

Potential for Solar Energy Development in Vietnam

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Abstract—The world is aiming to reduce its dependence on fossil energy sources, which is reflected in the fact that most countries contribute to the common efforts to reduce pollution and increase the advantages of energy in development. Therefore, investing in clean energy is an indispensable trend for a nation to ensure energy security and sustainable development in the future. This energy source is invested, researched and used worldwide to reduce environmental pollution and is considered an effective solution to limit global warming. Vietnam has great potential for developing energy sources, but the development of these power sources, especially solar power in Vietnam is still limited. Difficulties and challenges are always posed to managers in the process of developing this renewable power development policy. The paper analyzes the potential energy sources that have been used in Vietnam to determine the importance of this energy source. At the same time, the article also provides a few suggestions to find solutions to effectively apply solar source in accordance with the actual situation of the country. The opportunities for passive solar technologies are mentioned, in parallel, the use of integrated methods to reduce carbon emissions generated from buildings and the techniques commonly used in passive solar recovery system has a huge meaning.

Index Terms—Energy, environment, potential, technology.

I. INTRODUCTION

Green energy is a source of energy generated from sustainable natural resources and non-fossil energy sources, such as solar, wind, hydropower, biomass, geothermal and energy. This energy is a sustainable source of energy, does not release pollutants that cause harm to the environment and can be exploited without harming ecosystems. Renewable energy can contribute to sustainable economic growth, especially at the national level, by harnessing local resources and creating new industries and creating jobs. So how important is clean energy during the Industrial Revolution 4.0?

Vietnam is assessed as a country with great potential for developing clean energy. The exploitation of clean energy sources is extremely important in terms of economy, society, energy security and sustainable development. Vietnam has been planning the national electricity development in the 2011-2020 periods, with a vision to 2030. The clean power source is prioritized to use, which creates a breakthrough in ensuring energy security, national energy, contributing to the conservation of energy resources, minimizing negative impacts on the environment in electricity production. Vietnam's specific objective is to prioritize the development of renewable energy sources for electricity production. At the

same time, to increase the percentage of electricity produced from clean energy sources, excluding hydroelectricity, to reach around 7% by 2020 and over 10% by 2030. Power sources from energy such as hydroelectricity, wind power, and solar power gradually increased the proportion of electricity production [1].

In fact, we are becoming more and more aware of the extreme heat of the weather caused by global warming. And then we tackle the problem by burning more fossil fuels for the heating and cooling systems in buildings. Sadly, this is a quick way to bring people to greater challenges. Global energy crisis, soaring cost, the future will be much hotter. While solar is completely free, it is very environmentally friendly. Why don't we turn challenges into opportunities, make full use of this abundant resource?

II. RESEARCH CONTENT

A. Status of Electricity Supply - Demand in Vietnam

The average growth rate of electricity production in Vietnam in the past 20 years has been very high, about 12-13% / year - nearly double the GDP growth rate of the economy. The strategy of industrialization and maintenance of high growth rates to implement the "rich people and strong country" and to avoid the risk of falling behind will continue to put on the power sector many important responsibilities and great challenges in the next decades [2].

Demand for electricity in industry and daily life accounts for a major proportion of total demand. In 2005, electricity for consumption and industry accounted for a very large proportion, respectively 43.81% and 45.91%, while the remaining 11% was for agriculture and other needs. The rising demand of electricity in the industrial sector is a direct consequence of the industrialization and modernization of the economy, one of which is the average growth rate of industrial production value. In the consumer sector, together with the population growth rate, the urbanization rate is quite high, and the increase of the people's income, the demand for electricity consumption also increases at a very high rate (Fig. 1). As a result, the demand for electricity of the whole economy has increased by an average of nearly 13% per year, and the growth rate of the past few years has been even higher than the average.

According to Vietnam Electricity Corporation's forecast, if the average GDP growth rate continues to be maintained at 7.1%/year, Vietnam's electricity demand in 2020 will be around 200,000 GWh, in 2030 is 327,000 GWh. Meanwhile, even when mobilizing the maximum of traditional power sources, the domestic electricity output only reached 165,000 GWh (2020) and 208,000 GWh (2030) respectively. This means that the economy will suffer a serious electricity shortage, and the rate of shortage can be as high as 20-30%

Manuscript received November 24, 2019; revised May 24, 2020.

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per year [3].

