JURNAL BALI MEMBANGUN BALI
Volume 5 Nomor 2, Agustus 2024
e-ISSN 2722-2462, p-ISSN 2722-2454
DOI 10.51172/jbmb
http://ejournal.baliprov.go.id/index.php/jbmb

New Renewable Energy for Bali Tourist Destination: Potential and Challenges

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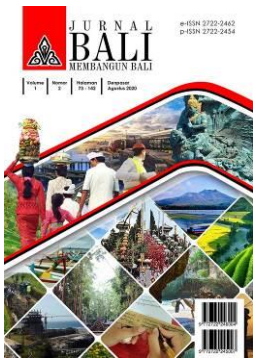

Sejarah Artikel

Diterima pada
23 Juni 2024

Direvisi pada
26 Juni 2024

Disetujui pada
27 Juni 2024

Abstract
Purpose: This research aims to explore potential and challenges of new renewable energy in Bali, which is a popular international tourist destination.
Research methods: The research is based on several existing sources, both from daily news and existing articles regarding several renewable energy potentials in Bali. Almost all of the data is secondary data obtained from various agencies in Bali. The data are analyzed using qualitative analysis technique.
Results and discussion: Economic growth and the very rapid number of tourist visits to Bali are driving problems in the energy sector. The potential for developing new renewable energy in Bali is very large, such as sunlight, wind and geothermal resources. In this case there are several challenges such as limited land, electricity grid integration, technology and costs, permits and regulations, public awareness, and the influence of weather.
Implications: Collaboration between government, private sector, and society is needed to find the right solution. There is a need for a comprehensive action plan and appropriate policy support to accelerate the transition to renewable energy in Bali as an international tourist destination.

Keywords: Tourist destination, new renewable energy, potential, challenge.

Abstrak
Tujuan: Penelitian ini bertujuan untuk mengeksplorasi potensi dan tantangan energi baru terbarukan di Bali yang merupakan tujuan wisata internasional yang populer.
Metode penelitian: Penelitian didasarkan pada beberapa sumber yang ada, baik dari berita harian maupun artikel yang ada mengenai beberapa potensi energi terbarukan di Bali. Hampir seluruh datanya merupakan data sekunder yang diperoleh dari berbagai instansi di Bali. Data dianalisis dengan menggunakan teknik analisis kualitatif.
Hasil dan pembahasan: Pertumbuhan ekonomi dan sangat pesatnya jumlah kunjungan wisatawan ke Bali menjadi pendorong permasalahan di bidang energi. Potensi pengembangan energi baru terbarukan di Bali sangat besar, seperti sumber daya sinar matahari, angin, dan panas bumi. Dalam hal ini terdapat beberapa tantangan seperti keterbatasan lahan, integrasi jaringan listrik, teknologi dan biaya, perizinan dan peraturan, kesadaran masyarakat, dan pengaruh cuaca.
Implikasi: Diperlukan kolaborasi antara pemerintah, swasta, dan masyarakat untuk mencari solusi yang tepat. Perlu adanya rencana aksi yang komprehensif dan dukungan kebijakan yang tepat untuk mempercepat transisi menuju energi terbarukan di Bali sebagai destinasi wisata internasional.

Kata kunci: destinasi wisata, energi baru terbarukan, potensi, tantangan.

INTRODUCTION

With its extraordinary artistic and cultural wealth (Kusuma et al., 2023; Wulan & Karja, 2023), Bali is one of the world's famous tourism destinations. However, this destination has unique challenges in meeting ever-increasing energy needs. Rapid economic growth and a high number of tourist visits have driven demand for electrical energy on this island. However, limited natural resources and the environmental impact of the use of fossil fuels have encouraged Bali to look for more sustainable and environmentally friendly alternatives in building its future (Dibya, 2020).

The potential for developing new and renewable energy in Bali is very large. This island has abundant natural resources such as sunlight, wind and geothermal resources. The sun shines all year round in Bali, making it an ideal place to harness solar energy. Winds blowing along coastlines also offer significant wind energy development potential. Apart from that, Bali is also known to have potential geothermal resources which can be utilized to produce electrical energy.

