

# On The Establishment of the National Renewable Energy Center in Vietnam: a Technological and Economic Study of the Potential of Renewable Energy Sources

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**Abstract** — Currently, the structure of Vietnam's energy sources is changing, with renewable energy sources starting to play an increasing role in meeting the electricity demand and reducing greenhouse gas emissions from fossil energy sources. Vietnam's energy development strategy suggests building some renewable energy centers, of which Ninh Thuan is the first province to become the national renewable energy center. This is because of Ninh Thuan's endowment as a province having the highest renewable energy potential in Vietnam. The development of a large renewable energy center allows power system planners to overcome the mismatch in timescales associated with expanding transmission power grid and renewable energy generation. Besides, the renewable energy center can facilitate large-scale renewable energy and storage projects. The province of Ninh Thuan, however, is located far from the main load centers of Vietnam, which is why the economic indicators need to be calculated and analyzed. This paper presents the results of an analysis of economic indicators of major renewable electricity sources in Ninh Thuan (onshore wind power, offshore wind power, and solar power) to provide scientific arguments for developing a renewable energy center in Vietnam.

**Index Terms:** energy structure, energy sources, electricity demand, gas emissions, fossil energy sources, renewable energy.

## I. INTRODUCTION

The overall global renewable power capacity increased to around 2,378 GW by the end of 2018 and reached more than 33% of the world's total installed power generating capacity [1]. A new renewable power installed capacity was estimated at 181 GW worldwide in 2018, of which the total capacity of solar power accounted for 55% of renewable capacity additions, followed by wind power (28%) [1]. The power system can receive a large proportion of renewable energy without using fossil fuels and nuclear power that provide "base load," relying on the flexibility of the electricity system, power grid connection, advanced technology solutions such as information-communications technology (ICT), power storage systems and virtual power plants. It helps both to balance the change in the electricity generation stage and to optimize the power system and reduce generation costs. As a result, some countries successfully control peak loads or surpass the target of 100% of electricity produced from renewable energy.

There is a tremendous difference between renewable energy centers (wind and solar power) and traditional power centers, such as a thermal power center in the national power system. This is due to the specific features of its primary energy sources. For the development of a thermal power center, the preferred conditions for its location are near large load centers or a power grid or infrastructure (coal ports, for example). In the case of renewable energy (RE) center, the preferred condition is the geographical areas with high solar radiation or good wind speed and efficient land use. This difference makes it challenging to synchronize and optimize the transmission and distribution grids so that RE resources can be fully utilized in the considered geographical areas to reduce transmission losses as the load centers are usually far from the RE sources. Some countries build large RE centers such as Asia RE Hub - AREH [2] in Western Australia and RE Zone [3] of Texas, USA. A large RE center (RE

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Hub or RE Zone) is a geographic area supporting cost-effective renewable energy (RE) development, including high-quality RE resources, suitable topography, and strong developer interest. The large RE centers allow power system planners to overcome the difference in timescales associated with developing transmission power grid and RE generation. Besides, RE Hub or RE Zone can release a significant pipeline of large-scale renewable energy and storage projects.

Vietnam's electricity consumption increased steadily in recent years, from 90 TWh in 2010 [4] to 227 TWh in 2019 [5], with an annual growth rate of about 11 %/year. At the same time, the power system's maximum installed capacity also rose from about 20000 MW in 2010 [5] to about 55000 MW in 2019 [6]. Vietnam's electricity demand is expected to reach about 570 billion kWh by 2030 [7]. Currently, Vietnam is changing energy source structure, in which renewable energy sources will play a crucial role in meeting electricity demand and reducing greenhouse gas emissions from fossil energy sources. Solar power is projected to reach 4,000 MW in 2025 and 12,000 MW by 2030, while the wind power capacity may increase to 2,000 MW by 2025 and 6,000 MW by 2030 [8]. At the end of 2019, the actual installed solar power capacity reached about 5.6 GW [9], while the total wind power installed capacity was about 425 MW [10]. The feed-in-tariffs (FIT) introduced for solar and wind power projects were 7.09 US\$ cent/kWh for ground-mounted PV project and 7.69 US\$ cent/kWh for floating solar projects [11], 8.5 US\$ cent/kWh for onshore wind, and 9.8 US\$ cent/kWh for offshore wind [12].

