Binh Thuan Province
Wind Power Master Plan

MOIT/GIZ Support to the Up-Scaling of Wind Power
Imprint

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INTRODUCTION
Introduction

Binh Thuan has significant wind potential that is feasible to develop large scale wind power projects. Nevertheless, investment in wind power requires essential criteria such as wind resource, land usage, grid connecting capacity, etc. In order to support investors/developers, each province with good wind potential e.g. Binh Thuan, carries out a study to develop its own Provincial Wind Power Master Plan. The study then is submitted to the Ministry of Industry and Trade (MOIT) for approval.

In the first phase of the wind power project development process, i.e. the preliminary development, project developers/ investors can investigate areas defined in the Provincial Wind Power Master Plan. In case the project developers/ investors are interested in areas not defined in the Provincial Wind Power Master Plan, they have to submit their project proposals to the MOIT for approval. These procedures are introduced in details in the MOIT/GIZ Wind Power Investment Guidelines (2016).

This document will assist project developers/investors to obtain a better understanding of the Provincial Wind Power Master Plan, and make a decision for the next step of the development process. The process to develop provincial wind power master plan includes the following major steps:

- Evaluation of wind potential based on Vietnam wind resource map and reference met masts in the province. From the data, allocate technical wind potential areas (zones with average wind speed above 6 m/s).
- Using GIS map to exclude areas which are not suitable for wind development based on land use law. The remaining areas are potential for wind power planning.
- Defining priority areas with average wind speed above 6.5 m/s for investment (economic wind potential) from present to 2020 with a vision to 2030.
- Based on Provincial Wind Power Master Plan to propose the connection schemes of wind farms to the grid.

The methodology and development process of Binh Thuan Province Wind Power Master Plan are presented in details in the following sections.
Chapter 01
General Information
1. General Information

![Geographical map of Binh Thuan](image)

Source: Power Engineering Consulting Joint Stock Company 3 (PECC3)

Figure 1. Geographical map of Binh Thuan
Chapter 1 – General Information

1.1 Geographical location

Binh Thuan is a coastal province of southern central area of Vietnam. It is located in south-east economic zone, influenced by the Southern Key Economic Zone. Binh Thuan has an area of 7,828.5km$^2$ with a coastal length of 192km; it shares borders to Lam Dong Province and Ninh Thuan Province to the North, Dong Nai Province to the West, Ba Ria-Vung Tau Province to the South and East Sea to the East and Southeast. The island Phu Quy is located approximately 120km southeast of Phan Thiet.

The distance from the center of Binh Thuan Province to Ho Chi Minh City is 200km and to Nha Trang City is 250 km.

1.2 Population

Binh Thuan population was 1,187,559 in 2008. Population density was 152 people/ km$^2$. Population is not evenly distributed as most inhabitants settle in the delta regions near Phan Thiet River, La Nga River, Luy River and Long Song River. In Tuy Phong and Bac Binh regions, population is highly concentrated in coastal delta regions.

1.3 Topography

Binh Thuan province stretches approximately 160km along the east coast from northeast towards southwest direction; 95 km width with the narrowest spot is 32km wide. The north is bounded by ending massifs of Truong Son Range, the south are run along by the sand hills. Most of Binh Thuan’s territory is made of low hills as well as low mountains and coastal plains. Binh Thuan’s topography can be classified into 4 different categories as follow:

<table>
<thead>
<tr>
<th>Topographical category</th>
<th>Average altitude (m)</th>
<th>Distribution region</th>
<th>Percentage of area (%)</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average-elevated mountains</td>
<td>500</td>
<td>North, northwest</td>
<td>31.65</td>
<td>Steep and comprises of complex terrains, most of which are protection forests</td>
</tr>
<tr>
<td>Low-elevated hills</td>
<td>200-500</td>
<td>Tuy Phong plain (Long Song), Phan Ri, Song Mao (Song Luy), Phan Thiet (Song Quao, Ca Ty), Duc Linh, Tanh Linh (La Nga River)</td>
<td>40.7</td>
<td>Mainly forest land and forests</td>
</tr>
<tr>
<td>Silt deltas</td>
<td>5-10</td>
<td>Tuy Phong plain</td>
<td>9.43</td>
<td></td>
</tr>
<tr>
<td>Coastal sand dunes and hills</td>
<td>100-200</td>
<td>Along the coast from Tuy Phong to Ham Tan</td>
<td>18.22</td>
<td>Composed of wavy-shaped sand hills</td>
</tr>
</tbody>
</table>

Table 1. Topographical features of Binh Thuan

Topographic features of Binh Thuan facilitate the development of a diversified economy; however they also make economical production and daily life challenging.

1.4 Climate

Binh Thuan is located in the most arid region of the country and falls within the monsoon tropical climate region with plenty of sunshine and wind.

Average temperature varies from 26.5°C to 27.5°C.
Chapter 1 – General Information

There are 2 distinct seasons: rainy season from May to November and dry season from December to April of the following year. This region is slightly affected by hurricanes. Annual average precipitation ranges from 800 to 1600 mm/year, which is lower than the national average. Average relative humidity per year ranges from 79% to 81%.

Wind: Main wind direction is north-northeast (from November to April of the following year) and west-southwest (from May to October). Monthly average wind speed at 12m altitude is between 2.3m/s and 4.0m/s. Annual average wind speed is 3.1 m/s.

1.5 Socio- economic conditions

The global economic recession in 2009 and overall difficulties of the whole country had a great impact on the national economy. However, in 2009 Binh Thuan obtained several changes and positive achievements in socioeconomic conditions. Estimated gross domestic products (GDP) including hydropower in 2009 reached VND19,791 billion. If the price factor was excluded, GDP would increase by 10.1% compared to that of the previous year; in which agriculture, forestry and fishery sectors development rate increased by 5.4%, industry and construction group rose by 11.3%, service group increased by 12.7%.