According to IESR (Institute for Essential Service Reform) News (https://iesr.or.id/mebayar-peluang-dan-tantangan-transisi-energi-di-region): (1) The potential for energy independence in these villages, from a business perspective, is not good because the scale is relatively small for a business scale, but if we don't make examples such as installing 20 kWp PLTS for 8 MSMEs in Jepara, off grid PLTS for water pumps, or according to Ganjar, "A PLTMH with a capacity of 15 kWp that electrifies 75 families, by truly utilizing the potential that exists locally, will not be implemented, so we need the courage to change" (IESR, March 2022). (2) Ida Ayu Giriantari, Special Staff to the Governor of Bali, stated that the people, especially the Balinese people, have quite high awareness of protecting the environment and switching to more environmentally friendly energy sources (https://iesr.or.id/mebayar-peluang-dan-energy-transition-challenges-in-the-region). (3) Clean energy has been the cornerstone of Bali's life and development vision for a long time and is stated in Pergub 45/2019, when the central government made a national clean energy policy, we felt there was support from the central government (https://iesr.or.id/mebayar-opportunities-and-challenges-of-energy-transition-in-the-region). (4) In March 2022, the Governor of Bali issued a circular calling on government offices and tourism buildings to install rooftop PLTS. This is partly to achieve Bali's target of achieving carbon neutral status by 2045 (https://iesr.or.id/mebayar-peluang-dan-tantangan-transisi-energi-di-region). (5) With the cooperation of all stakeholders and the community Ida Ayu Giriantari, Ida Ayu Giriantari, is optimistic that they can achieve Bali Net Zero Emission 2045.

The development of renewable energy in Bali will not only help meet increasing energy needs, but will also have various other benefits. The use of renewable energy will reduce Bali's dependence on imported fossil fuels and reduce greenhouse gas emissions that contribute to climate change. Additionally, it will also create new investment opportunities, encourage technological innovation and create jobs in the renewable energy sector. However, there are several challenges that need to be overcome in developing Bali through renewable energy. One of the main challenges is the limited availability of land on this island. Limited physical space can be an obstacle in developing renewable energy projects, especially for solar and wind power installations that require large areas of land. Additionally, existing power grid infrastructure may require upgrades to accommodate the integration of renewable energy. Apart from technical challenges, financial and regulatory aspects also need to be considered. Investment in the development of renewable energy infrastructure requires large funds, and clear policies and incentives from the government will be key to driving the growth of this sector. Increasing capacity and training of the workforce is also important so that the renewable energy industry can develop optimally.

With increasing awareness of the importance of sustainability and environmental protection, Bali has taken steps towards developing renewable energy. Through its potential and by overcoming existing challenges, Bali has the opportunity to build a better and more sustainable future through renewable energy. With this opportunity, why hasn't much new renewable energy been developed in Bali? Against this background, the researchers are trying to discuss "developing Bali through new renewable energy: potential and challenges". In this research, what will be discussed includes: (1) What potential renewable energy resources the island of Bali has and how their use can help meet the increasing need for electrical energy. (2) What are the main challenges in developing renewable energy in Bali, especially related to limited land availability and integration with existing electricity network infrastructure.

RESEARCH METHODS

This research is a qualitative research which consists of descriptions from several existing sources, both from daily news and existing articles. To clarify the description and discussion, data is needed about several renewable energy potentials in Bali. In developing Bali in the field of renewable energy in Bali, especially in the form of electrical energy, it is necessary to know data on the potential of available energy sources.

In this research, almost all of the data is secondary data obtained from various agencies in Bali, namely formulating a sustainable action plan which includes concrete

steps in developing Bali through renewable energy and compiling performance indicators to measure the success of implementing the action plan and conducting regular evaluations.

RESULTS AND DISCUSSION

Potential Renewable Energy Sources Possessed by Bali and Their Utilization

(1) Water energy potential

Bali has quite a lot of hydropower potential but cannot produce large capacity, because in Bali there are no large rivers like in Kalimantan or Sumatera. However, in Bali there are also quite a lot of water energy sources in relatively small capacities and scattered (Rahmawati et al., 2022). Likewise, there are several water dams such as the Palasari Dam, Telaga Tunjung Dam, Tamblang Dam, and several dams that are still in the planning stage such as the Sidan Dam. The dam is mainly used to store water to meet agricultural irrigation water needs, but the water flow has untapped hydropower potential. For example, at the Tamblang Dam in Singaraja, under normal conditions the dam will flow water. If the flow capacity is 450 m3/sec at a head of 60 meters, this means that this dam has a hydropower potential of 27 kW (0.27 MW).

