

# Research on the Influence of Electric Vehicle Integration in Island Microgrid, Vietnam

# Nguyen Van Hung, Nguyen Quoc Minh



Abstract: Vietnam's economy is developing strongly, and the energy demand will increase rapidly. The development of smart grids significantly contributes to the transition to and sustainable development of energy from renewable sources, thereby improving the quality of the national power supply and promoting the economically and efficiently sustainable use of electricity. Thus, this is highly beneficial in reducing carbon emissions and other types of pollution. Additionally, the transportation industry is undergoing rapid electrification, as evidenced by the development of Electric Vehicles (EVs) and Metros in recent years. Integrating electric vehicles into the grid will enable two-way energy exchange, reactive power compensation and load balancing. However, the number of EVs participating in charging at a time will cause some conflicts, such as voltage and power loss at the nodes. Therefore, balancing the load demand and the generation source is a challenging task in planning operations. This paper presents a method to optimize island Microgrid (MG) operation with the participation of electric vehicles based on renewable energy sources. Optimisation techniques in intelligent resource forecasting and management algorithms are implemented in MATLAB to meet various requirements. The proposed Microgrid manages energy efficiency that adapts to the variability of Renewable Energy with improved efficiency.

Keywords: Plug-in hybrid electric vehicles, Optimisation, vehicle-to-grid, Renewable energy, Vehicle to grid on MG.

## I. INTRODUCTION

Energy is always an indispensable development need and a pressing global concern. Fluctuations in energy prices caused economic recession and political instability in many countries worldwide. Energy from fossil fuels is the primary source of energy that fuels global industry and serves as the foundation for the development of the modern world, accounting for approximately 80% of total energy, with 27% derived from coal. Renewable energy accounts for about 11% [1], [2]. Over the past century, the widespread use of fossil energy has emitted a massive amount of greenhouse gases, contributing to global warming and its unpredictable consequences for humanity. At the Global Conferences on Climate Change (COP), it was noted that harnessing renewable energy sources is a crucial solution for diversifying energy sources to support development,

Manuscript received on 16 August 2023 | Revised Manuscript received on 23 August 2023 | Manuscript Accepted on 15 October 2023 | Manuscript published on 30 October 2023. \*Correspondence Author(s)

Nguyen Van Hung\*, Department of Electrical–Electronics Engineering Vietnam Maritime University, Haiphong, Vietnam. Email: hung.ddt@vimaru.edu.vn, ORCID ID: 0009-0000-0067-4273

**Nguyen Quoc Minh**, Department of Electrical Engineering Hanoi University of Science & Technology, Hanoi, Vietnam. Email: <u>minh.nguyenquoc@hust.edu.vn</u>, ORCID ID: <u>0000-0001-5827-6390</u>

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an <u>open access</u> article under the CC-BY-NC-ND license <u>http://creativecommons.org/licenses/by-nc-nd/4.0/</u>

Retrieval Number:100.1/ijeat.A42831013123 DOI: <u>10.35940/ijeat.A4283.1013123</u> Journal Website: <u>www.ijeat.org</u>

gradually replacing fossil fuels, and combating the global climate change caused by their use [3]. According to the International Renewable Energy Agency (IRENA)'s forecast, renewable energy is expected to increase by 28% in 2030 and by 66% in 2050 [4]. In addition, the share of renewable energy's contribution to the global energy sector is expected to reach 57% by 2030 and 86% by 2050 (the current percentage is 26%). According to a study [5], global renewable energy investment has grown significantly, increasing by approximately 14.1% in 2016 and 29% in 2020. Renewable energy increased by approximately 9% in 2016 in the United States, accounting for 14% of the country's electricity production. The proportion of wind and radiation energy electricity accounts for 5.2% and 0.8%, respectively. In recent years, electrification in transportation has been promoted and developed rapidly. Therefore, vehicles such as Electric vehicles and metros are commonly used to help reduce CO<sub>2</sub> emissions into the environment. Besides, a large number of electric vehicles charging on the grid will sometimes affect the power quality and capacity of the generator. Many researchers worldwide are interested in the influence of electric vehicles on the distribution grid. In the study [6], the effect of charging stations on highways was shown when electric vehicles were involved. The load demand increases at that time, affecting the system's reliability. In works [7] and [8], some bottlenecks on the medium-voltage grid are identified, analysing breakdowns caused by electric vehicle charging points. Severity depends on grid structure, EV penetration and charging station plan. The research [9] presents a method for constructing a random frame using the point estimation method to facilitate the detection of solar radiation prediction, battery temperature, and plant service prices. In the study [10], an MG with an intelligent energy management system is built, which schedules grid operations in real-time and balances energy between different sources. The algorithm can predict the mains with relatively high accuracy on an hourly basis, thereby reducing the risk associated with investments in distributed energy resources. Wind energy and solar radiation are two renewable energy sources that have been recognised and utilised by humanity for a long time, but have only become the subject of significant investment in research and development in recent decades. Although energy sources are inexhaustible and distributed throughout the Earth, their potential for exploitation differs due to the uneven distribution in time and space. The world's islands have different possibilities for Wind and Solar energy. In Vietnam, a research study [11] proposed building an MG model based on renewable energy sources, specifically solar cells. At the same time, calculate the investment

same time, calculate the investme costs and operational economic problems. In the paper [12], an approach is developed for integrating EV chargers into