In the overall growth rate of 10.1%, agriculture, forestry and fishery sectors contributed 1.5%, industrial and construction sectors contributed 4.2% and service sector contributed 4.4%. There has been a shift in the economic structure: agriculture-forestry-fishery group accounted for 22.6% compared to 24.4% in 2008; industrial and construction group's contribution is 34.4% compared to 34.2% in 2008; service sector accounted for 43% compared to 41.4% in 2008. GDP per capita in 2009 reached VND16.9 million (equivalent to US$937).

1.6 Current and future economic development plan

The orientation for socioeconomic development is based on the Socioeconomic Development Plan until 2020 of Binh Thuan Province approved by the Prime Minister.

Overall objectives:

- Develop Binh Thuan to become a modernized and dynamic industrial services province. A modern socioeconomic infrastructure will be formed and synchronized to the nation standards. Economical production relation will become more advanced and people’s living standards will continuously be improved.

- The overall socioeconomic development plan of Binh Thuan determines the growing rate during the period from 2011 to 2016 which ranges between 13.0 and 14.3% per year and throughout 2016-2020 this target will vary between 12.0 and 12.8% per year. Economic structure will undergo a strong shift towards industrialization and modernization; until 2015 industry-construction sectors will account for 45.6% of the GDP of the province and will increase to 47.72% in 2020.

- Regarding industrial development, the energy sector (including thermal, hydro and wind energy) will act as a major leverage for economic shifting. Estimated value of energy production and distribution will account for 60-65% gross industrial production value in 2015 and 2020 (according to the "Draft of Industry Development of Binh Thuan until 2020 with the outlook towards 2025").
Chapter 02
Binh Thuan Provincial Power Development Plan
2. Binh Thuan Provincial Power Development Plan

2.1 Current supply and demand

2.1.1. Energy supply sources

The power supply of Binh Thuan comes from energy sources produced and fed into the national grid which includes:

- Ham Thuan hydropower plant, which consists of 2 generator sets, each of which has the installed capacity of 150 MW. Electricity is transmitted to the 220kV power grid via 3 routes: route 271 connecting to Da Mi hydro power plant, route 272 to the 220kV- power- station Long Thanh and route 273 to the 220 kV-power-station Bao Loc. At the moment, another route connecting to the 220kV power station Phan Thiet is being deployed. Electricity is transmitted to the 110kV power grid via 3 routes: route 173 to Duc Linh power station, route 171 and 172 to Phan Thiet power station.

- Da Mi hydropower plant, which consists of 2 generator sets with the installed capacity of 2x 87.5 MW. Electricity is transmitted to the 220kV power grid via 2 routes: one connecting to Ham Thuan hydropower plant, the other route to Long Thanh station.

- Dai Ninh hydropower plant, which consists of 2 generator sets with the installed capacity of 2x150 MW. Electricity is transmitted to the 220kV power grid via 2 routes, one of which connecting to 500/220 kV Di Linh power station and the other via 110kV-station Phan Ri connects to Dai Ninh.

- Bac Binh hydropower plant which consists of 2 generator sets with the installed capacity of 2x16.5 MW. Electricity is transmitted to the 110kV power grid at the distribution center of Dai Ninh hydropower plant.

2.1.2. Power grid

Currently, in Binh Thuan the electricity load is powered from seven 110kv stations as listed in the following table:

<table>
<thead>
<tr>
<th>No.</th>
<th>Station’s name</th>
<th>Voltage (kV)</th>
<th>Capacity (MVA)</th>
<th>$P_{max}/P_{min}$</th>
<th>No. of 15-22kV routes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Phan Thiet</td>
<td>110/22</td>
<td>63+40</td>
<td>61.8/23.2</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>Luong Son</td>
<td>110/22</td>
<td>25</td>
<td>19.2/7.0</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Phan Ri</td>
<td>110/15</td>
<td>16+25</td>
<td>15.8/9.8</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Ham Tan</td>
<td>110/22/15</td>
<td>40</td>
<td>15.9/9.8</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Duc Linh</td>
<td>110/22</td>
<td>25</td>
<td>15.4/7.7</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Thuan Nam</td>
<td>110/22</td>
<td>2x40</td>
<td>47.7/5.5</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>Mui Ne</td>
<td>110/22</td>
<td>40</td>
<td>12.8/7.9</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 2. Existing 110kV stations of Binh Thuan
In the future, according to Binh Thuan Provincial Power Development Plan, in order to meet the continuously rising power demand, several existing power stations will be improved to increase their power capacity and new stations will be constructed.

Besides the 110kV power transmission line Duc Linh-Xuan Truong which is currently under construction, most of the 110kV grids in the area are interconnected in loops, the South point the power grid is connected to the one of Ba Ria-Vung Tau Province via the 110kV transmission line Xuyen Moc-Ham Tan, at the North point the grid is connected to the one of Ninh Thuan Province via the 110kV transmission line Phan Ri-Ninh Phuoc. However, under the “Evaluation” section of the Binh Thuan Provincial Power Development Plan, this connection is relatively weak due to long transmission line, resulting in voltage drop at the ending line, thus reducing power quality. A number of solutions have been proposed such as the construction of a 220kv station Phan Thiet to shorten the radius of the power supply, or connection of the 110kv line from Dai Ninh hydropower plant to Phan Ri station, etc.

2.1.3. Power demand

According to the provincial power development plan during the period 2006-2010, with the outlook towards 2015, the estimated annual growth rate of commercial power in Binh Thuan is 17.6%/year (from 2006-2010) and 16.4%/year (2011-2015).