Furthermore, the untapped hydropower potential is the hydropower in the Ayung River which is estimated to have a hydropower potential of 43.90 MW and the Tukad Unda River which is estimated at 32.30 MW (Bali Energy Profile, 2005), as well as many other sources of the waterfall flow in Bali. Even though the capacity is small, if the potential of water energy sources is utilized optimally, it will certainly contribute significantly to meeting Bali's energy needs.

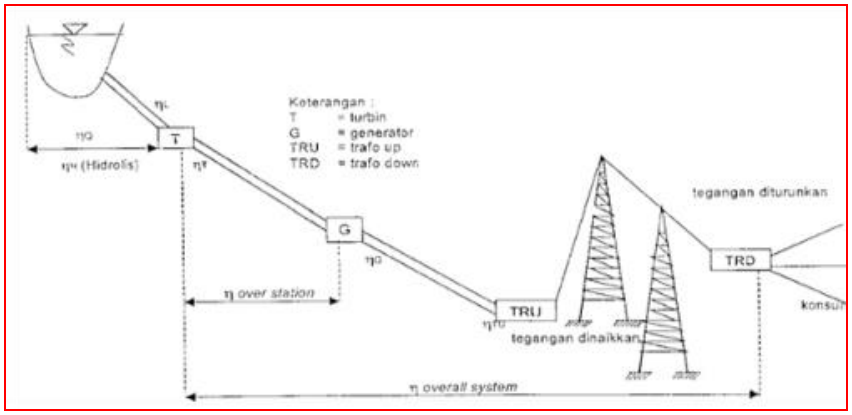

Figure 1. Tamblang dam water flow
[Source: Yasa, 2023]

(2) Wind energy potential

Wind potential in Indonesia is generally small because wind speeds are generally low, namely between 3-5 m/sec. But in several areas in the eastern region the wind is more than 5 m/sec. The current installed capacity of wind power plants is still relatively small compared to the existing potential (Andiyantama et al., 2021).

Figure 2. Windmills on Nusa Penida
[Source: https://kabar24.bisnis.com/read/20140622/78/237821/berfunction-setahun-pembangkit-listrik-nusa-penida-seputar-rp25-miliar-mangkrak]

The wind speed is low, namely around 3.4 meters/second. The areas with good wind speed are Nusa Penida, Klungkung, and Seraya, Karangasem which have greater wind energy potential, namely with an average wind speed of 4.8 m/second. dt. This means that it is only possible to build small-scale wind/wind power plants (PLTB), not to mention that the wind does not blow at all times. Currently a PLTB has been built with installed power (2 x 80 kW), which is designed for a maximum wind speed of 12.5 meters/second (Hasibuan et al., 2023).

The power generated from a windmill is proportional to the density of the air mass which varies with height and air temperature, proportional to the swept area of the windmill blades which means it is also proportional to the radius of the windmill, and directly proportional to the cube of the wind speed. So if the wind speed, Va = 4.8 m/s, mass density, ρ = 1.2 kg/m3, gravitational acceleration g = 9.8 N/s2, and efficiency cp = 55%, then the shaft power produced by the wheel wind is:P_s = Cp x 1/2 x ρ x A V_a^3. So, P_s = 0,55 x 1/2 x 1,2 (kg/m^3) x $4,8^3$ (m/dt)^3 = 36,495 Watt/ m^2. Meanwhile, if the wind speed is 12.5 m/s, then: Ps = 0.55 x ½ x 1.2 (kg/m3) x 12.53 (m/s)3 = 644.5 Watts/m2. To produce 80 kW, the windmill's sweeping area is around 124 m2, which means the wheel's diameter is 12.5 meters. Wind energy in Bali is considered less reliable, apart from the fact that the wind speed is low, it is also not continuous or fluctuates greatly.

