	Semi-finished imports. Domestic industries are capable of assembling them into PV modules for sale under local brands.
Battery	Stores electricity in DC form. Electricity generated by solar power systems (PLTS) is produced during daylight hours, while electricity usage typically occurs at night when there is no sunlight; therefore, storage is required.	Imported as finished products. Some brands import semi-finished components and assemble them into batteries domestically, but they still retain foreign brand names.
Solar Charge Controller	Regulates:	Imported as finished products.

	1. The charging of electricity from the solar module to the battery; and 2. The discharge of electricity from the battery to electrical devices, to prevent overcharging or excessive usage. Uncontrolled charging and discharging can damage the battery.	
Inverter	Converts DC electricity from the battery into alternating current (AC), enabling it to power electronic devices.	Imported as finished products.

Upon reviewing the table above, Indonesia still faces significant challenges in achieving national energy self-sufficiency, particularly in the production phase of PV modules and their components, which are still largely imported from Europe and China. The government has actually planned to halt silica sand exports and promote downstream processing of silica into PV modules. One of its initiatives involves cooperation with China to develop Rempang Eco City in Batam as a pilot project for renewable energy implementation and silica sand industrial development.

However, this National Strategic Project has generated considerable controversy due to plans to relocate approximately 7,500 residents of Rempang, as the project will occupy around 45% of the island's total land area. Local residents are concerned about losing their livelihoods as fishermen because they would be relocated from coastal areas to inland regions (Rois, 2024). The researcher recommends that the government pursue a diplomatic and participatory approach to communicate and coordinate the project with local communities, as forced evictions cannot be justified even under the pretext of development or national economic interests. The government must consider human rights, which in *maqasid al-shariah* are referred to as *hifz al-mal* (protection of

wealth/property) at the level of *daruriyyat* (essential necessity—if violated, the very existence of property would be threatened).

Below are several recommendations for the Government, industry, and society in implementing the silica sand industry to support the renewable energy transition:

Table 4: Recommendation in Implementing Silica Sand as Renewable Energy Resources

Target	Recommendations
	- The government needs to develop policies that support the silica sand processing industry and PV module production, including tax incentives, subsidies, and financial support for research and development. - Implement strict regulations to ensure that silica sand mining and PV module production processes are environmentally friendly. - Invest in infrastructure and workforce training to ensure the availability of skilled human resources in this industry. - Fund research and development related to renewable energy in Indonesia, particularly solar energy. - The government should not immediately impose a total ban on silica sand exports but instead implement restrictions gradually. - Strengthen regulations to ensure that renewable energy development projects, especially solar power plants (PLTS), do not harm local communities. - Provide subsidies to households or industries that wish to install solar power systems (PLTS), considering the high upfront installation costs, even though long-term energy supply costs are cheaper than conventional energy.
Industry	- Collaborate with institutions and renewable energy researchers. - Integrate and cooperate with local miners and craftsmen, particularly for raw materials and PV production equipment. - Implement sustainable production practices to reduce environmental impacts and improve energy efficiency in the

	production process. Renewable energy production should not result in excessive carbon emissions. - Actively participate in raising public awareness and education to encourage the transition to renewable energy. - Conduct silica sand purification. This process aims to remove metal content and other contaminants to prevent solar panel degradation and improve energy efficiency.
Communities	- Support government policies that promote renewable energy and advocate for stricter regulations on environmentally damaging industries. - Encourage community participation in renewable energy projects, including community-based programs that support PV module installations

D. CONCLUSION

The progressive depletion of fossil fuels and the decreasing global supply of crude oil have drawn serious attention to the need for alternative and more environmentally friendly energy sources, such as renewable energy (EBT). One of the renewable energy sources with significant potential in Indonesia is solar energy, with silica sand serving as a primary raw material. This study successfully synthesizes the structural challenges, technical feasibility, and long-term macro prospect of the domestic silica industry through the perspective of *maqasid al-shari'ah* (objectives of Islamic law). However, the findings reveals several obstacles remain, including the need for more integrated industrial regulations and the high investment costs associated with manufacturing solar panel cells. Therefore, this study contributes to several sectors, particularly the silica sand industry, from a *maqasid al-shari'ah* perspective, which emphasizes principles of justice and environmental sustainability by applying *fiqh al-bi'ah* (Islamic environmental jurisprudence). There are four stages of implications in the implementation of renewable energy. First, supportive macro-level regulatory consolidations is required to ensure that investment security and financial viability in solar power plant (PTS) infrastructure..