Vietnam's energy development strategy suggests building some renewable energy centers, of which Ninh Thuan is the first province to become a national renewable energy center as it has the highest renewable energy potential in Vietnam. The national renewable energy center to be established in Ninh Thuan will play a significant role in supporting the development of the renewable power industry in Vietnam.

However, the province of Ninh Thuan is situated far from the main load centers of Vietnam, which is why the economic indicators need to be calculated and analyzed. This paper presents the results of the assessment of economic indicators of key renewable electricity sources in Ninh Thuan (onshore wind power, offshore wind power, and solar power) to provide scientific arguments for developing a renewable energy center in Vietnam.

## II. POTENTIAL OF SOLAR AND WIND ENERGY SOURCES IN NINH THUAN PROVINCE

### 1. Geographical site

Ninh Thuan, located in the southern part of the Vietnam Central Coastal region, borders Khanh Hoa in the north, Binh Thuan in the south, Lam Dong in the west, and East Sea in the East.

The province has a total natural surface of 3,360 km<sup>2</sup>, 7 administrative units, including 1 city and 6 districts. The city of Phan Rang - Thap Cham constitutes a political, economic, and cultural center of the province. It is situated at a 350 km distance from Ho Chi Minh City, 60 km from the international Cam Ranh airport, 105 km from the city

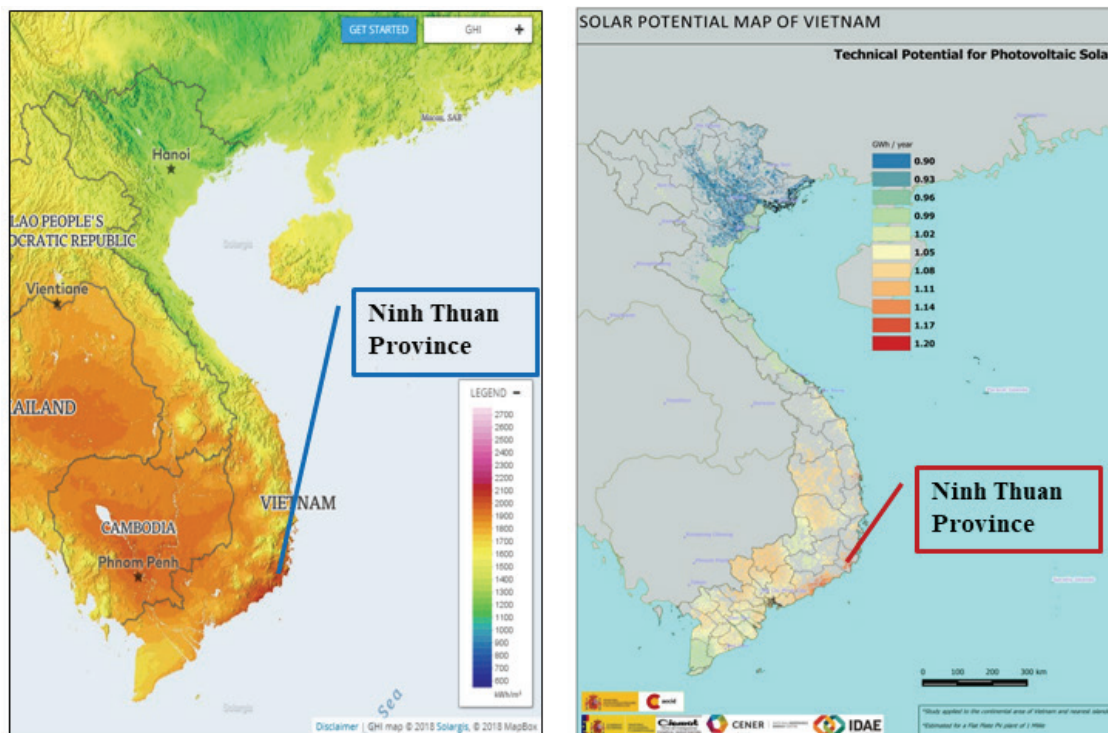


Fig. 1. The solar energy potential of Ninh Thuan province [6]