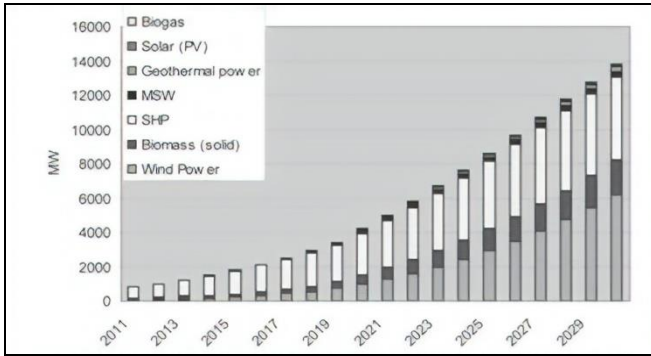


Fig. 1. Overview of current status and trends of Vietnam's renewable energy market (Source: Vietnam Institute of Energy).

B. Status of Using Clean Energy Source in Vietnam

Energy is one of the essential human needs and an indispensable input of economic activity. As people's living standards become higher, the production level of the economy is more and more modern, the demand for energy is also increasing, and satisfying this demand is really a challenge for most people. In Vietnam, the prosperity of the economy since "Doi Moi" policy has caused a sharp increase in electricity demand while the supply capacity has not developed timely. If this situation continues, the risk of electricity shortage will still be a permanent concern of Vietnam's electricity industry as well as businesses and people nationwide. Therefore, the application of clean energy sources is indispensable [3].

1) Hydroelectric

The territory of Vietnam is located in the tropics, with a high average annual rainfall, about 1,800-2,000 mm. With the northern terrain and high mountainous western border, the east is a long coastline of over 3,400 km so our country has a fairly dense river system, with more than 3,450 systems. And with such favorable natural conditions, Vietnam country's hydroelectric potential is relatively large [4].

Total hydroelectricity of Vietnam is about 35,000MW, of which 60% is concentrated in the North, 27% is distributed in the Central and 13% in the South. The potential can be exploited at about 26,000MW, corresponding to nearly 970 planned projects, each year can produce over 100 billion kWh, of which small hydroelectricity alone has up to 800 projects, with a total power capacity about 15-20 billion kWh / year. It can be said that, so far, large hydroelectric projects with capacity of over 100MW have almost been exploited. Projects with favorable locations and low investment costs have also been implemented. Remaining in the near future, small capacity hydropower projects will be invested and exploited.

Vietnam prioritizes the development of hydropower resources, especially integrated projects. These projects are responsible for flood control, water supply and electricity generation. Hydroelectric plants are also studied in operation in accordance with the development of the national electricity system in order to improve the operation efficiency of the electricity system. The total capacity of hydropower sources, including small and medium hydropower, from nearly 17,000

MW currently (2016) will be about 21,600 MW in 2020, about 24,600 MW, and about 27,800 MW in 2030.

2) Wind electricity

Until the 1990s, many people thought that the cost, including the installation and operation costs of wind stations, were quite high. But today, this thinking is being reevaluated, especially when the notion of cost includes not only economic costs but also external costs (such as social costs due to the relocation). While energy sources from fossil fuels such as coal, oil, and gas are considered to be less stable and tend to increase prices, along with the rapid development of technology, wind power is getting cheaper and cheaper. It is predicted that by 2020, the price of wind power will decrease significantly, only about 600 USD / KW, then the management and operation costs will reduce significantly, only about 30 USD / MWh. The total capacity of wind power will be increased from the current 140 MW to about 800 MW in 2020 and about 6,000 MW in 2030 [5].

3) Solar power

Solar power sources are accelerated, including concentrated sources installed on the ground and distributed sources installed on the roof. The total capacity of solar power sources will be raised from the current negligible level to about 850 MW in 2020 and about 12,000 MW in 2030. In Vietnam, there are many businesses investing in producing solar water heaters such as Polarsun, Megasun, Son Ha, Sunflower, Thai Duong Nang, etc. Different from equipment made for the poor, this is a product targeted to the average income households. Although the initial installation cost is quite high (minimum VND 5 million), this is still considered an economic problem for people in sunny cities all year round, when electricity prices continue to rise [6].