Second, industrial policy must actively incentivize the development of the upstream–downstream stages of the solar power industry. Third, socioeconomics parametersmust be carefully managed to align extractive activities with sub-national fiscal requirements and local community welfare. Fourth, the overarching developmental framework must maintain strict alignment with Sharia governance principles, balancing technological modernization with ethical resource management.

REFERENCES

Ali, A., Radulescu, M., & Balsalobre-Lorente, D. (2023). A dynamic relationship between renewable and nonrenewable energy consumption, economic growth, and carbon dioxide emissions: Evidence from Asian emerging economies. *Energy & Environment, 34*(8), 3529–3552.

Ambarsari, D. C., Nachrowi, D. N., Hartono, D., & Widyawati, D. (2022). Between insufficiency and efficiency: Unraveling households' electricity usage characteristics of urban and rural Indonesia. *Energy for Sustainable Development, 69*, 103–117.

Anam, S., & Fauzi, R. A. (2021). Wakaf dan energi terbarukan: Analisis potensi wakaf energi dalam mengurangi dampak perubahan iklim. *Al-Waqf, 14*(2), 123–138.

Anggito, A., & Setiawan, J. (2018). *Metodologi penelitian kualitatif*. Sukabumi: CV Jejak.

Bimanatya, T. E., & Widodo, T. (2018). Fossil fuels consumption, carbon emissions, and economic growth in Indonesia. *International Journal of Energy Economics and Policy, 8*(4), 90–97.

Damayanti, A. (2023, February 6). 2 perusahaan China lirik tambang pasir silika di RI, buat bahan baku kaca. *Detik Finance*. Retrieved from https://finance.detik.com/energi/d-6554837

Dewi, R. (2023). *Energi terbarukan: Pemanfaatan energi terbarukan sebagai energi alternatif yang berkelanjutan dan ramah lingkungan*. Jakarta: Rajawali Press.

Forest Insight. (2024, March 24). Pemanfaatan PLTS di Indonesia perlu dukungan regulasi yang terintegrasi. Retrieved from https://forestinsights.id

Giriantari, I. A. D., Kumara, I. N. S., & Lestari, N. M. N. (2021). Review status panel surya di Indonesia menuju realisasi kapasitas PLTS nasional 6500 MW. *Jurnal Spektrum, 8*, 27.

Gokhale-Welch, C., Darghouth, N., McCall, J., Aznar, A., & Keyser, D. (2020). Distributed photovoltaic economic impact analysis in Indonesia.

Halimatussadiah, A., Kruger, W., Wagner, F., Afifi, F. A. R., Lufti, R. E. G., & Kitzing, L. (2024). The country of perpetual potential: Why is it so difficult to procure renewable energy in Indonesia? *Renewable and Sustainable Energy Reviews, 201*.

Hanawindy, A.S., & Mawardi, M. (2023). Ekstraksi Silika (SiO2) dari Mineral Tanah Napa Pesisir Selatan. *Jurnal Periodic Jurusan Kimia UNP*.

Hasyim, I. (2020). *Arah bisnis energi*. Jakarta: Kompas.

Humas EBTKE. (2024, January 18). Kinerja subsektor EBTKE 2023 dan program 2024. Retrieved from https://ebtke.esdm.go.id

Istiani, M., & Purwanto, M. R. (2022). Fiqh bi'ah dalam perspektif al-Qur'an. *At-Thullab Jurnal, 1*(1), 24–29.

Jadhav, N. Y., Dubey, S., & Zakirova, B. (2013). Socio-economic and environmental impacts of silicon-based photovoltaic technologies. *Energy Procedia, 33*, 322–334.

Jauhari, W. (2018). Kaidah fikih adh-dhararu yuzal.