Maximum power in 2010 would be $P_{\text{max}}=182\text{MW}$, equivalent to 884 million kWh of commercial power. In 2015, the forecasted $P_{\text{max}}$ is 363 MW, or 1,886 million kWh of commercial power.

In fact, commercial power production of Binh Thuan in 2009 was 809,499,035 kWh, which increased by 21.8% compared to 2008 (664,614,429 kWh). This is a considerably high growth rate compared to other provinces and to the original plan.

2.2 Power generation and transmission development plan for 2020 with the vision for 2030

2.2.1. Power generation and transmission development plan for the 220-500kV power grid

*Power sources during the period 2001-2015-2020 (with the vision to 2025)*

According to Decision 1208/QĐ-TTg of the Prime Minister dated 21/07/2011 and the approved Decision 6949/QĐ-BCT dated 30/12/2010 of the Ministry of Industry and Trade, during the planning stage until 2020 there will be:

- Vinh Tan Power Center with the power of 5,668MW. This center consists of the following thermal power plants:

<table>
<thead>
<tr>
<th>Thermal power plant</th>
<th>Power (MW)</th>
<th>Voltage level(kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vinh Tan 1</td>
<td>2x600</td>
<td>500</td>
</tr>
<tr>
<td>Vinh Tan 2</td>
<td>2x622</td>
<td>220</td>
</tr>
<tr>
<td>Vinh Tan 3</td>
<td>3x660</td>
<td>500</td>
</tr>
<tr>
<td>Vinh Tan 4</td>
<td>2x622</td>
<td>220</td>
</tr>
</tbody>
</table>

*Table 3. Operating thermal power plants of Vinh Tan Power Center*
Figure 2. Map of current and planned power plants and transmission grids
• Son My Thermal Power Center with the power of 3,900MW at 220kV and 500kV voltage levels. This center has 2 thermal power plants:

<table>
<thead>
<tr>
<th>Thermal power plant</th>
<th>Power (MW)</th>
<th>Voltage level(kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Son My 1</td>
<td>5x390=1950</td>
<td>2015-2020</td>
</tr>
<tr>
<td>Vinh Tan 2</td>
<td>5x390=1950</td>
<td>2020-2025</td>
</tr>
</tbody>
</table>

Table 4. Operating thermal power plants of Son My Thermal Power Center

**Power grid**

• Period 2011 - 2015.

During this period, according to calculated data, it is required to put the 220/110kV-1x250MVA Son My (Ha Tan) power station into operation, while increasing the power of the 220/110kV Phan Thiet station to (125+250) MVA and that of the Dai Ninh station to (2x63)MVA.

• Period 2016 - 2020.

The power of the 220/110kV Son My (Ham Tan) station will be increased from 250MVA to 2x250MVA and that of the Phan Thiet station from (125+250)MVA to 2x250MVA.

**2.2.2. Planning of 110kV grid development**

**Period 2011-2015**

110kV line:

• Construction of a new 110kV line of 150.65km length.

• Construction and upgrade of the 2nd circuit of the 110kV line with the total length of 124.65km.

110kV power stations:

• Construction of 07 new 110kV substations with the total power of 296MVA.

• Increase the power of 7 110kV stations from total 354MVA to 651MVA.

**Period 2016-2020**

110kV line:

• Construction of a new 110kV line of 98.7km length.

110kV power stations:

• Construction of 04 new 110kV substations with the total power of 269MV.

• Increase the power of 13 110kV stations from total 821MVA to 1,346MVA.
Chapter 03

Wind Resource Assessment of Binh Thuan Province
Chapter 3 – Wind Resource Assessment of Binh Thuan Province

3. Wind Resource Assessment of Binh Thuan Province

3.1 Methodology

3.1.1. Initial data

Initial data used for wind power planning include:

- Wind atlas of Binh Thuan Province, which was extracted from “Wind Energy Resource Atlas of Southeast Asia” (World Bank) completed by True Wind Solution (USA) in 2001. This atlas has low resolution (1km) and is used for preliminary screening of potential wind regions.

- Wind monitoring data at some potential sites throughout the province: data of more than 10 met masts are available, however a number of met masts have not finished the one year cycle measurement (minimum criterion to properly assess wind potential in 1 area), moreover some met masts are too close to each other, and therefore their measurement data can be interchangeable. The assessment selected 3 typical sets of data collected at Tuy Phong, Bac Binh and Tien Thanh to analyze and create wind atlas in order to support the next phases of research and analysis.

- Digital maps of the current status and planning for provincial land use: an important document to identify areas potential for wind power planning. Although this map is not yet completed as it does not show the areas that are allocated or have mineral planning, the data is important for planning and can be later updated.

- Regulations on criteria for excluded zones and buffer zones for wind energy activities are temporarily used as the basis for planning while the national regulations have not been in place. These regulations were compiled by the MOIT and provided input data for the plan.

3.1.2. Tools and software

In addition to the common tools and software, the following specialized tools and software were used:

- MapInfo Pro.10.0 for maps and geographical information system.

- WAsP 8.0 (Wind Atlas Analysis and Application Program) for simulation and calculation of potential wind power.

- Google Earth.

- Handheld GPS (Global Positioning System).
3.2 Wind resource map of Binh Thuan province in details

Source: PECC3

Figure 3. World Bank's wind atlas at the altitude of 65m of Binh Thuan Province
Chapter 3 – Wind Resource Assessment of Binh Thuan Province

3.3 Data from reference met masts

3.1.3. Information on the reference met masts

- **Tuy Phong**
  
The met mast was constructed at Binh Thanh Commune, Tuy Phong in January 2005 under the framework of the project "Wind Energy for Power Generation in the southern coastal provinces of Vietnam" funded by EVN. This mast was moved to another location from February 2006. The monitoring data of this mast was used to create a color-coded wind potential map for Tuy Phong District.