(3) Solar energy potential

Remote residential areas are difficult to connect to the PLN electricity network, so in these areas electricity generation from other alternatives is needed, especially those sourced from renewable energy such as Solar Power Plants (PLTS). It is estimated that the Solar Home System could be an alternative solution as an electricity provider in remote villages (Ridwan et al., 2021). As a tropical area. Bali has high solar energy potential. This can be seen from the daily radiation, which is 4.8 kWh/m2/day. If only solar cells could be produced in Indonesia so that the price could be cheap, then the use of solar energy for electricity generation in Bali would be very possible. But solar cells (photovoltaic cells) are still very expensive and the best efficiency currently available is only 17%, not including the efficiency of other supporting components.

The intensity and duration of electrical radiation in Bali, as an example, is taken from BMG data at station 511014.

Table 1. Intensity and duration of exposure
[Source: MKG at station 511014]

Month	Intensity (kwh/m^2/ari)	Sunshine duration (%)
January	2.04	**30.30**
February	1.85	**47.04**
March	1.82	**30.38**
April	2.04	**37.42**
May	2.08	**47.28**
June	1.95	**36.72**
July	1.94	**48.62**
August	2.20	**47.00**
September	2.34	**48.48**
October	2.73	**44.58**
November	1.78	**35.90**
December	1.74	**34.80**
Average	2.04	**40.71**
Minimum	1.74	**30.30**
Maximum	**2.73**	**48.62**

The daily average solar radiation is Is = 2.04 kWh/m2/day. Average duration of sunlight per day, Ts = 40.71% x 24 hours = 9.77 hours/day Solar Module Efficiency, □ = 11.9% (according to specifications installed in Bali). So the power generated by PLTS is: Pm = (2.04 kWh/ m2/day) / (9.77 hours/day) x (11.9%) = 25 Watt / m2

_solar_panel. So to produce 1 MW of electrical power you will need solar panels as large as: = (1,000,000 Watts) / (25 Watts/ m2) = 40,000 m2 _solar_panels.

So a very large solar panel is needed to generate electrical power, this is because the efficiency of solar panels is still very low and currently it is still being researched and developed to obtain higher efficiency. Besides that, the price of solar panels is still quite expensive (Suripto, 2021).

(4) Geothermal energy potential

Geothermal energy is a natural source of heat in the layers of the earth that arises from heat released from within the earth's core as a result of tectonic earthquakes which cause friction in the structure of the layers of the earth's crust which collide with each other (Elvira, 2022). Geothermal heat comes from the combustion of a mixture of dust and gas that was four billion years old. In the earth's core, at a depth of around 6,000 km, the temperature can reach 5,000ºC. Heat constantly flows from the interior of the earth to the hydrothermal surface, magma, dry hot rocks, and geopressured resulting from the concentration of geothermal energy in certain areas below the earth's surface.

Figure 3. Geothermal potential of Bedugul
[Source: Elvira, 2022]

In Bali there is geothermal potential, namely in Bedugul-Tabanan as seen in Figure 3, with an area of around 80 km2, which is estimated to be able to supply around 80 MWe of energy for 30 years with energy equivalent to 10 MW/km2. The results of research and studies by the Ministry of Mining, Energy and Natural Resources of the Republic of Indonesia since 1976, which were repeated again in 1979, show that the Bedugul area and its surroundings contain geothermal potential

that produces 400 MW of electricity. From the Batukaru protected forest area, it was planned to supply 10 MW in 2006, then 55 MW each in 2008, 2009 and 2010. However, due to the economic crisis in 1997, the project was postponed and finally received rejection from the Balinese people, even though previously it had been Drilling was carried out and the results of the tests that were carried out showed that one of the wells could produce up to 56 tonnes/hour of steam and water with an enthalpy of 1744 kJ/kg.