Published By: Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP) © Copyright: All rights reserved.



the distribution grid, analysing essential parameters related to EV impacts in Vietnam.

However, the study of the impacts of electric vehicles on the marine environment in Vietnam is not yet widespread. Additionally, these islands are famous tourist destinations, such as Cat Ba and Co To, attracting approximately 2 million tourists each year. The increasing number of electric vehicles participating in traffic puts the power grid under tremendous pressure. This paper develops an MG model on an island in Vietnam and analyses the effects of electric cars and various types of charging stations using MATLAB software. Next, several algorithms are proposed to optimise grid operation, aiming to reduce power loss. Voltage and frequency parameters are within the allowable range for the Vietnamese power grid. The rest of the paper is described as follows in Section II, where we build an MG model on Cat Ba Island, and Section III proposes an intelligent load and power management algorithm. Section IV presents an analysis of

various charging scenarios and their impacts on the grid. The conclusions and future work are summarised in Section V.

## **II. STRUCTURE OF MICROGRID WITH** ELECTRIC VEHICLE

## A. Microgrid Definition

According to The Consortium for Electric Reliability Technology Solutions (CERTS) in the United States, an MG consists of essential components such as an electrical power supply and a portion of thermal energy to the load demand [11]. In particular, the power source can be small turbines, solar panels, wind power, and battery storage systems. Energy sources are connected to the grid through circuit breakers and sustainably supply electricity with modern monitoring and control technology [12], [13]. Fig. 1 shows the MG model.



Fig. 1. Microgrid components

## **B.** Wind Power

The relationship between wind speed ( $v_W$ ) and turbine output power ( $P(v_w)$ ) is nonlinear, with characteristic parameters including cut-in  $(v_i)$ , cut-out  $(v_o)$  and rated Wind  $(v_r)$ speeds. Speed is calculated in approximately 24 hours, and this is essential data required when building a model. The capacity of the wind farm is modelled by the following [11], [14]:

$$P(v_{W}) = C_{W} \times \begin{cases} 0 & 0 \le v_{W} \le v_{i} \\ a + bv_{w}^{3} & v_{i} \le v_{W} \le v_{r} \\ 1 & v_{r} \le v_{W} \le v_{o} \\ 0 & v_{W} \ge v_{o} \end{cases}$$
(1)

where parameters a and b are given as follows:



2

Published By:



$$a = v_i^3 / (v_i^3 - v_i^5) b = 1 / (v_i^3 - v_i^3)$$
(2)

Wind farm model with a capacity of 6MW. The overall wind speed is 15m/s, and the nominal wind speed is 13.5 m/s. The wind generator produces electricity at a voltage of 600 volts and a frequency of 50 Hz.

## C. Solar Farm

The electricity generated from the PV farm relies on sunlight and converts it into electricity. PV power is proportional to the solar radiation received by PV. The mathematical model of the solar plant is described as follows [14]:

$$P_s(t) = P_{s,r} \, \eta_s \, \left( \left( E_s(t) \,/ \, E_{stc} \right) \, (1 + \alpha_s \, (\tau_s(t) - \tau_{stc})) \right) \tag{3}$$

where  $P_{s,r}$  Is the rating of the PV panel?  $\eta_s$  Is the efficiency of the PV panel?  $E_s(t)$  is solar radiation-induced,  $E_{stc}$  Is the average radiation at standard test conditions and  $\alpha_s$  It is the PV panel temperature coefficient.  $\tau_s$  and  $\tau_{tsc}$  Are PV panel temperature and the average temperature of cells, respectively?

Solar panel farm with a total capacity of 4MW and built on three factors: PV refinishing area, solar radiation, and panel efficiency. Solar radiation is measured in real-time, and shade is assumed to last for approximately 250 seconds, starting at 11:30. The output voltage through the transformer is 25 kV with a frequency of 50 Hz. Additionally, a small generator is built to help mitigate the frequency deviation of the grid, in conjunction with renewable energy sources. The generator has a capacity of 10 MW, a frequency of 50 Hz, and an output voltage of 25 kV. This source of 24-hour maintenance makes up for the shortfall in capacity when renewable energy sources are affected. In the MG grid, Diesel generators are used to provide electricity, so limiting the amount of gas emitted into the environment is necessary. The formula for expressing emissions to the environment is as follows:

$$Em^{DG} = \sum_{t=1}^{T} \sum_{i=1}^{I} E_{CO_2}^{DG,i} \cdot P_{DG}(i,t)$$
(4)

where  $E_{CO_2}^{DG,i}$  Is the CO<sub>2</sub> emission rate of the DG i?