- **Bac Binh**
  
The met mast was constructed in Hoa Thang Commune, Bac Binh District in October 2007. This mast was built and owned by PECC3 for consulting service. Until now, this mast is still operating properly. Monitoring results of this mast are used to create color-coded map of wind potential for the following districts: Bac Binh, Ham Thuan Bac, and northern Phan Thiet.

- **Tien Thanh**
  
The met mast was constructed in Tien Thanh Commune, Phan Thiet City in November 2007 within the framework of "Wind Energy of Tien Thanh". This mast was constructed and owned by AGECO Ltd in order to do measurements of wind potential for Tien Thanh Wind Power Project. This mast is still operating. Monitoring results of this mast are used to create color-coded maps of wind potential for the following regions: Ham Tan District, La Gi Town, Ham Thuan Nam, and southern Phan Thiet.

The wind data collected from the met masts include:

- **Wind speed at 12m, 40m and 60m height** (in Tuy Phong and Bac Binh districts). At 60m height, 2 sensors were used to measure wind speed with one in the vertical position, while the other is horizontal. In Tien Thanh, wind speed was measured at different heights of 60m, 50m and 40m.

- **Wind direction at 60m and 40m heights**. At Tien Thanh commune, wind direction was measured at 60m and 50m heights.

- **Temperature and pressure measured at 10m heights**.

The met masts collected and recorded average data every ten minutes into the memory card. Each measuring channel includes four values: average value, standard deviation, minimum and maximum calculated from data measured every two seconds.

Monitoring data was collected over a period of one year.
### 3.1.4. Wind monitoring data of reference met masts

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Average wind speed at 60m high (m/s)</td>
<td>6.71</td>
<td>6.27</td>
<td>5.96</td>
</tr>
<tr>
<td>Max wind speed during 10min(Vmax10') (m/s)</td>
<td>20.2</td>
<td>20.2</td>
<td>15.5</td>
</tr>
<tr>
<td>Instantaneous max wind speed (Vmax2'') (m/s)</td>
<td>24.9</td>
<td>26.2</td>
<td>21.4</td>
</tr>
<tr>
<td>Principal wind directions</td>
<td>Northeast</td>
<td>East-northeast</td>
<td>East-northeast</td>
</tr>
<tr>
<td></td>
<td>Southwest</td>
<td>Southwest</td>
<td>South-southwest</td>
</tr>
<tr>
<td>Period of low wind velocity</td>
<td>April, May, September, October</td>
<td>October</td>
<td>September</td>
</tr>
<tr>
<td>Period of high wind velocity</td>
<td>December, January</td>
<td>January</td>
<td>February</td>
</tr>
<tr>
<td>Difference between the highest wind speed and lowest wind speed (m/s)</td>
<td>4.1</td>
<td>4.7</td>
<td>3.62</td>
</tr>
<tr>
<td>Time of strongest wind</td>
<td>1am-5am</td>
<td>2pm-4pm</td>
<td>1am-5am</td>
</tr>
<tr>
<td>Corresponding Velocity (m/s)</td>
<td>9.3</td>
<td>9.2</td>
<td>7.19</td>
</tr>
<tr>
<td>Time of weakest wind</td>
<td>7pm-8pm</td>
<td>8am-9am</td>
<td>7am-8am</td>
</tr>
<tr>
<td>Corresponding Velocity (m/s)</td>
<td>5.2</td>
<td>4.5</td>
<td>3.57</td>
</tr>
<tr>
<td>Distribution frequency of wind velocity (m/s)</td>
<td>0-14</td>
<td>0-12</td>
<td>0-14</td>
</tr>
<tr>
<td>Frequency of wind velocities from 3m/s or more</td>
<td>91.28%</td>
<td>88.15%</td>
<td>92.95%</td>
</tr>
<tr>
<td>Wind density</td>
<td>305W/m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air density</td>
<td>1,225kg/m³</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Wind monitoring data of reference met masts
3.1.5. Wind atlas of the coastal area of Binh Thuan

Based on the calculation results of continuous series of data over one year at the chosen met masts, it can be seen that the average wind speed at 60m height along the coastal area of Binh Thuan Province decreases from North to South; from 6.71m/s at Tuy Phong to 5.96m/s at Tien Thanh; the wind speed varies by month.

- The maximum wind speed during 10 minutes (Vmax10′) is between 15.5m/s and 20.2m/s.
- The maximum instantaneous wind speed (Vmax2″) is between 21.4m/s and 26.2m/s.
- Two main seasonal wind directions are northeast and southwest.
- The months when the strongest wind occurs are from December to February (respective to the northeast monsoon) and when the lowest wind occurs are between September and October (respective to the monsoon transition period).
- During daytime, the average wind speed is relatively uniform. The strongest wind and weakest wind are 30% difference in speed. The strongest wind occurs during 1.00 to 5.00 and from 14.00-16.00 hours; whereas the weakest wind occurs during 7.00 to 9.00 or 19.00 to 20.00 hours.
- Wind speed in Binh Thuan ranges from 0m/s to 14m/s. Frequency of wind speed of more than 3m/s reaches over 88%.

Comparing this data with the corresponding results derived from meteorological data series from 1980 to 2005, it can be seen that there is a relative match between short-term data over 1 year and the long-term data series.
Figure 4. Wind atlas of Tuy Phong Commune based on Tuy Phong reference met masts
Chapter 3 – Wind Resource Assessment of Binh Thuan Province

Figure 5. Wind atlas of Bac Binh, Ham Thuan Bac, north of Phan Thiet based on Bac Binh reference met masts
Figure 6. Wind atlas of Ham Thuan Nam, south of Phan Thiet, La Gi Town, Ham Tan based on Tien Thanh reference met masts.
3.4 Technical wind potential

Based on the wind atlas and digital topographic map, areas of technical wind potential are identified as those which:

- Average wind speed is 6.0m/s.
- The topography are either flat or consist of small slope (smaller than 5\(^\circ\)).
- Have the possibility to access and connect to the national power grid.