(5) Biomass energy potential (waste)

There are many different types of biomass, which are basically the result/production of living things. Biomass can come from plantation or agricultural plants, forests, livestock or even waste. For special purposes, the use of biomass is a very promising solution to waste problems in big cities. Utilizing waste as biomass into electrical power through a direct combustion process or through a methane gas production process (gasification) (Aldi, n.d.) could be a solution, although this project is more expensive than other power generation projects for the same capacity. There is also hope of utilizing waste, considering that in Bali the volume of waste per day is quite large. It seems that power generation using waste as an energy source will soon become a reality. Based on waste management considerations, the Sarbagita region (Denpasar, Badung, Gianyar and Tabanan) has established a centralized regional waste processing system with an Integrated Waste Processing Plant (IPST/Instalasi Pengolahan Sampah Terpadu) using GALFAD (Gassification, Landfill Gas, Anaerobic Diggestion) technology. The result of this process is biogas which is put into the gas treatment to be used as fuel to drive the gas turbine. The amount of electricity produced is 10 MW for every 400 tons of waste. Besides that, 10% -15% compost will be produced from the waste. For Sarbagita, the waste produced is around 3,000 m3 or equivalent

1,000 tons per day will produce around 25-30 MW of electrical energy. With this technology, apart from producing electricity, it also provides other benefits, namely that the waste problem is handled well and produces compost.

Main Challenges in Renewable Energy Development in Bali

In this research, several challenges in developing new renewable energy can be described, including (https://www.google.com/search?q=tantangan+development+new+renewable+energy+in+bali): (1) Limited Land: Bali has a limited area, especially on the island which has many tourist areas and dense settlements. The development of renewable energy such

as solar and wind power plants requires large areas of land. Limited land can make it difficult to optimally place and develop renewable energy projects, so finding suitable land and getting permits from various parties can be a challenge. (2) Electricity Network Integration Challenges: The electricity network system in Bali is built based on conventional energy needs. Integrating renewable energy with existing electricity grid infrastructure requires adjustments so that electricity from renewable sources can be smoothly integrated into the grid and distributed efficiently. A lack of match between renewable energy production patterns (such as variable sunlight and wind) and energy demand can cause instability in the electricity grid system. (3) Technology and Cost: Although renewable energy has developed rapidly, renewable energy technology and infrastructure still require significant investment, especially in terms of initial costs. Building renewable energy projects requires large capital investments, and it can be a challenge for developers and investors to find sufficient funding sources. (4) Licensing and Regulation: The licensing and regulatory process for developing renewable energy projects can be complex and time consuming. Unclear or changing policies and regulations can hamper the process of developing renewable energy projects. Government support is needed in developing clear and stable policies to support the development of renewable energy. (5) Public Awareness: The level of public awareness about the benefits of renewable energy and the importance of the transition to clean energy is also a challenge. Lack of awareness about the importance of developing renewable energy can cause resistance or lack of support from the community for renewable energy projects. (6) Weather Influence: The potential of renewable energy such as solar and wind energy is greatly influenced by weather and climate factors. Sudden weather changes or unstable climate patterns can affect renewable energy production and cause power fluctuations that can pose challenges in power grid operations.

CONCLUSION

Renewable energy development in Bali has great potential to provide significant economic benefits. In an effort to achieve sustainability and face the challenges of climate change, Bali as international tourist destination has directed attention to diversifying energy sources through renewable energy. With rapid economic growth and increasing energy demand, this step has become increasingly crucial.

The expected economic benefits of renewable energy development include attractive new investment opportunities for the private sector and investors. This will encourage Bali's economy with significant capital flows for the development of

renewable energy projects. Investment in renewable energy will also create new jobs and improve workforce skills, supporting the growth of the island's employment sector.

The development of renewable energy will also encourage technological innovation in the energy sector, such as the development of smart grid systems, energy storage technology and sophisticated energy management solutions. This innovation will create opportunities for local technology developers and increase Bali's competitiveness in the global market.

Apart from economic benefits, the use of renewable energy will also bring environmental benefits by reducing greenhouse gas emissions and negative impacts on the natural environment. The potential long-term reduction in energy costs from renewable energy will also help reduce the financial burden on consumers and businesses in Bali.

To overcome these challenges, collaboration between government, the private sector and society is needed to find the right solutions. There is a need for a comprehensive action plan and appropriate policy support to accelerate the transition to renewable energy in Bali. Strengthening public awareness about the benefits and importance of renewable energy is also an important step to achieve sustainable development goals in the energy sector on this island.

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