## D. V2G Model

All residential, commercial, industrial, and office buildings on the island are required to be equipped with smart grid technology and PEV charging and discharging facilities. It is assumed that PEVs are parked in residential areas of the island from 17:00 to 06:00 and in commercial, industrial, and office areas from 07:00 to 16:00. The V2G model is built in 5 different configurations. The VF9 electric vehicle was tested in a model with a 92kWh capacity and a production quantity of 50 cars. Additionally, the Vfe34 vehicle, with a total capacity of 42 kWh, is integrated into some residential areas. The following mathematical equation represents the electric vehicle model.

PEV Discharging mode [14], [16]:

$$Cap_{BEV,t+1} = \max\left\{ (Cap_{BEV,t} - \frac{\Delta t.P_{BEV,t}}{\eta_{Dis}}, Cap_{BEV,\min} \right\}; t = 1, ..., NT$$

$$P_{BEV_{\min},t} \leq P_{BEV,t} \leq P_{BEV_{\max},t}; t = 1, ..., NT$$
(5)

Retrieval Number:100.1/ijeat.A42831013123 DOI: <u>10.35940/ijeat.A4283.1013123</u> Journal Website: <u>www.ijeat.org</u> PEV Charging mode:

$$Cap_{BEV,t+1} = \min\left\{ (Cap_{BEV,t} - \Delta t.P_{PEV,t}, \eta_{Ch} \right\}; t = 1, ..., NT$$

$$P_{BEV,in,t} \le P_{BEV,t} \le P_{BEV,in}; t = 1, ..., NT$$
(6)

where

$$P_{BEV_{\min},t} = \min\left\{\frac{P_{BEV,\max}.(Cap_{BEV,t} - Cap_{BEV_{\min}}).\eta_{Dis}}{\Delta t}\right\}$$
(7)  
$$t = 1, ..., NT$$

$$P_{BEV_{\max},t} = \max\left\{\frac{P_{BEV,\max}.(Cap_{BEV,t} - Cap_{BEV_{\max}})}{\Delta t.\eta_{Ch}}\right\}$$
(8)

t = 1, ..., NT

where,  $Cap_{BEV_{max}}$ ,  $Cap_{BEV_{min}}$  Maximum and minimum capacity of BEV in kWh;  $P_{BEV,t}$  Generated power of BEV in kW;  $P_{BEV_{max},t}$ ,  $P_{BEV_{min},t}$  Maximum discharging and charging rates of BEV in kW;  $Cap_{BEV,t}$  Stored energy in BEV [14], [15], [16].

## E. Weather Conditions Influence

The generating capacity of Wind and solar energy depends on the weather [17]. Wind Energy is related to wind speed in generating the maximum power source. Based on (1), which shows the characteristic that depends on wind speed, the authors have built a wind turbine model in MATLAB. They have used real-time wind speed data to simulate the wind turbine's generating capacity. The chart of wind speed is shown below:





Solar farm capacity depends on solar radiation, temperature and shade factor. Use (2) to calculate the generating capacity of the solar farm in 24 hours. Additionally, certain conditions, such as PV dirtiness, significantly impact the ability. Similar to Wind, solar radiation is received every day. Additionally, the model can forecast the solar farm's generation capacity for the following day.

Published By: Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP) © Copyright: All rights reserved.



3

## Research on the Influence of Electric Vehicle Integration in Island Microgrid, Vietnam





Monitoring data show that the total number of sunny hours in Vietnam is approximately 1,857.0 hours per year, ranging from 1,653.0 to 1,819.8 hours per year in the North and 2,312.4 to 2,502.6 hours per year in the South. In the Northern Delta region, the average Wind is about 3-5 m/s, but the coastal area of Nam Dinh and Ninh Binh provinces can reach 5-7 m/s (from January to July and from October to December).