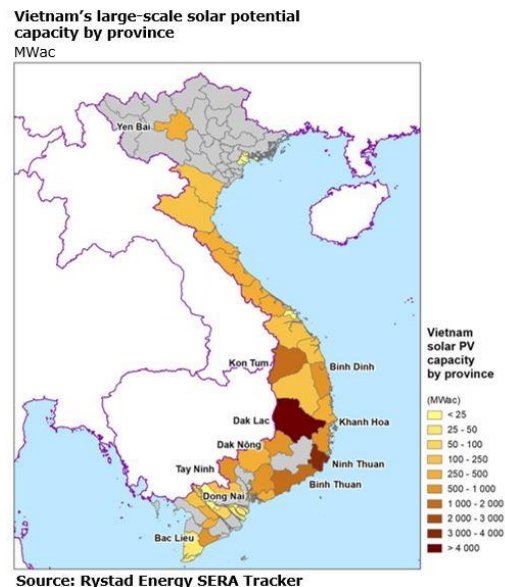


Fig. 2. Potential of using solar energy in Vietnam.

Solar energy in Vietnam is available year-round, quite stable and widely distributed in different regions of the country. In particular, the average number of sunny days in the provinces of the central and southern regions is about 300 days/year. Solar energy can be harnessed for two uses including electricity generation and heat supply. There are

four types of solar technology currently available in Vietnam market. These are household-scale, commercial-scale solar technologies used for hotels, restaurants, hospitals, military and service centers, for villages such as public lighting and sound, TVs and charging stations (Fig. 2).

In Vietnam, solar power applications have grown rapidly since the 1990s. Applications include solar power for households and service centers, solar water heating systems, and electric lighting and drying systems. Hybrid technology of renewable energy sources, called Manicub, has been applied to ships, ambulances or solar powered villas. Among the applications, solar water heating technology is considered the most economical, efficient and popular today [7].

C. Passive Design in Architecture and Energy Saving

Passive design in architecture is one that takes advantage of favorable climatic conditions to maintain a range of indoor thermal comfort. Good passive design will reduce; eliminate the need for cooling or heating, thereby reducing energy consumption and reducing greenhouse gas emissions throughout the life of the building.

According to data of the Ministry of Construction, about 40% of the total energy consumption of a city is the energy supplied to construction works, in which tall buildings have the highest energy consumption index. According to a recent survey of the Ministry of Construction in conjunction with the Hanoi and Ho Chi Minh city Energy Conservation Center, Ho Chi Minh City is on the status of energy use and management, the most electric equipment is air conditioning, accounting for over 70% of total electricity use; lights accounted for 10%; Other equipment such as office machines, elevators and water pumps account for about 20%. For buildings such as commercial centers, supermarkets, these figures are 75%; 10% and 15%; for hotels, the above figures are 60%, 25% and 15%. Thus, the energy consumption in construction works in Vietnam is high compared to other countries in the world, due to the lack of design and construction of buildings according to green building criteria.

D. The Opportunities for Passive and Active Solar Systems

Collecting solar heat is simply collecting solar energy and using that energy to heat, cool, light day, and warm water in buildings. High-tech equipment may be required to capture solar heat, for example, a series of precisely aligned solar photovoltaic panels to generate enough energy to power a residential area. Or more simply, for example, in the house where there is a sunny yard, we can relax; enjoy drinking tea and reading books.

Whether energy is taken proactively or passively, using the sun to power lighting, heating or cooling buildings is one way to minimize the impact on the environment and replace the fossil fuel. Solar collectors can be set up on a large or small scale, installing the system locally or remotely, from free to costly.

E. Potential for Developing Solar Energy in Vietnam

Vietnam has a geographical location, a long coastline, unique tropical monsoon climate and agricultural economy, with abundant and diverse renewable energy sources, so it can be exploited for energy production such as hydroelectricity, wind power, solar power, geothermal,

biofuels. By the end of 2018, Vietnam successfully developed many clean energy projects with 285 small hydropower plants, with a total capacity of about 3,322 MW; 08 wind power plants, total capacity of 243 MW and 10 biomass power plants, total grid capacity of about 212 MW [7].

Vietnam is considered a country with huge potential for solar energy, especially in the central and southern regions of the country, with an average solar radiation intensity of about 5 kWh/m². Meanwhile, solar radiation intensity is lower in the Northern regions, estimated at 4 kWh/m² due to weather conditions with cloudy weather and drizzle in winter and spring. In Vietnam, the average solar radiation of 150 kcal/m² accounts for about 2,000-5,000 h per year, with a theoretical potential estimate of about 43.9 billion TOE. Solar potential is also appreciated when Vietnam is a country with a lot of sunshine time of year with high radiation intensity in the Central and the South. Provinces have the number of sunny hours in the year about 1400-2700 h/year. According to the assessment, areas with sunlight hours of 1,800 h/year or more are considered to have potential to exploit and use. For Vietnam, this criterion is suitable for many regions, especially the southern provinces [8].

