Impact of Duyen-Hai Wind Farms on Tra-Vinh Power Transmission Systems

Thanh-Nhan Vo, Van-Tan Tran, and Hoa Minh Nguyen

Abstract – ***This study has estimated energy production and simulated the impacts of four planned wind farms on the local power systems in the southern Vietnam. The WAsP 10.0 software, a commercial software package, was used to simulate and estimate the energy production of Tra-Vinh (30 MW) WFs. The results show that the WFs could avoid about 32 million ton of carbon dioxide emitting the air annually. The impacts of the WFs on the local power system were simulated by using the ETAP 7.0 commercial program. Three case studies, which are wind disturbance, tripping off a WF and three-phase fault, were investigated. The results point out that there were only slight impacts from the WFs on the local power systems.***

Keywords: ***CO_2 emission, transient stability, three-phase fault, wind farm, wind disturbance.***

I. INTRODUCTION

In the last decade, there has been fast development of wind energy worldwide. At the end of 2017, the global cumulative installed capacity was 2,094 MW [1], of which China had the largest installed capacity amounting to 37% of total installed capacity. Wind energy is green, free and inexhaustible. Recently, researchers have shown an increasing interest in wind energy potential and impacts of wind farm on power distribution systems. The prospects for wind farm development in Algeria were analyzed in [2-5]. The researchers pointed out that a wind farm of 30 MW installed capacity could avoid of 23,252 tones/year of CO_2 entering into the environment [4]. Wind energy at three stations in Algeria was investigated with 30 MW installed rated capacity at each site [5, 6]. In Taiwan, researchers have pointed out that Penghu is a promising area for developing wind farms [7-9]. The impacts of 10 onshore planned wind farms on the Penghu network was analyzed in [10]. Wind energy potential at four locations in Jordan was investigated in [11]. The study showed that if developed, the wind farms could produce 18,900 GWh annually. A wind farm with 20 MW installed capacity in Saudi Arabia was analyzed in [12]. The results pointed out that the wind farm could produce 59.073 GWh each year with plant capacity factor 33.7%. Other researchers have focused on the impact of wind farms on power system stability. The short term voltage stability of large wind farms was examined by using the PSS/E tool [13]. The impact of wind power on the transient fault behavior of the Nordic power system was investigated in [14]. An aggregate model of an offshore wind farm comprising 72 wind turbines of 2 MW rated capacity each was used in a voltage stability analysis [15].

In Vietnam, researchers have shown an increasing interest in wind energy. There is about 31,000 km^2 of land available for the development of wind energy [16]. The most windy area is in Nha-Trang province with mean wind speed over 10 m/s [17]. The impact of wind power generation and CO_2 emissions on future fuel choices was shown in [18]. A wind farm of 99 MW installed capacity in Bac-Lieu province could produce 332 GWh and prevent 232,470 tons of CO_2 annually [19]. So far, however, there has been little discussion about the impact of wind farms on power system stability. This study has simulated impacts of four planned wind farms on power network in the Tra Vinh Province, Vietnam. Figure 1 shows the location of six planned wind farms and power transmission systems in the Tra Vinh Province, Vietnam [20].

This study is divided into 4 sections: Following the introduction is a site description section. Section 3 is Impact of wind farms on power system. Finally, conclusions will be drawn.

II. SITE AND SYSTEM DESCRIPTION

The wind farms are located in Tra Vinh Province of Vietnam. Wind data was supported by Department of Industry and Trade of Tra Vinh Province. Figure 2 shows the wind energy potential. The wind farms are offshore so there are no obstructions to wind flow or speed.