Analytical results show that the total area having technical wind potential in Binh Thuan is 156,739 ha; accounting for 20% of the total area of the province. The table below shows the details of the results:

<table>
<thead>
<tr>
<th>Wind speed(m/s)</th>
<th>Area(ha)</th>
<th>Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.0-6.5</td>
<td>118,100</td>
<td>Tuy Phong, Bac Binh, Phan Thiet, Ham Thuan Bac, Ham Thuan Nam, La Gi</td>
</tr>
<tr>
<td>6.5-7.0</td>
<td>27,820</td>
<td>Tuy Phong, Bac Binh, Phan Thiet, Ham Thuan Bac, Ham Thuan Nam, La Gi</td>
</tr>
<tr>
<td>7.0-7.5</td>
<td>8,976</td>
<td>Tuy Phong, Bac Binh, Phan Thiet</td>
</tr>
<tr>
<td>7.5-8.0</td>
<td>1,809</td>
<td>Tuy Phong, Bac Binh</td>
</tr>
<tr>
<td>8.0-8.5</td>
<td>34</td>
<td>Tuy Phong</td>
</tr>
</tbody>
</table>

Table 6. Technical wind potential of Binh Thuan Province in details

3.5 Potential areas for Wind power planning

A region may be suitable for multiple land use purposes; however can only be assigned for one purpose at a time.

The DOIT of Binh Thuan issued several regulations on buffer zones and excluded zones for temporary use. Excluded zones are defined as areas whose land use is incompatible wind power. Buffer zones are defined as transition areas meeting the minimum parameter which make other areas unaffected by those planned for wind power development. Regulation details are summarized in table 7.

Additionally, the distance between wind turbines and the power transmission lines are temporarily specified to be at least 1.5 times the total height of the wind turbine from the ground to the wingtip of the turbine at its highest point(i.e. at the vertical position).

Results show that the total area potential for wind power planning in Binh Thuan is 75,468 ha, representing 9.6% the total area of the whole province.

Total installed wind capacity in the region is estimated to be approximately 5,030MW, which is calculated based on the total potential area for wind power planning and the assumption that the density capacity distribution of wind turbines is 1MW/15ha.
<table>
<thead>
<tr>
<th>No.</th>
<th>Purpose of land use as planned</th>
<th>Excluded zone</th>
<th>Buffer zone (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Arable land</td>
<td>X</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Land for fruit crops, industrial crops, annual crops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Forest land</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Land for salt production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Land for residence and office use</td>
<td>X</td>
<td>800</td>
</tr>
<tr>
<td>6</td>
<td>Land for military and security purpose</td>
<td>X</td>
<td>300</td>
</tr>
<tr>
<td>7</td>
<td>Land for industry, production and business use</td>
<td>X</td>
<td>300</td>
</tr>
<tr>
<td>8</td>
<td>Land for mineral mining activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Land for transportation</td>
<td>X</td>
<td>200 (from the outer-edge of the road safety corridor)</td>
</tr>
<tr>
<td>10</td>
<td>Land with rivers, lake and for irrigation purpose</td>
<td>X</td>
<td>300</td>
</tr>
<tr>
<td>11</td>
<td>Cemetery land</td>
<td>X</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>Conservation area</td>
<td>X</td>
<td>300</td>
</tr>
<tr>
<td>13</td>
<td>Tourist and religious sites</td>
<td>X</td>
<td>500</td>
</tr>
<tr>
<td>14</td>
<td>Virgin forests, ecological areas</td>
<td>X</td>
<td>300</td>
</tr>
</tbody>
</table>

Table 7. Regulations on excluded zones and buffer zones for wind power projects

<table>
<thead>
<tr>
<th>Average wind speed at 80m (m/s)</th>
<th>6.0-6.5</th>
<th>6.5-7.0</th>
<th>7.0-7.5</th>
<th>7.5-8.0</th>
<th>&gt;8.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (ha)</td>
<td>51,919</td>
<td>16,052</td>
<td>5,990</td>
<td>1,476</td>
<td>31</td>
</tr>
<tr>
<td>% of total area</td>
<td>6.6</td>
<td>2.0</td>
<td>0.8</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>Potential MW</td>
<td>3,461</td>
<td>1,070</td>
<td>399</td>
<td>98</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 8. Potential area distribution for wind power planning
3.6 Economic wind potential

Under current conditions, the areas having economic wind potential are defined to have the average wind speed higher or equal to 6.5m/s.

The area of Bình Thuan having economic wind potential is 23,549 ha, representing 3.0% of the total area of the province. The overall installed capacity of wind power within this region is estimated to be 1,570MW. This capacity is estimated based on the economic wind potential area of Bình Thuan, assuming that the density of capacity distribution is 1MW/15ha.

The economic wind potential area is distributed into regions with different wind speed levels. Details are given in table 9.

<table>
<thead>
<tr>
<th>Average wind speed at 80m</th>
<th>Average</th>
<th>Quite good</th>
<th>Good</th>
<th>Very good</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>16,052</td>
<td>5,990</td>
<td>1,476</td>
<td>31</td>
</tr>
<tr>
<td>% of the total area</td>
<td>2.0</td>
<td>0.8</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>Potential MW</td>
<td>1,070</td>
<td>399</td>
<td>98</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 9. Area distribution of economic wind potential in Bình Thuan
4. Binh Thuan Provincial Wind Power Master Plan for the period 2011 - 2020, with outlook towards 2030

4.1 Total potential capacity of wind power

The total potential wind power capacity which can be installed in Binh Thuan Province is estimated to be approximately 5,030MW.