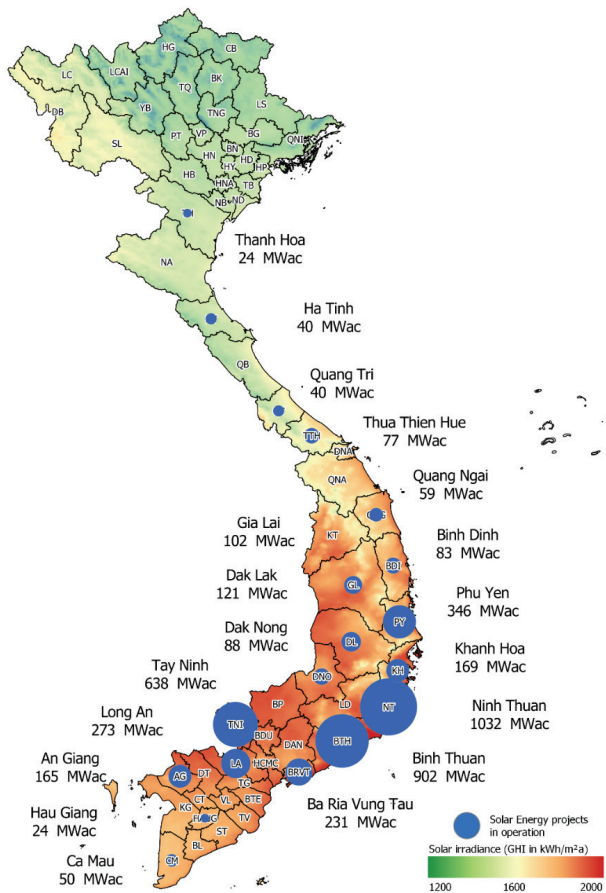


Fig 2. Installed solar power capacity in Vietnam [6].

of Nha Trang, and 110 km from Da Lat with favorable conditions for socio-economic development.

### 2. Solar energy potential

Ninh Thuan is located in an area with an annual average solar radiation of about 5.5 kWh/m<sup>2</sup> a day, the average number of sunshine hours is about 2,600-2,800 hours per year (equivalent to 200 sunny days/year), and a total solar power installation scale of about 1,500 MW. In Ninh Thuan, there is the area of Ninh Phuoc district and Thuan Nam district, where the high solar energy potential can be effectively exploited [13].

Until August 2019, the number of completed solar power projects in Ninh Thuan had been the highest in Vietnam, with a total installed capacity of about 1032 MW [6].

### 3. Wind energy potential

Ninh Thuan province has also the highest wind power potential in Vietnam, with an annual average wind speed of about 7m/s at a height above 65m. The whole province has 14 potential wind regions with an area of about 8,000 ha concentrated mainly in three districts of Ninh Phuoc, Thuan Nam, and Thuan Bac. Storms are rare in Ninh Thuan, and the wind blows steadily for ten months at a speed of 6.4 - 9.6 m/s, ensuring stability for wind power development. The technical wind power potential is 1,442 MW, and the highly feasible area of Ninh Thuan is 21,642 ha [14].

Up to August 2019, Ninh Thuan had commissioned the largest number of wind power projects in Vietnam with a total installed capacity of about 109 MW, as shown in Figure 4 [6].