F. Forms of Solar Heat Gain Can be Applied in Vietnam

Direct gain is the simplest form of solar heat gain. Energy from the sun passes through the glass of the building into the inner space and warms the space. This warming can reduce a large amount of heat depending on the building's artificial heating system (for example, electric heating and cooling systems). Usually in large-scale commercial buildings, this extra heat is undesirable, causing an overload of the cooling system, leading to higher energy costs. In these cases, it is important to minimize direct solar heat gain. Light shelves, exterior blinds, awnings and landscaping all serve to control direct solar heat gain.

First is sunspace, that is, a space of any shape and size can always receive heat from the sun (indirect or isolated heat collection system); however, the key to achieving maximum performance is related to the size and criteria of the project in Vietnam. Solar spaces can be residential areas, such as solariums and greenhouses. Larger commercial projects can also utilize solar spaces in the form of skylights or courtyards. Solar space collects the sun directly and transmits that heat to the whole building through mechanical or natural convection. These solar spaces can often meet the heat needs to operate the entire building, significantly reducing heat load and cooling. An additional feature of the solar space is usually its aesthetics. Solar space creates a sustainable internal environment for plants to thrive, creating a natural ecosystem in the home that grows year-round.

Next is convective loop which can be used in a hot country like Vietnam; it is the use of a convection loop (indirect or isolated heat collection system) in combination with other passive design strategies and allows a solar heat recovery system to use no lateral energy. The convection loop technology works on the basic principle of enhanced hot air flow. As the air moves through a space in which the heat gain is equal to solar energy, the convection occurs naturally. This air can be directed to heat other areas of the building or draw coolant in, thus cooling the space. The control of convection

systems can be very precise with the right size, the ability to control direct solar gain and heat block storage system.

And, the last one is thermal mass storage which uses building blocks to collect solar energy during the day and release it at night. The building structure of a heat storage system is usually masonry and can be placed on floors, walls or roofs. These surfaces are usually warmed by direct sunlight through adjacent glass. Stored heat is radiated back into space at night. One of the best examples of heat block storage is the adobe houses of Navajo in the southwestern United States.

III. THE CHALLENGE OF DEVELOPING SOLAR ENERGY IN VIETNAM

Although Vietnam is a country with great potential for renewable energy, so far, the number of projects implemented is very small, the proportion of renewable electricity in the total amount of electricity produced is negligible due to There is a lack of strong and comprehensive policies, ranging from surveys and potential assessments to exploitation and use. The lack of effective financial mechanisms for investing, managing and operating renewable power projects in remote and off-grid areas is also an obstacle. And another challenge is the lack of a sufficiently strong authority to run [9].

Besides, technological and technical challenges are another obstacle. According to the report of Electricity of Vietnam, developing solar energy is creating a number of challenges in operating the electricity system. Renewable power sources have an impact on the national grid (such as equal effect, mobilization of other power plants and must increase the reserve of the electricity system to ensure the stability of the electricity system) no standards, no national technical regulations on rooftop solar power systems, or even no regulations on licensing electricity activities for the installation [10].

Economics and finance are also the biggest challenges for renewable energy development, which lie in the investment capital and the investor's ability to arrange capital. Financial barriers impede the execution of an economic project due to lack of access to appropriate financing, or lack of a sustainable mechanism to provide funding. Renewable energy development in Vietnam is currently constrained by both barriers [11].

IV. APPLICATION OF SOLAR ENERGY

Clean energy is used in many areas. The first is the solar application. Solar energy has been exploited by humans since ancient times. Today, people use this type of electricity to apply in many areas such as space heating and cooling, distilling drinking water and disinfection, lighting, cooking, etc. There are a number of solar racing competitions in the world today, including two relatively famous ones, The World Solar Challenge, held in Australia with the requirement that participants have to go a long way to 3,000 km across Australia. The second prize is The North American Solar Challenge which was first held in 2008 with a race from Texas - USA to Canada.