Solar radiation and wind speed measured in typical months of the year are shown in Figs. 4 and 5. It can be seen that the two renewable energy sources can offset each other throughout the year. The map of Wind and solar energy in the East Sea of Vietnam in 2022 is shown as follows:



Fig. 4. Radiation potential energy map (kWh/m2/day) for three months, according to observed (a) January, (b) May, (c) December





# III. MODEL DESIGN

#### A. Microgrid Model Design

The authors build the grid on MATLAB software from the MG component in section II. There are two medium-voltage and low-voltage grids within the MG grid. Solar farms and wind power are connected to the medium voltage grid through circuit breakers CB1 and CB2. Additionally, the generating capacity of the diesel turbine is connected to the grid via CB3, with a rated capacity of 10 MW. An energy

storage system of approximately 2000kVA is charged when the regenerative energy source is available. Loads include residential areas and industrial zones. Additionally, the intended vehicle is integrated to test the grid's load capacity. Fig. 6 shows a schematic diagram of the power grid.

Published By: Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP) © Copyright: All rights reserved.







Fig. 6. Microgrid model in MATLAB

Next, the authors develop two optimisation algorithms, with Algorithm 1 describing the ability to manage and forecast the power supply to the grid. Planning and managing the load is presented in Algorithm 2.

## B. Intelligent Power Management Algorithm 1

For optimised grid operation and cost savings, it is

necessary to use optimisation algorithms when theists design the grid. Electric vehicles joining the grid at any time, including during peak hours, impact the grid's parameters. On the other hand, three typical parameters for the Vietnamese power grid are critical: voltage, frequency and voltage loss.



Fig. 7.Intelligent Power Management Algorithm

5



The EMS algorithm is described as follows: voltage is maintained by supply sources such as Solar Panels, Wind Power, and a storage battery. Initially, the algorithm receives input data, such as irradiance and wind speed, to calculate the capacity of the renewable energy source and then plans to mobilise power to the grid. In addition, battery storage is also involved when the time is insufficient to compensate for the lack of capacity.

The battery storage system is charged under low load demand (20% < SOC < 80%). The generated energy will be connected to the grid to supply the loads.

#### C. Load Management Algorithm 2 (LMA)

Three key parameters for the Vietnamese power grid are critical: voltage, frequency, and voltage loss, as well as power losses. Therefore, the grid should have optimal algorithms to meet this task. Additionally, forecast the capability of generating sources such as solar cells and wind energy, as these are unstable energy sources. Charging scenarios must calculate and coordinate the most suitable charging stations to prevent damage to the MG system.

The capacity of the grid and the load demand must be within the limits of the maximum and minimum generating capacities. The load demand and the system losses must be within these limits [12], [18], [19]

$$P_{G,\min} \le P_{Load} + P_{Losses} \le P_{G,\max} \tag{9}$$

where  $P_{G,\text{max}}$  is the maximum generating capacity of MG;  $P_{G,\min}$  is the maximum generating capacity of MG; and  $P_{Load}$ Power consumption of the load.

The power losses index (  $P_{\rm Losses}\%$  ) of the considered feeder is calculated using the following equation:

$$P_{Losses}(\%) = \frac{P_{Losses}(MW)}{P_{Load}(MW)}.100\%$$
(10)

MG in Vietnam, the voltage performance indices ( $\Delta V\%$ ) of the buses on the distribution grid is calculated using the following equation:

$$\Delta V\% = \frac{|V - V_N|}{V_N}.100\%$$
(11)

where  $V_N$  Is the nominal voltage of the feeder? V Is the bus voltage? In the MG, the voltage across the nodes must remain within the upper allowable voltage limits and the lower allowable voltage limits as follows [12], [18]:

$$V_{B,\min} \le V_B \le V_{B,\max} \tag{12}$$

where  $V_B$  Is the bus voltage,  $V_{B,\min}, V_{B,\max}$  The minimum and maximum allowable bus voltages, respectively.

The charging capacity of the EV must not exceed the maximum capacity of the charger. The battery is fully charged at the end of the cycle. The incoming energy equals the battery capacity.  $C_{\max} x_n$ . In case there is no PEV, the battery capacity is 0. Otherwise, it is one if there are EVs at nodes. The objective function is to reduce the power losses to a minimum with some constraints as follows:

$$\min \sum_{t=1}^{t_{max}} \sum_{l=1}^{lnes} R_l \cdot I_{l,t}^2$$

$$s.t \begin{cases} \forall t, \forall n \{nodes\} : 0 \le P_{n,t} \le P_{max} \\ \forall n \{nodes\} : \sum_{t=1}^{t_{max}} P_{n,t} \cdot \Delta t \cdot x_n = C_{max} \\ x_n \in \{0,1\} \end{cases}$$
(12)

For optimization algorithm 2, the authors propose a real-time load management technique. The peak reduction and peak shift of the load graph can be adjusted to improve voltage and power stability. The sole objective is to optimize costs and enhance MG stability. The proposed LMA technique is based on prioritising EVs. During peak hours, low-priority EVs will be moved to off-peak hours. EV battery health and priority information are communicated to the monitoring centre when the vehicle is plugged in. Algorithm 2 is described as follows:

Algorithm 2: Load Management			
Input: Daily load profile, Vnode, Iline, price profile,			
sub-intervals, EVs_priority, EVs_priority_List,			
Reference level.			
1. If ( EV priority level is high)			
Call Algorithm 1			
Assume a flat voltage profile.			
Calculate $V_{node}$ , $I_{line}$ , and $P_{losses}$ as follows (10) and (11)			
Compare P <sub>losses</sub> follow (9), (12)			
$P_{Load}^{LMA} = P_{Load}$			
2. else			
Calculate the optimal charging profile			
Calculate $V_{node}$ , $I_{line}$ , and $P_{losses}$ as follows (10) and (11)			
/*EVs stop charging*/			
<b>3.</b> $P_{Load}^{LMA} = P_{Load}(t+1)$			
4. <i>EV</i> _ <i>priority</i> = <i>high</i>			
5. UpdateEV _ priority _ List			
6. Save Optimal charging profile.			
7. Goto1			
Output: */ Energy consumption of EVs*/			
$P_{Load}^{LMA}$ / *MG_power_load * /			

## IV. RESULT AND DISCUSSION

#### A. EVs Charging Scenario

Published By:

In this section, the authors develop scenarios to assess how electric vehicles, during charging, impact the grid. Vietnam divides the time of day into parts when using electricity as follows [20]

- Peak hours: 9h30-11h30; 17h00-20h00.
- \_ Off-peak hours: 22h00-04h00.
- Normal hours: 04h00-09h30; 11h30-17h00; 20h00-22h00.

The electricity price will change differently with each time frame, and the load graph will change.





Therefore, it is necessary to consider charging electric vehicles at these time frames to avoid overloading the grid. The time frame chart is shown in Fig. 8. VND/kWh



Fig. 8. Electricity price when charging EVs in time frames.

Some critical requirements for the MG grid when integrating EVs using the conditions of operation of the electrical distribution system in Vietnam's Circular No. 39/2015/TT-BCT, stipulating the electrical distribution system [12] and the Circular No. 30/2019/TT-BCT [21], [22]. Besides the rapid development of electric vehicles, charging stations are also being built and combined with gas stations in

Vietnam. Depending on customers' needs, these charging stations are installed with different capacities tailored to the specific usage conditions. There are three types of Vinfast popular charging stations today: charge level 1, charge level 2, and charge level 3 [12].

- Charge Level 1: This charger is used in households and residential areas. The station is designed with an output capacity of 2.2 kW. The charging time is approximately 19.4 hours, and the current is 10A with a voltage range of 85-365VAC. This charger has a low investment cost and is easy to transport to any area.
- Charge Level 2: This is a DC fast charging station with a 30kW capacity, typically used at rest stops and public parking areas. Short charging time, reducing from 40 minutes to 120 minutes for an 80% battery charge. The 3-phase charging station's input voltage ranges from 304 to 465 VAC.
- Charge Level 3: This is a 250kW DC super-fast charging station for commercial centres and public parking lots. The electric vehicle's DC power supply is directly supplied, the operating voltage is 400VAC, and the output voltage is about 200-1000VDC.
- <u>Table 1</u> shows the characteristics of the three charging levels.

Parameters	Level 1	Level 2	Level 3
Operating Voltage	85-305V	304-465V	400V
Operating frequency	50Hz	50Hz	50Hz
Charger Speed	Slow	Fast	Rapid
Power	2.2kW	<60kW	250kW
Charging duration	19.4h	40-120 min	<30 min
The number of charging posts	1	2	1
Loacations	Home	Public, workplace	Public

## Table I: Three Charging Types of Electric Vehicles.

Some requirements when integrating electric vehicles into the MG grid include power supply voltage, frequency and power loss. The MG operates by these requirements to maintain a stable and reliable grid.

Vietnam's electricity system has a nominal frequency of 50 Hz. The requirements for operating the power grid with frequency are as follows:

- Normal operation mode:  $49.8Hz \le f \le 50.2Hz$
- Unstable operation mode:  $49.5Hz \le f \le 50.5Hz$

## **B.** Simulation results

In this section, the authors simulate MG with EVs in MATLAB. There are two typical seasons of the year, winter and summer. During winter, wind power output increases significantly due to high wind speeds. On the contrary, in the summer, solar energy will generate much power when solar radiation is high. Wind Power's capacity depends on wind speed. With increased wind speed, the output power of wind power increases. On the contrary, the output power will decrease if the wind speed decreases. Additionally, the wind power capacity is 6 MW, and the capacity fluctuates between summer and winter. During the peak time frame, from 18:00

to 19:30, the primary energy source is a diesel turbine, which accounts for approximately 83% of the total grid generating capacity. Meanwhile, solar cells and wind energy capacity are 0% and 14.5%, respectively. The period from 10:00 to 15:30 is when PV creates power for the grid. The primary energy source is the solar farm, which accounts for approximately 46% of the total grid's generating capacity. Meanwhile, diesel turbines and wind power energy are 47% and 7%, respectively.