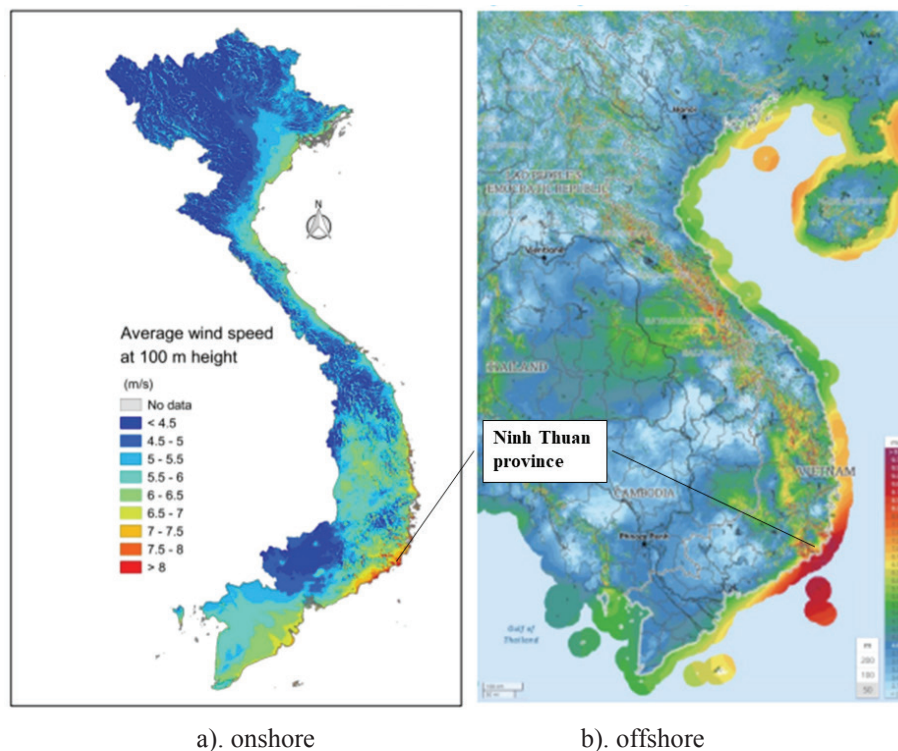


Fig 3. Wind energy potential in Vietnam [15].