Solar energy is used a lot in lighting, that is, this can be applied well in a tropical country like Vietnam. This source of energy can be converted into electrical energy to light bulbs. Every year from November to February, a small village called Viganella in Italy falls into darkness because the sun does not reach the bottom of the valley where the village is located. In order to bring sunlight to this village, a giant mirror made of metal up to 8.5 meters in diameter was installed on the top of a 1,100 meter high mountain on the Alps, this mirror was regulated and controlled by a computer to turn in the direction of the sun and reflect the sun down to an area of about 250 square meters in the center of the village within 6 hours of sunny days.

Next is the application of energy to light the traffic lights. Traffic lights used by solar energy have the advantage of not needing to use wires and are quite flexible, can save a lot of electricity money when operating continuously for a long time. They are designed with some environmentally friendly LED light bulbs and do not need to be recharged for quite a long time. In the event of a power outage, these traffic lights continue to operate.

Another utility is phones, music players, etc. all need to be charged with solar energy. This device is fitted with a solar panel to store solar energy into electricity. This device is relatively cheap and very convenient, compact, helping to charge handheld devices where there is no mains power. The larger this device is, the more powerful it can be to charge tablets, laptops and other mobile devices.

In arid and coastal areas of Vietnam, drinking water is scarce, but abundant sunlight in these areas can be used to convert saline water into distilled water that can be consumed by energy distillation. In this method, solar radiation is collected through a tightly sealed glass plate in the air in a shallow black tank of salt water.

Solar radiation passes through the mantle and is absorbed and transformed into heat in the blackened surface, which evaporates water from the brine. The generated steam is condensed to form pure water in the cool interior of the roof.

Solar hot water system is also a popular solution but not everyone knows, especially in remote areas in Vietnam that have not been exploited effectively. A solar water heater in Vietnam includes a collection of heat collectors, hot water storage tanks, auxiliary tanks, cold water supply tanks, brackets, etc. The collection tube has a transparent glass cover in on top and a layer of insulation below (Fig. 3).



Fig. 3. PV and solar heating panels.

The receiver's metal pipes are connected by pipes leading

to an insulated storage tank to store hot water on cloudy days. The absorber absorbs solar radiation and transfers heat to the circulating water via a gravity pipe or a pump.

This hot water is supplied to the tank by metal pipes. This hot water system is often used in individual households, hotels, guest houses, hospitals, canteens as well as industrial units, etc.

Currently, solar energy is applied in many areas of life, especially the application of solar technology to dry and preserve agricultural and aquatic products after harvest. Some practical applications are derived from solar energy in daily life such as drying food [12].

In the past, for long-term preservation of food after harvest, people often exposed the food to direct sunlight. However, today this method is no longer effective because it depends on the weather and does not guarantee food safety.

The solar yacht MS *Tûranor PlanetSolar*, installed at the HDW shipyard in Kiel, Germany, is the largest ship in the world and has a special design. This boat is 35 meters long and 23 meters wide. Above the ship was installed about 500 square meters of solar panels to power the two engines in the hull. It travels around the world at a speed of about 12 km/h and uses only electric motors powered entirely by solar energy.

Currently, in Dong Thap province, Vietnam also has a model of solar powered boats for tourism. The boat operates on the principle of storing energy from sunlight through the battery and then charging it to the battery, which helps to run for 30 km continuously for 3 hours at a speed of 8-12 km/hour. Large cities such as Hanoi and Ho Chi Minh, with high population densities or congestion, should use this technique to improve the environment and minimize traffic flow (Fig. 4).



Fig. 4. Solar powered boat in Dong Thap province.

Besides, the potential to use solar panels as a sunshade device, for both roofs and facades, is very feasible. The energy production of photovoltaic integrated buildings is essential and is the key for cities to be at least self-sufficient in energy. Seven billion people will live and work in urban areas by 2050 and the energy needs for all these people will be enormous. The solar power generation of photovoltaic integrated buildings is essential and is the key for cities to be at least self-sufficient in energy. The rapid development of generations of solar cells with increasing efficiency enhances the applicability to photovoltaic integrated buildings, providing great opportunities for material suppliers and construction companies.