Finally, from 4:00 to 5:00, the lowest load demand is approximately 3.3 MW. Additionally, wind capacity is approximately 1.8 MW, accounting for 54% of the total grid capacity. The ability of the MG grid to utilise renewable energy sources is shown in the figure below.

Published By: Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP) © Copyright: All rights reserved.





Fig. 9. The total capacity of the load and the Microgrid in summer

Similarly, the power consumption of the load in winter has decreased significantly. Additionally, the power generated by solar farms is approximately 2.5 MW, while wind energy contributes around 4 MW, accounting for 70% of the total at peak hours. The load graph in winter is shown in Fig. 10. Next, the EV component is considered when integrating it into the MG system. Between 17:00 and 19:00, the power consumption of the load reaches up to 14.5 MW, which typically occurs when people return home from work and tend to charge their vehicles.





Currently, the diesel generator's capacity is at 89% of the total grid capacity. Additionally, the Energy storage component is mobilised to compensate for power, accounting for approximately 0.19%. Fig. 11 shows the total control of the MG and the energy consumed by the load when there is a random charging EV, the total power of the MG when algorithms 1 and 2 (LMA) are active. The power consumption of the load did not exceed the maximum capacity threshold of the MG grid.





In winter, the power consumption of the load decreases compared to summer, so the number of EVs participating in the grid and affecting the grid will be less. However, there will still be an overload on the grid at some point. The number of EVs integrated randomly in the grid when algorithms 1 and 2 are applied. Thus, the total power load consumption does not exceed the capacity limit of the MG.





Fig. 13. Voltage measured at Solar Farm.

Figure 13 demonstrates the measured voltage of the Solar Farm over 24 hours. Sometimes, when there is a change in load switching or a large number of electric vehicles participate, fluctuations in the power grid's voltage occur.

Published By: Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP) © Copyright: All rights reserved.







Fig. 14. Voltage measured at Solar Farm (a) from 11h30 to 13h30; (b) from 5h00 to 7h30; (c) between 21h00 and 22h30; (d) from 2h00 to 3h00



Fig. 15. Voltage measured at Solar Farm (a) from 11h30 to 13h30; (b) from 5h00 to 7h30; (c) between 21h00 and 22h30; (d) from 2h00 to 3h00



Fig. 14a shows a voltage deviation of wind power of approximately 0.28% between 3:00 and 5:00. Especially in Figure 14b, between 17:00 and 19:00, the voltage drop increased to 5.43%, exceeding the allowable limit of the power grid. In addition, Figs. 14c and 14d, between 21:00 and 22:30 and 2:00 to 3:00, detail transient components with magnitude amplitude deviations of 0.218% and 0.213%.

Fig. 15a shows the voltage deviation of the solar farm during the period from 3:00 to 5:00, approximately 1.77%. Fig. 15b shows that the voltage drop during peak hours, from 17:00 to 19:00, is 4.62% when there is a high demand for equipment. Additionally, the figures of 2.33% and 2.12% correspond to the voltage deviations in the hours from 21:00 to 22:30 and 3:00 to 4:30.



Fig. 16. Power losses in MG (a) with random EVs; (b) with MLA Algorithm

Fig. 16. a depicts the power loss of the power grid during the periods from 11:00 to 12:30 and from 18:00 to 19:30, with a maximum power loss of approximately 120 kW. Additionally, Fig. 16b illustrates power deviation with intelligent power and load management algorithms. The power loss of the grid has been reduced to approximately 60 kW.

Finally, when integrating EVs into the grid, frequency is considered.

Fig.17 illustrates the effect of EV on the grid frequency. Between 5:00 and 6:30, the grid frequency drops to 49.4 Hz, resulting in a frequency difference of approximately 1.2%. Similarly, the frequency during the period from 18:00 to 19:00 ranges from approximately 49.48 Hz to 50.45 Hz. Meanwhile, figure 17. shows the results when using the LMA algorithm in tram control. The results show that the frequency within approximately 24 hours is within the allowable value of the power grid.