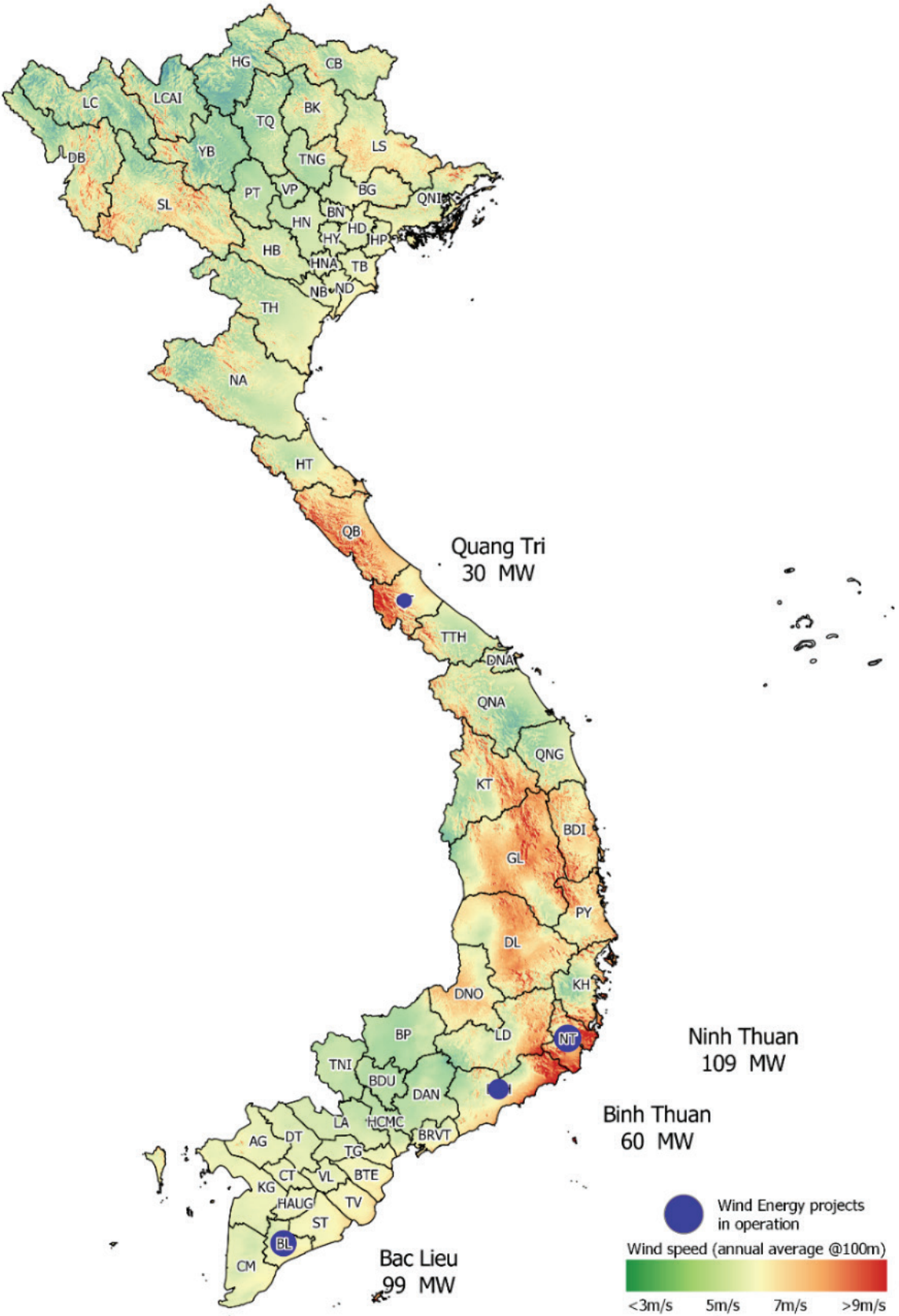


Fig 4. Installed wind power capacity in Vietnam [6].