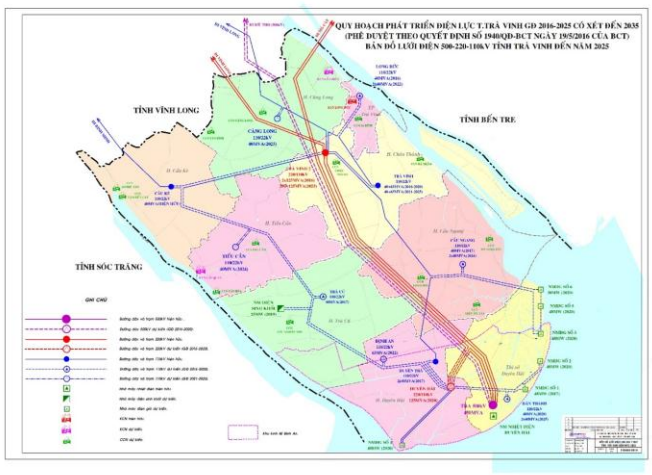


Figure 1: *Wind farms and power transmission system in Tra Vinh Vietnam*

The south of Vietnam has only two seasons: sunny (from October to April) and rainy (from May to September). The average monthly rainfall is 164.7 mm. The average annual temperature, relative humidity and atmospheric pressure are 27.6°C, 81.5% and 100.9 kPa, respectively [22].

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Figure 1 shows the power transmission system in southern Vietnam. Maximum voltage of the system is 500 kV. The installed rated capacity of power generation is 4,400 MW. The total load is 170 MW. The wind farms are connected to power systems on the mainland by underground cables of 11-kV rating.

Figure 2 shown the wind speed simulation in the planning area at the high 80 m.

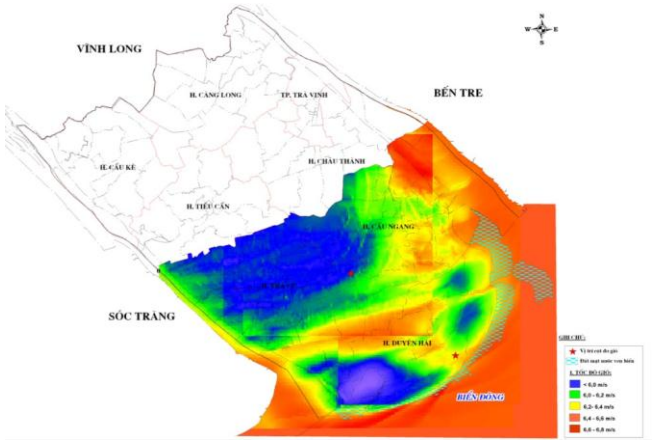


Figure 2. *wind farms in practical locations, shown by WAsP simulation tool*

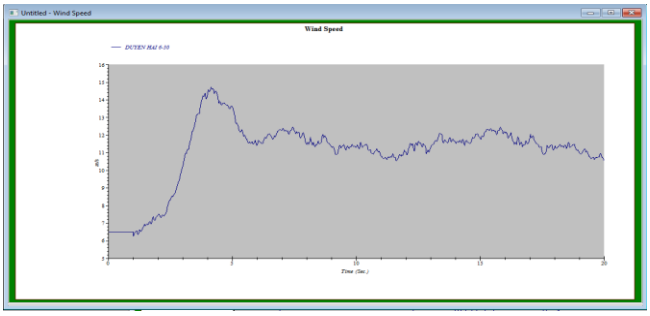


Figure 3. *Wind speed disturbance*

III. IMPACT OF WIND FARMS ON POWER SYSTEM

A. *Wind speed disturbance*

We assume that the wind speed disturbance as shown in Figure 3. Wind speed increased from 6.5 m/s to 15 m/s in 4 s. After disturbance stopped, wind speed of each wind farm was stable at 12 m/s with noise as shown in Fig. 4. The wind speed disturbance at Tra-Vinh occurred at 1 s. It can be observed that the wind speed disturbance of a wind farm affect real power output of wind farms. In addition, the voltage at Tra-Vinh WF was affected a little when the wind speed disturbance.