More than half of the planet's population today lives in

urban areas. This number will increase to 75% in the next 30-35 years. That means seven billion people will live in more crowded or sparsely populated areas, all of which need shelter, food and lots of energy. Concrete bricks and bituminous products dominate the roofing market, but both have drawbacks. Plastics have a short shelf life, heavy concrete bricks and cannot be used on flat roofs. And none of them can produce renewable energy. The solution uses thin solar panels, on the contrary, can be gentle and flexible, especially in a year-round hot country like Vietnam. They can be installed on the roof as well as facades without perforating and can be bent.

In fact, a small-scale rooftop solar power project with a capacity of 51KWp has been implemented at the Office building of Vietnam - Singapore I Industrial Park (Thuan An Town, Binh Duong City), including more than 130 pieces of solar panels. The solar panels installed here are expected to provide renewable energy and reduce the amount of carbon emissions in the building. By using green energy, businesses will reduce operating costs and improve competitiveness. Following VSIP industrial park in Binh Duong province, similar rooftop solar power projects will be implemented in VSIP and Becamex IDC's projects nationwide.

V. SOME RECOMMENDATIONS

A new way of thinking must be applied to meet the goals of reducing carbon emissions associated with buildings. Our solution may start by integrating feasible methods. The first is the reduction of overall energy use in the home. Implementing solar heat acquisition techniques can directly reduce a building's overall energy use. Next is the selection of energy-efficient equipment and technology. Using system integration method to select energy-saving and maximum cost-saving devices, combined with solar collection systems is also considered to be quite effective. In addition, we need to educate contractors, investors, managers and occupants about economical and efficient use of energy [12].

The passive solar collector design system provides an almost infinite source of energy for our buildings. Selecting the right technology for the project will significantly reduce fossil fuel consumption, thereby eliminating carbon and greenhouse gas emissions. This will benefit from reduced operating costs, impact on the local environment [13].

Techniques that can be used in the design of buildings in Vietnam including building mass will be used later to adjust the building space temperature. It is necessary to choose the direction appropriate to the local climate and topography so that the maximum amount of solar heat can be obtained.

Passive solar cooling, also known as "thermosiphoning", aims to use rising heat from the sun to draw in cool air and facilitate cooling of the space inside the building.

A solar space can be utilized in a building, which allows cooling with daylight and solar heat. Besides, the combination of trees and plants provides shade, air conditioning to reduce heat load and cool the apartment. Therefore, when designing and shape the building, depending on the conditions of the region, we need to pay attention to make the most of the potential of local solar energy [14].

Architectural design solutions to save energy are not new to architectural designs but mainly need to innovate the

environmentally-friendly thinking of designers. Architects will weigh between an architectural linguistic solution and a free-form cube, the façade only focuses on aesthetics, regardless of the surrounding environment or an architectural solution that takes on special requirements and is from climatic conditions as a basis for design, to meet environmental protection requirements.

The energy-saving design solutions for the building cause architects to return to the traditional architectural style adapted to the tropical climate that generations of senior engineers and construction engineers have applied in Vietnam nearly 50 years ago. However, to apply energy-saving design solutions in the current age of information technology, it requires architects to coordinate architecture design and construction science, especially necessary certain knowledge of integrated design, engineering, construction and technology. Designers must properly apply architectural design strategies such as: “passive”, “active” and the type of active and passive mixture. The first is to optimize all the opportunities of a “passive” design in accordance with natural conditions to save energy; The next is the design of optimizing all equipment systems that use the energy of the building, such as energy control in design, detailed energy modeling, design of environmental consequence control. From there, find out the architectural solutions that are both modern and meet the requirements of energy efficiency and environmental protection.

The first is the design of the structure to cover the building in Vietnamese climatic conditions. Vietnam is a tropical country, with inline solar radiation regime, twice in the year the sun passes through the zenith. Total annual radiation is about 100-300 Kcal/cm² in the North and about 120-350 Kcal/cm² in the South. The sun’s altitude is quite large; radiation time in the whole country is relatively even. The annual total hours of sunshine is 4,300–4,500 h/year, but the hours of sunshine are unevenly distributed by months. Due to the influence of the cloudy sky, the amount of diffuse radiation (scattering of the sky) in Vietnam is relatively large, often accounting for up to 50% of the total solar radiation.

Due to the large diffuse radiation, Vietnam has a huge natural light resource, if the architectural design of the building knows how to take advantage of natural light for passive lighting and use direct radiation energy to heat water for living and producing clean, renewable electricity will save a significant amount of electricity. In contrast, solar radiation through the structure into the house (which is a large source of heat load) needs to be minimized in order to reduce the cooling load for the air conditioning system.