Fig. 17. Frequency of the MG when integrating EVs (a) with random EVs; (b) with LMA Algorithm



Retrieval Number: 100.1/ijeat. A42831013123 DOI: 10.35940/ijeat.A4283.1013123 Journal Website: www.ijeat.org

Published By:



# V. CONCLUSION

In this paper, a model of island microgrids in Vietnam has been built utilising renewable energy sources. Additionally, they are integrating grid-connected Electric Vehicles to evaluate the technical criteria of the MG grid by national standards. The simulation results show that when the EV is combined, the voltage at the nodes decreases beyond the allowable limit and the power loss increases. Utilising two power optimisation algorithms and load management helped mitigate the impact of high EV penetration. Wind speed variation and radiative variation related to the grid's operating capacity were analyzed, and it was determined that the proposed design of V2G and the MG efficiently regulate all the parameters. In the future, with many optimisation algorithms applied to operate integrated grid EVs, it will help improve the efficiency of energy sources, allowing loads to be managed more effectively. The proposed method needs to be tested with large-scale island grids in Vietnam.

## ACKNOWLEDGMENT

I would like to express my sincere gratitude to the Faculty of Electrical and Electronics Engineering at Vietnam Maritime University for their constant support throughout this research project. I thank the Department of Electrical Engineering, School of Electrical and Electronic Engineering, Hanoi University of Science and Technology, Vietnam.

Funding/ Grants/ Financial Support	No, I did not receive.
Conflicts of interest	No conflicts of interest to the best of our knowledge.
Ethical Approval and Consent to Participate	No, this article does not require ethical approval or consent to participate, as it is based on evidence.
Availability of Data and Material/ Data Access Statement	Not relevant.
Authors Contributions	All authors have equal contributions to this article.

#### **DECLARATION STATEMENT**

#### REFERENCES

- Alam, Md Tanvir, Se-Won Park, Sang-Yeop Lee, Yean-Ouk 1. Jeong, Anthony De Girolamo, Yong-Chil Seo, and Hang Seok Choi, "Co-Gasification of Treated Solid Recovered Fuel Residue by Using Minerals Bed and Biomass Waste Blends," Energies *13*, no. 8 (2081), 2020, pp. 1-16. https://doi.org/10.3390/en13082081
- Park S-W, Lee J-S, Yang W-S, Alam MT, Seo Y-C, "A 2. comparative study of the gasification of solid refuse fuel in downdraft fixed bed and bubbling fluidised bed reactors," Waste and Biomass Valorisation, vol 11:2345 56, 2020, vol. 11 pp. 1-12. https://doi.org/10.1007/s12649-018-0431-6
- Imteaz MA, Shanableh A, Rahman A, Ahsan A, "Optimization 3 of rainwater tank design from large roofs: A case study in Melbourne, Australia," Resource Conserve Recycle, vol. 55, 1022-1029. 2011. pp. https://doi.org/10.1016/j.resconrec.2011.05.013
- International Renewable Energy Agency (IRENA), " 4. Renewable energy statistics," 2021, [Online]. Available:

Retrieval Number: 100.1/ijeat. A42831013123 DOI: 10.35940/ijeat.A4283.1013123 Journal Website: www.ijeat.org

https://irena.org/publications/2021/Aug/Renewable-energystat istics-2021.

- BP Statistical Review of World Energy, [Online]. Available: 5. https://www.bp.com/en/global/corporate/energy-economics/st atistical-reviewof-world-energy.html.
- Dzobo, Oliver, Awodele, "Kehinde.Probabilistic Power 6. Reliability Assessment," Distributed Renewable System Energy Sources, 2021. pp.1-8. https://doi.org/10.4018/978-1-7998-9152-9.ch028
- Green II RC, Wang L, Alam M, "The impact of plug-in hybrid 7. electric vehicles on distribution networks: a review and outlook," Renew Sustain Energy Rev, vol. 15, 2011, pp. 544-553. https://doi.org/10.1016/j.rser.2010.08.015
- Shaaban MF, Atwa MY, El-Saadany EF, "PEVs modelling and 8. impacts mitigation in distribution networks," IEEE Trans Power vol.22, 2013, 1122-1131. System, pp. https://doi.org/10.1109/TPWRS.2012.2212467
- Lund, H., Munster, E., "Integrated transportation and energy 9. sector CO2 emission control strategies," Transport Policy 13, 2006, 426-433. vol. 5, pp. https://doi.org/10.1016/j.tranpol.2006.03.003
- Saffar, Afsaneh & Ghasemi, Ahmad, "Energy management of 10 a renewable-based isolated micro-grid by optimal utilization of dump loads and plug-in electric vehicles," Journal of Energy Storage, 39. 2021, vol pp. 1-13 102643. https://doi.org/10.1016/j.est.2021.102643
- Tran. Q.T. Davies. K, Sepasi. S, "Isolation Microgrid Design 11. for Remote Areas with the Integration of Renewable Energy: A Case Study of Con Dao Island in Vietnam," Clean Technology, 2021, 804-820. vol. 3. pp. https://doi.org/10.3390/cleantechnol3040047
- Nguyen, Nam Hoai, Quynh T. Tran, Thao V. Nguyen, Nam 12. Tran, Leon Roose, Saeed Sepasi, and Maria Luisa Di Silvestre, "A Method for Assessing the Feasibility of Integrating Planned Unidirectional EV Chargers into the Distribution Grid: A Case Study in Danang, Vietnam," Energies 16, no. 9: 3741, 2023, pp. 804-820. https://doi.org/10.3390/en16093741
- Dan T. Ton, Merrill A. Smith, "The US Department of 13. Energy's microgrid initiative," The Electricity Journal, vol. 15, issue 8, 2012, pp. 84-94. https://doi.org/10.1016/j.tej.2012.09.013
- Saffar, Afsaneh, Ghasemi, Ahmad, "Energy management of a renewable-based isolated micro-grid by optimal utilization of dump loads and plug-in electric vehicles," Journal of Energy Storage. vol. 39. 2021, 1-13. pp. https://doi.org/10.1016/j.est.2021.102643
- 15. Deng. Changhong, Ning Liang, Jin Tan, and Gongchen Wang, "Multi-Objective Scheduling of Electric Vehicles in Smart Distribution Network," Energy Conversion and Management, vol. 79, 2014, pp. 43-53. https://doi.org/10.3390/su8121234
- 16. Mahela Om, Khan Baseem, Pachauri, Rupendra, "Development of Vehicle-to-Grid System to Regulate the System Parameters of Microgrid," Energy Engineering: Journal of the Association of Energy Engineers, vol. 119, no. 4, 2021, pp. 1262-1298. https://doi.org/10.32604/ee.2022.018913
- 17. NSRDB Data Viewer. Available online: https://nsrdb.nrel.gov/data-viewer.
- Tan.Kang, Ramachandaramurthy.Vigna K, Yong.Jia Ying, 18. "Integration of electric vehicles in smart grid: A review on vehicle to grid technologies and optimization techniques," Renewable and Sustainable Energy Reviews, vol. 53, 2016, pp. 720-732