4.2 Criteria for site planning

In order to evaluate the feasibility of a project in a local area, various factors are taken into consideration such as: investment rate, output of electricity production, electricity selling prices, the ability to sell credits for emission reduction, subsidy policy of the government, etc.

- **Investment rate:** currently investment rate into wind power is relatively high, which is approximately US$2 million/installed MW which is expected to not decrease in the near future, due to the overheating growth of wind power worldwide which creates an imbalance between supply and demand of the production of wind turbines and related equipment.

- **Output of electricity production** depends heavily on wind potential, represented by the average wind speed over the year.

- **Electricity selling prices:** in fact wind power selling price in the world (excluding subsidies from the state or consumers) are lower than production cost. This is typical for all clean or green electricity produced from renewable energy sources. At the end of June 2011 for the first time the Prime Minister issued Decision No. 37/2011/QĐ-TTg on supporting mechanisms to develop wind power projects in Vietnam. One of the important issues is that buyers are obliged to buy the entire electricity output of wind power projects at a price of US cent 7.8/kWh.

- **The ability to sell credits for emission reduction:** the Kyoto Protocol in December 1997 observed commitment from developed countries to reduce emission of greenhouse gases via three mechanisms, among which is the Clean Development Mechanism (CDM).

Financial ability and the ability to implement the project of the investor: due to large investment and difficulties in raising capital, investors tend to invest in phases to ease financial burdens and reduce risks.

4.3 Detailed project planning

4.3.1. Installed capacity planning

By 2020, the cumulative installed capacity is expected to reach 700MW, including 21 projects (areas) divided into 4 planning regions. These 21 projects are within the areas assigned for wind power planning, however some of which are not entirely of economic wind potential, which is due to the fact that when investors applied for land to conduct research and implementation of the project, they did
not have sufficient data on wind atlas of the area and employed World Bank’s wind atlas, which is perceived to be over-optimistic.

### 4.3.2. Planned wind power projects

<table>
<thead>
<tr>
<th>No.</th>
<th>Project’s name</th>
<th>Expected capacity</th>
<th>Permanent area(ha)</th>
<th>Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2010-2015</td>
<td>2015-2020</td>
<td></td>
</tr>
</tbody>
</table>

**Region 1**

1. **Binh Thanh Wind Power-120MW**
   (Wind power 1- Binh Thuan)
   (Vietnam Renewable Energy Co Ltd)
   - Permanent area: 120 ha

2. **Phu Lac Wind Power-50MW**
   (Thuan Binh Wind Power Joint Stock Company (TBW))
   - Permanent area: 50 ha

3. **Phuoc The Wind Power-28MW**
   (Asia Development & Investment Green Energy Co., Ltd (AGECO))
   - Permanent area: 28 ha

4. **Vinh Hao Wind Power-60MW**
   (TBW)
   - Permanent area: 0 ha

5. **Hoa Minh Wind Power-100MW**
   (Pacific Corporation)
   - Permanent area: 20 ha

**Region 2**

1. **Phan Ri Thanh Wind Power-120MW**
   (Mien Dong Joint-Stock Company)
   - Permanent area: 30 ha

2. **Hoa Thang Wind Power 1**
   - Permanent area: 325 ha

   2.1 **Hoa Thang Wind Power (Hoa Thang 1.1)**
      (PV Power-120MW)
      - Permanent area: 50 ha

   2.2 **Hoa Thang Wind Power (Hoa Thang 1.2)- IMPSA-100MW**
      - Permanent area: 40 ha
      - Capacity: 60 MW (2010-2015), 0 MW (2015-2020)

   2.3 **Hoa Thang Wind Power 1.3-330MW**
      - Permanent area: 30 ha

   3. **Hoa Thang Wind Power 2-200MW**
      (Investment and Development of Power Plant Saigon-Binh Thuan Joint-Stock Co.)
      - Permanent area: 40 ha

4. **Hoa Thang Wind Power 3-50MW**
   (Renergy Corporation)
   - Permanent area: 32 ha

5. **Hoa Thang Wind Power 4-150MW**
   - Permanent area: 40 ha

**Region 3**

1. **Hong Phong Wind Power-120MW**
   (Van Thanh Co. Ltd)
   - Permanent area: 40 ha

2. **Hong Phong Wind Power 2-50MW**
   - Permanent area: 20 ha

3. **Thien Nghiep Wind Power-50MW**
   (Dai Phong Development Investment Co.Ltd)
   - Permanent area: 40 ha

**Region 4**

1. **Tien Thanh Wind Power 1-50MW**
   (Asia Development & Investment Green Energy Co., Ltd (AGECO))
   - Permanent area: 20 ha

2. **Tien Thanh Wind Power 2-50MW**
   (Hop Long Trading and Investment JSC)
   - Permanent area: 15 ha
### Table 10. Binh Thuan province wind power projects planning