It is easy to understand that only when the development takes the interest and direction of the State through a system of policies, a unified program and appropriate funding of the budget, as well as assistance of international technology, finance can then achieve certain results. The biggest difficulty and challenge for developing this power source is the need for a stable policy mechanism and selection of financially capable investors, as well as experienced investment. The Government also needs to promulgate other preferential policies for investors such as giving priority to credit provision, exemption and reduction of corporate income tax, land rent, and use of standardized power purchase and sale contract [11].

VI. CONCLUSION

In short, we need to research and gain a deep understanding of radiation and apparent movement of Sun. An in-depth understanding of sunlight angle and solar radiation is the scientific basis for choosing “passive” design solutions including choosing the main direction of the building, determining its shape, selecting choose solutions to design the structures covering the building, the most important of which is the design of windows with high efficiency on solar radiation cover, natural light, natural ventilation and thermal insulation design of roof works; installing integrated photovoltaic panels for buildings or solar panels, thereby reducing the energy consumption that makes the building's ventilation, air-conditioning and artificial lighting systems. If properly planned and invested, clean energy application could change the country's economy as well as the life of Vietnamese people. Developed countries have planned to build smart cities just by using this economical but extremely abundant energy. So why we don’t hope for a future where solar power is more widely applied to its endless potential.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

- [1] B. Zhou, Z. Li, and C. Chen, “Global potential of rare earth resources and rare earth demand from clean technologies,” *Minerals*, vol. 7, no. 11, 203, 2017.
- [2] P. K. Toan, N. M. Bao, and N. H. Dieu, “Energy supply, demand, and policy in Viet Nam, with future projections,” *Energy Policy*, vol. 39, no. 11, pp. 6814-6826, 2011.
- [3] L. D. Hai and N. T. H. Lien, “Renewable energy policies for sustainable development in Vietnam,” *VNU Journal of Science: Earth and Environmental Sciences*, vol. 25, no. 3, pp. 133-142, 2009.
- [4] N. N. Quang, “Vietnam and the sustainable development of the Mekong river basin,” *Water Science and Technology*, vol. 45, no. 11, pp. 261-266, 2002.
- [5] K. Q. Nguyen, “Wind energy in Vietnam: Resource assessment, development status and future implications,” *Energy Policy*, vol. 35, no. 2, pp. 1405-1413, 2007.
- [6] K. Abdullah, “Renewable energy conversion and utilization in ASEAN countries,” *Energy*, vol. 30, no. 2-4, pp. 119-128, 2005.
- [7] J. Wu and J. Yang, “Control on green energy source and ecologic environment,” *Kongzhi Lilun yu Yingyong/Control Theory Applications (China)*, vol. 21, no. 6, pp. 864-869, 2004.
- [8] N. T. Nguyen, and M. Ha-Duong, “Economic potential of renewable energy in Vietnam's power sector,” *Energy Policy*, vol. 37, no. 5, pp. 1601-1613, 2009.
- [9] B. H. Nguyen and N. A. Tuan, “Current situations and solutions for renewable energy development in Vietnam,” *Asia Pacific Journal of Sustainable Agriculture, Food and Energy*, vol. 3, no. 1, pp. 20-23, 2015.
- [10] N. T. Phat, “Challenges of energy security to the industrialisation and sustainable development in Vietnam,” *Technology and Investment*, vol. 3, no. 3, p. 22080, 2012.
- [11] T. N. Nguyen, M. Ha-Duong, T. C. Tran, R. M. Shrestha, and F. Nadaud, “Barriers to the adoption of cleaner and energy efficient technologies in Vietnam,” *GMSARN International Journal*, vol. 4, no. 2, 2010.
- [12] T. Buragohain, “Impact of solar energy in rural development in India,” *International Journal of Environmental Science and Development*, vol. 3, no. 4, pp. 334-338, 2012.
- [13] A. Kahoorzadeh, S. Shahwarzi, E. Farjami, and S. Osivand, “Investigation of usage of passive solar energy in Salamis road's buildings, famagusta,” *International Journal of Environmental Science and Development*, vol. 5, no. 2, pp. 132-136, 2014.
- [14] S. Chinnammai, “A study on energy crisis and social benefit of solar energy,” *International Journal of Environmental Science and Development*, vol. 5, no. 4, pp. 404-411, 2014.

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