# https://doi.org/10.1016/j.rser.2015.09.012https://doi.org/10.10 16/j.rser.2015.09.012

Fazelpour. Farivar, Vafaeipour. Majid, Rahbari. Omid, Rosen. 19. Marc, "Intelligent optimization to integrate a plug-in hybrid electric vehicle smart parking lot

with renewable energy resources and enhance grid characteristics," Energy Conversion and

anced Tech lentuol lenoitematin xploring Innovation

Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP) © Copyright: All rights reserved.

Published By:

vol.77, 2014, 250-261. Management, pp. https://doi.org/10.1109/TSG.2011.2159816

- 20. Deilami. Sara, Masoum. Amir, Moses. Paul, Masoum. Mohammad, "Real-Time Coordination of Plug-In Electric Vehicle Charging in Smart Grids to Minimize Power Losses and Improve Voltage Profile," Smart Grid, IEEE Transactions, 2011, 456-467. vol. 2. pp. https://doi.org/10.1109/TSG.2011.2159816
- 21. Ministry of Industry and Trade. Circular Stipulating the Electrical Distribution System. [Online]. Available: http://vepg.vn/wp-content/ uploads/2020/07/39\_2015\_TT-BCT\_296868\_EN.pdf
- 22. Circular No. 30/2019/TT-BCT Amendments and Supplements to Several Articles of Circular No. 25/2016/TT-BCT and Circular

System. [Online]. Available: https://thuvienphapluat.vn/van-ban/Thuongmai/Thong-tu-30-2 019-TT-BCT-sua-doi-Thong-tu-25-2016-TT-BCT-39-2015-T T-BCT-he-thong-dien-phan-phoi-428704.aspx.

## **AUTHORS PROFILE**



Nguyen Van Hung received his B.E. degree in Automation of Electric Power Systems at Vietnam Maritime University. He currently works at the Faculty of Electrical and Electronics Engineering at Vietnam Maritime University. He is experienced in Virtual Reality substation projects and high-voltage equipment. He has received numerous national awards for his scientific research, particularly for his work with students. In addition, he is researching renewable energy, smart grids, wave and ocean

power, and wireless power transmission.



Nguyen Quoc Minh holds a degree in Engineering, majoring in electrical systems, Hanoi University of Science and Technology, 2007, Master's degree, majoring in electrical engineering, Hanoi University of Science and Technology, 2009 and PhD, majoring in electrical engineering, The University of Texas at Arlington, Texas, USA, 2016. He is a lecturer at the Department of

Electrical Engineering at Hanoi University of Science & Technology, Hanoi. His research interests include the Protection and control of electrical systems, SCADA and automation in electrical systems and the Application of AI in Smart Grid and Wireless Power Transmission. He has published 30 research papers in national and international journals, as well as conference proceedings.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of the Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)/ journal and/or the editor(s). The Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP) and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