#### 4.3.3. Grid-connection schemes

<table>
<thead>
<tr>
<th>No.</th>
<th>Station/Line</th>
<th>Voltage (kV)</th>
<th>Capacity/line length (km)</th>
<th>Investor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tuy Phong Station</td>
<td>22/110</td>
<td>3x45</td>
<td>Project developer</td>
</tr>
<tr>
<td>1</td>
<td>Phu Lac station</td>
<td>22/110</td>
<td>2x40</td>
<td>Project developer</td>
</tr>
<tr>
<td>2</td>
<td>Phuoc The station</td>
<td>22/110</td>
<td>1x40</td>
<td>Project developer</td>
</tr>
<tr>
<td>3</td>
<td>Hoa Minh station and its connection line</td>
<td>110/220</td>
<td>1x40</td>
<td>Project developer</td>
</tr>
<tr>
<td>4</td>
<td>Single circuit line Phu Lac-Phuoc The 2</td>
<td>110</td>
<td>4</td>
<td>EVN</td>
</tr>
<tr>
<td>5</td>
<td>Single circuit line Phuoc The-Phuoc The 2</td>
<td>110</td>
<td>2</td>
<td>EVN</td>
</tr>
<tr>
<td>6</td>
<td>Double circuit line Vinh Hao-Phuoc The</td>
<td>110</td>
<td>5</td>
<td>EVN</td>
</tr>
<tr>
<td>7</td>
<td>Double circuit line Vinh Hao-Ninh Phuoc</td>
<td>110</td>
<td>27.8</td>
<td>EVN</td>
</tr>
<tr>
<td>8</td>
<td>Double circuit line that connects Phuoc The 2 station to Vinh Tan-Phan Ri line</td>
<td>220</td>
<td>18</td>
<td>EVN</td>
</tr>
<tr>
<td>9</td>
<td>Phan Ri Thanh station</td>
<td>110/220</td>
<td>1x150</td>
<td>Project developer</td>
</tr>
<tr>
<td>10</td>
<td>Phan Ri Thanh substation (belongs to the 110/220kV Phan Ri Thanh station)</td>
<td>22/110</td>
<td>1x50</td>
<td>Project developer</td>
</tr>
<tr>
<td>11</td>
<td>Phan Ri Thanh 1 station</td>
<td>22/110</td>
<td>1x40</td>
<td>Project developer</td>
</tr>
<tr>
<td>12</td>
<td>Phan Ri Thanh 2 station</td>
<td>22/110</td>
<td>1x40</td>
<td>Project developer</td>
</tr>
<tr>
<td>13</td>
<td>Single circuit line Phan Ri Thanh 1-Phan Ri Thanh</td>
<td>110</td>
<td>3.5</td>
<td>Project developer</td>
</tr>
<tr>
<td>14</td>
<td>Single circuit 2 Phan Ri Thanh 2-Phan Ri Thanh</td>
<td>110</td>
<td>2.0</td>
<td>Project developer</td>
</tr>
<tr>
<td>15</td>
<td>Hoa Thang 1 station</td>
<td>110/220</td>
<td>3x250</td>
<td>Project developer</td>
</tr>
<tr>
<td>16</td>
<td>Hoa Thang 1.1 station</td>
<td>22/110</td>
<td>3x50</td>
<td>Project developer</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Voltage</td>
<td>Capacity</td>
<td>Developer</td>
</tr>
<tr>
<td>---</td>
<td>-------------</td>
<td>---------</td>
<td>----------</td>
<td>-------------------</td>
</tr>
<tr>
<td>18</td>
<td>Hoa Thang 1.2 station</td>
<td>22/110</td>
<td>3x50</td>
<td>Project developer</td>
</tr>
<tr>
<td>19</td>
<td>Hoa Thang 1.3 station</td>
<td>22/110</td>
<td>3x50</td>
<td>Project developer</td>
</tr>
<tr>
<td>20</td>
<td>Hoa Thang 1.4 station</td>
<td>22/110</td>
<td>3x50</td>
<td>Project developer</td>
</tr>
<tr>
<td>21</td>
<td>Single circuit line that connect Hoa Thang stations</td>
<td>110</td>
<td>13.4</td>
<td>Project developer</td>
</tr>
<tr>
<td>22</td>
<td>Hoa Thang 2 station</td>
<td>110/220</td>
<td>2x125</td>
<td>Project developer</td>
</tr>
<tr>
<td>23</td>
<td>Hoa Thang 2.1 station</td>
<td>22/110</td>
<td>2x40</td>
<td>Project developer</td>
</tr>
<tr>
<td>24</td>
<td>Hoa Thang 2.2 station</td>
<td>22/110</td>
<td>2x40</td>
<td>Project developer</td>
</tr>
<tr>
<td>25</td>
<td>Hoa Thang 2.3 station</td>
<td>22/110</td>
<td>2x40</td>
<td>Project developer</td>
</tr>
<tr>
<td>26</td>
<td>Single circuit line that connects Hoa Thang 2.1 station to Hoa Thang 2 station</td>
<td>110</td>
<td>2x4</td>
<td>Project developer</td>
</tr>
<tr>
<td>27</td>
<td>Single circuit line that connects Hoa Thang 2.2 station to Hoa Thang 2 station</td>
<td>110</td>
<td>2.27</td>
<td>Project developer</td>
</tr>
<tr>
<td>28</td>
<td>Hoa Thang station (public)</td>
<td>220/500</td>
<td>2x450</td>
<td>EVN</td>
</tr>
<tr>
<td>29</td>
<td>Double circuit Hoa Phu-Phan Thiet</td>
<td>220</td>
<td>18</td>
<td>EVN</td>
</tr>
<tr>
<td>30</td>
<td>Double circuit line that connects Hoa Thang 1 station to Hoa Phu-Phan Thiet line</td>
<td>220</td>
<td>8</td>
<td>EVN</td>
</tr>
<tr>
<td>31</td>
<td>Double circuit line that connects Hoa Thang 2 station to Hoa Phu-Phan Thiet power line</td>
<td>220</td>
<td>7</td>
<td>EVN</td>
</tr>
<tr>
<td>32</td>
<td>Double circuit line that connects to Vinh Tan-Song May line</td>
<td>500</td>
<td>25</td>
<td>EVN</td>
</tr>
</tbody>
</table>