Figure 5 shows the voltage of the bus WF connected. In the second and the third disturbance, the voltages of buses were almost the same as those in normal condition. These findings suggest that in general, wind speed disturbance of WFs did not affect bus voltage, to which the WFs were connected.

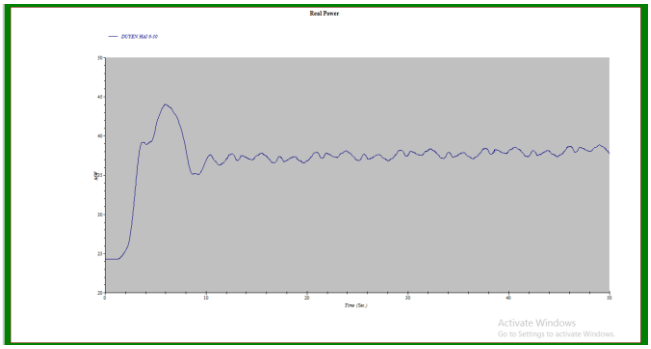


Figure 4. *Power out put at the wind farm 30 MW*

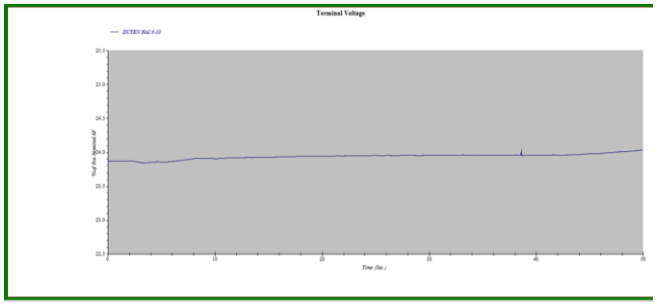


Figure 3. *Wind speed disturbance impact on bus voltages*

B. *Three phase fault*

Figure 6 shows the wind farms' dynamic behavior when a three phase fault occurred at the Cau-Ngang bus. The fault occurred at 0.2 s and was cleared after 1 s. The voltage at WFs dropped immediately to zero at Cau-Ngan bus and 10 kV at Duyen-Hai bus. After the fault was cleared at 1 s, the voltages of WFs returned to normal. The fault did not much affect WFs stability.

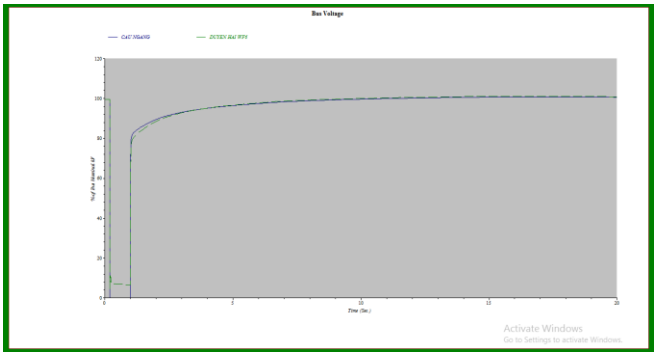


Figure 6. *Bus voltage of wind farm and Cau Ngang bus*

IV. CONCLUSION

This study is based on practical planned wind farms in the Tra Vinh Province, Vietnam, to estimate the energy production and CO_2 emission reduction, and to simulate the impacts of wind farms on local power system networks. The following conclusions can be drawn:

- 3 MW wind turbine for all WFs will produce the most energy. The total energy production of the WF, if well developed, will be 172 GWh annually.
- The wind farm will avoid 32,544 tCO2 emitting into the air.

- Wind speed disturbance will not significantly affect the wind farms or the bus voltages around wind farms. The bigger wind farm will affect other wind farms more than that of the smaller.
- A three-phase fault at the bus near a wind farm will not cause any wind farm to trip off.

This study estimated and simulated the practical planning for wind farms in the southern Vietnam in various possible transient cases. The results point out that there will cause only slight impacts from the operation of WFs on the local power systems. The results should contribute to the development of wind farms in the southern Vietnam.

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