Jelita, N. (2023, September 16). Kemenperin dorong pengembangan hilirisasi komoditas silika bahan baku panel surya. *Media Indonesia*. Retrieved from https://mediaindonesia.com

Julian, M. (2023, September 10). Dukung hilirisasi pasir silika, ini catatan HIPKI untuk Indonesia. *Kontan*. Retrieved from https://kontan.co.id

Kementerian Energi dan Sumber Daya Mineral Republik Indonesia. (2019). *Indonesia energy outlook 2019*. Retrieved from https://www.esdm.go.id/id/publikasi/indonesia-energy-outlook

Kementerian Perindustrian RI. (2023, September 16). Kemenperin dorong hilirisasi silika untuk pengembangan industri semikonduktor. Retrieved from https://kemenperin.go.id

Klass, D. L. (2004). *Biomass for renewable energy and fuels* (Vol. 1). Elsevier.

Langer, J., Quist, J., & Blok, K. (2021). Review of renewable energy potentials in Indonesia and their contribution to a 100% renewable electricity system. *Energies, 14*(21), 7033.

Makmun. (2020). Green economy: Konsep, implementasi, dan peranan Kementerian Keuangan. *Jurnal Ekonomi, 1*(1).

Meilani, H. (2023, March 24). Kendala pengembangan PLTS atap. Retrieved from https://dpr.go.id

Mulvaney, D., & Bazilian, M. (2023). Price volatility, human rights, and decarbonization challenges in global solar supply chains. *Energy Research & Social Science, 102*.

Nurdifa, A. R. (2023, December 30). Kemenperin dorong hilirisasi silika buka penawaran investasi lokal asing. *Bisnis.com*. Retrieved from https://ekonomi.bisnis.com

Oktarina, Y., Risma, P., Yudha, H. M., & Dewi, T. (2018). Life cycle analysis for the feasibility of photovoltaic system application in Indonesia. *IOP Conference Series: Earth and Environmental Science, 124*, 012005.

Pramudiyanto, A. S., & Suedy, S. W. A. (2020). Energi bersih dan ramah lingkungan dari biomassa untuk mengurangi efek gas rumah kaca dan perubahan iklim yang ekstrim. *Jurnal Energi Baru dan Terbarukan, 1*, 86–99.

Rahman, A., et al. (2023). Pathways to reduce Indonesia's dependence on oil and achieve longer-term decarbonization. *Renewable Energy, 202*, 1305–1323.

Repno. (2023, July 16). Lewat co-firing 40 PLTU PLN grup mampu turunkan emisi hingga 429 ribu ton. Retrieved from https://jabarprov.go.id

Rois, C., Jannani, N., & Mufid, M. H. (2024). Islamic law paradigm responding conflicts of interest of economic development and ecological conservation: Hifdz al-Bi'ah perspective. *Al-Istinbath: Jurnal Hukum Islam, 9*(1), 193–210.

Sambodo, M. T., Silalahi, M., & Firdaus, N. (2024). Investigating technology development in the energy sector and its implications for Indonesia. *Heliyon, 10*(6).

Septyaningsing, L. (2023, September 17). Kembangkan industri semikonduktor, pemerintah dorong hilirisasi silika. *Republika*. Retrieved from https://republika.co.id

Sugiyono. (2017). *Metode penelitian kualitatif, kuantitatif, dan R&D*. Bandung: CV Alfabeta.

Sullivan, W. A., & Christian Teo Purwono & Partners. (2013). *Mining law and regulatory practice in Indonesia: A primary reference source*. Wiley.

Sutiawan, D. E. J., Notosudjono, D., Rijadi, B. B., & Yamato. (2024). Analisis teknis dan ekonomi pembangkit listrik tenaga surya atap berbasis PVsyst. *Journal of Electrical Engineering and Computer, 6*(1), 110–119.

Tarigan, E. (2023). Financial analysis of solar rooftop PV system: Case study in Indonesia. *International Journal of Energy Economics and Policy, 13*(3).

Wen, D., Gao, W., Qian, F., Gu, Q., & Ren, J. (2021). Development of solar photovoltaic industry and market in China, Germany, Japan and the United States using incentive policies. *Energy Exploration & Exploitation, 39*.

Wiloso, E. I., et al. (2024). Indonesia's contribution to global carbon flows: Which sectors are most responsible for the emissions embodied in trade? *Sustainable Production and Consumption, 48*, 157–168.

Windarta, J., & Kadang, J. M. (2021). Optimasi sosial-ekonomi pada pemanfaatan PLTS PV untuk energi berkelanjutan di Indonesia. *Jurnal Energi Baru dan Terbarukan, 2*, 74–83.