**Region 3**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Voltage</th>
<th>Capacity</th>
<th>Developer</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td>Hoa Thang 3 station</td>
<td>22/110</td>
<td>2x40</td>
<td>Project developer</td>
</tr>
<tr>
<td>34</td>
<td>Hoa Thang 4 station</td>
<td>22/110</td>
<td>3x50</td>
<td>Project developer</td>
</tr>
<tr>
<td>35</td>
<td>Hong Phong 1 station</td>
<td>22/110</td>
<td>2x63</td>
<td>Project developer</td>
</tr>
<tr>
<td>36</td>
<td>Hong Phong 2 station</td>
<td>22/110</td>
<td>2x40</td>
<td>Project developer</td>
</tr>
<tr>
<td>37</td>
<td>Dai Phong Thien Nghiep station and its connection line</td>
<td>22/110</td>
<td>2x40</td>
<td>Project developer</td>
</tr>
<tr>
<td>38</td>
<td>Mui Ne 2 station (public)</td>
<td>110/220</td>
<td>2x250</td>
<td>EVN</td>
</tr>
<tr>
<td>39</td>
<td>Double circuit line Hong Phong 2-Mui Ne 2</td>
<td>110</td>
<td>8</td>
<td>Project developer</td>
</tr>
<tr>
<td>40</td>
<td>Double circuit line Hoa Thang 3-Mui Ne</td>
<td>110</td>
<td>19</td>
<td>EVN</td>
</tr>
<tr>
<td>41</td>
<td>Double circuit line Hoa Thang 4- Mui Ne</td>
<td>110</td>
<td>19</td>
<td>EVN</td>
</tr>
<tr>
<td>42</td>
<td>Double circuit line that connects Hong Phong 1 station to Hoa Thang 3-Mui Ne line</td>
<td>110</td>
<td>1</td>
<td>EVN</td>
</tr>
<tr>
<td>43</td>
<td>Double circuit line that connects Mui Ne 2 station to Hoa Phu-Phan Thiet line</td>
<td>220</td>
<td>1</td>
<td>EVN</td>
</tr>
<tr>
<td>Region</td>
<td>Project</td>
<td>Voltage</td>
<td>Capacity (MVA)</td>
<td>Developer</td>
</tr>
<tr>
<td>--------</td>
<td>---------</td>
<td>---------</td>
<td>----------------</td>
<td>-----------</td>
</tr>
<tr>
<td>44</td>
<td>Tien Thanh 1 station</td>
<td>22/110</td>
<td>2x40</td>
<td>Project developer</td>
</tr>
<tr>
<td>45</td>
<td>Tien Thanh 2 station</td>
<td>22/110</td>
<td>2x40</td>
<td>Project developer</td>
</tr>
<tr>
<td>46</td>
<td>Tien Thanh 3 station</td>
<td>22/110</td>
<td>2x40</td>
<td>Project developer</td>
</tr>
<tr>
<td>47</td>
<td>Ham Cuong 1 station</td>
<td>22/110</td>
<td>2x40</td>
<td>Project developer</td>
</tr>
<tr>
<td>48</td>
<td>Ham Cuong 2 station</td>
<td>22/110</td>
<td>2x40</td>
<td>Project developer</td>
</tr>
<tr>
<td>49</td>
<td>Ham Kiem 1 station</td>
<td>22/110</td>
<td>2x40</td>
<td>Project developer</td>
</tr>
<tr>
<td>50</td>
<td>Ham Kiem 2 station</td>
<td>22/110</td>
<td>2x40</td>
<td>Project developer</td>
</tr>
<tr>
<td>51</td>
<td>Ham Cuong station (public)</td>
<td>110/220</td>
<td>2x250</td>
<td>EVN</td>
</tr>
<tr>
<td>52</td>
<td>Double circuit line Ham Kiem 2-Ham Kiem 1</td>
<td>110</td>
<td>2.2</td>
<td>Project developer</td>
</tr>
<tr>
<td>53</td>
<td>Double circuit line Ham Kiem 1-Ham Cuong</td>
<td>110</td>
<td>7.0</td>
<td>Project developer</td>
</tr>
<tr>
<td>54</td>
<td>Single circuit line Tien Thanh 1-Ham Cuong</td>
<td>110</td>
<td>4</td>
<td>EVN</td>
</tr>
<tr>
<td>55</td>
<td>Double circuit line Ham Cuong 1–Ham Cuong 2</td>
<td>110</td>
<td>2</td>
<td>EVN</td>
</tr>
<tr>
<td>56</td>
<td>Double circuit line Ham Cuong 2-Ham Cuong</td>
<td>110</td>
<td>3</td>
<td>EVN</td>
</tr>
<tr>
<td>57</td>
<td>Double circuit line Tien Thanh 2- Ham Cuong</td>
<td>110</td>
<td>5.6</td>
<td>EVN</td>
</tr>
<tr>
<td>58</td>
<td>Double circuit line that connects Ham Cuong station to 220kV Phan Thiet-Ham Tan power line</td>
<td>220</td>
<td>10</td>
<td>EVN</td>
</tr>
</tbody>
</table>

**Table 11. Grid-connection schemes for wind power projects planning**

**Conclusion**

Binh Thuan is one of the provinces with highest potential to develop wind power in Vietnam with total capacity of 5000 MW and 800 MW is the Government target until 2020. Developing large scale wind power projects is an effort to reduce the dependence on fossil fuels, protect environment and restructure the local economy and move towards a sustainable development. The Wind Power Master Plan of Binh Thuan Province provides a reliable source of information to assist project developers/investors in the first stage of a wind power project development. Nevertheless, developers/investors should conduct further investigation such as site survey, meeting with local authorities, install wind measurement mast, etc. in order to reach investment decisions.