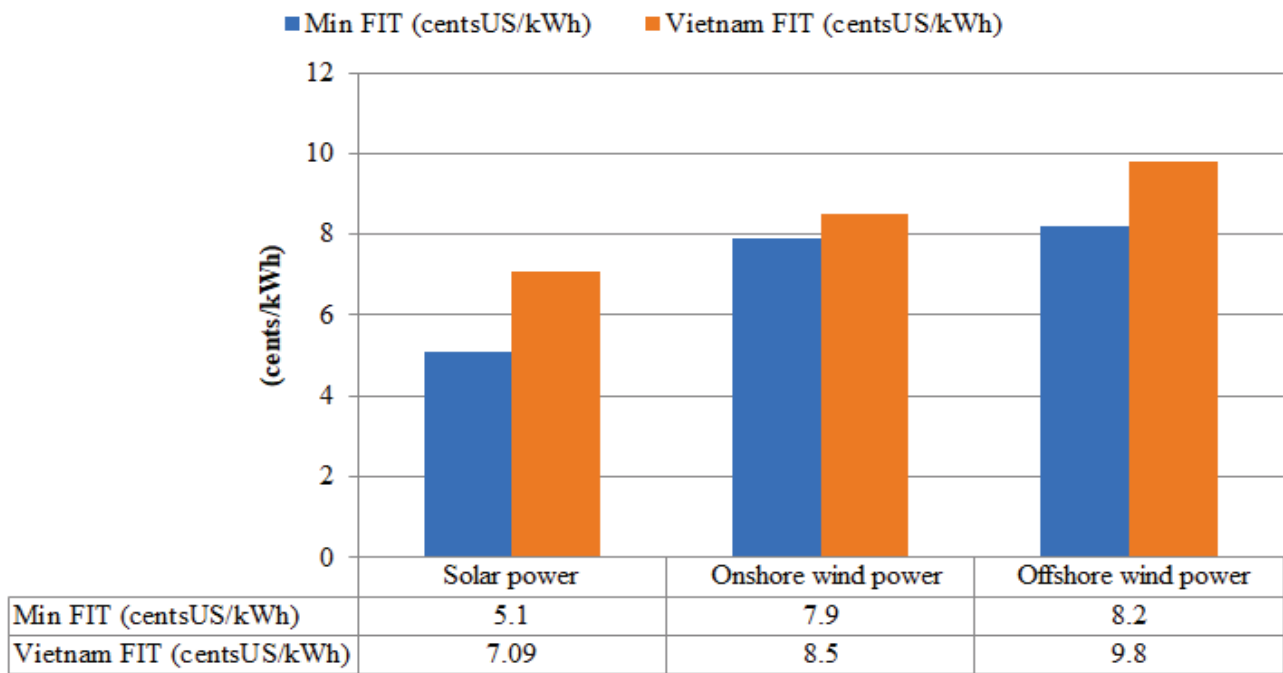


Fig 5. Minimum FIT versus Vietnam FIT.

Table 1. Input parameters

Parameters	Ground-mounted PV power	Onshore wind power	Offshore wind power
Initial Investment Cost (\$)	25,278,015	53,892,216	66,723,695
Operations and Maintenance Costs (\$)	126,390	1,077,844	1,334,474
O&M Growth Rate (%)	2	2	2
Capacity (MW)	30	30	30
Annual Electricity Output (MWh)	48,450*	73,584	86,724
Project Lifespan (years)	25	25	25
Discount Rate (%)	6	6	6

\*Note: Power degradation of solar power is no more than 2.5% in the first year, then 0.7% per year until the 25th year.

### III. METHODOLOGY

In this study, the electricity of solar farms is calculated using the PVSYST program [16, 17], while the output from the wind turbine is determined based on the design data of wind farm projects, which were used to plan the wind power development in Ninh Thuan [14].

The economic potential was assessed considering annualized investment costs and the annual operations and maintenance (O&M) costs. The objective was to calculate the minimum feed-in tariff (FIT). Currently, the FIT level can be determined from the calculation of the levelized cost of electricity (LCOE) produced from renewable energy (RE) projects [19]. By which, the investor can recover different costs (capital, O&M, fuel, financing) while realizing a return on his investment that depends on the assumed financing costs. LCOE is used to assess the average lifetime costs of providing one MWh

for a range of power production technologies or power savings. The cost elements comprising the LCOE include investment costs, fuel costs, operation and maintenance costs, environmental externalities, and system costs for solar and wind power plants. LCOE is calculated by the following formula

$$LCOE = \frac{\sum_{t=1}^n (I_t + M_t + F_t)}{\sum_{t=1}^n \frac{E_t}{(1+r)^t}}$$

where:

- $I_t$ : Investment cost by the year  $t$
- $M_t$ : Operations and Maintenance costs by the year  $t$
- $F_t$ : Fuel costs by the year  $t$
- $E_t$ : Electricity production by the year  $t$
- $r$ : Discount rate
- $n$ : Project lifetime (year)

Table 2. Calculated economic indicators

Parameters	Ground-mounted PV power	Onshore wind power	Offshore wind power
Net present value (NPV) (\$)	27,074,753	69,214,650	84,046,360
LCOE (US\$ cent/kWh)	5.1	7.9	8.2

#### IV. RESULTS

The key parameters used for the calculations are shown in Table 1.

The LCOE and minimum FIT of minimum renewable electricity sources in Ninh Thuan (onshore wind power, offshore wind power, and solar power) are indicated in Table 2.

Figure 4 presents the results of the comparison of the minimum FIT of onshore wind power, offshore wind power, and solar power projects in Ninh Thuan with the existing Vietnam FIT for such projects in the country. The min FIT of onshore wind power in Ninh Thuan is closer to Vietnam FIT than solar power and offshore wind power.

#### V. CONCLUSIONS

This study has presented the potential of solar power and wind power in the province of Ninh Thuan, where the annual average solar radiation is about 5.5 kWh/m<sup>2</sup>/day and wind speed is 6.4 - 9.6 m/s.

The calculation of the economic indicators shows that the minimum FITs of onshore wind power, offshore wind power, and solar power projects in Ninh Thuan were lower than the current Vietnam FIT. The gap between the minimum FIT and Vietnam FIT for onshore wind power was smaller than for offshore wind power and solar power projects.

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