Application TAPM-AERMOD system model to study impacts of thermal power plants in SouthEast and SouthWest areas to the air quality of HCMC: current status and according to Vietnam power planning VII toward 2030

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Abstract. Vietnam’s urban areas have faced serious environmental pollution issues, including water pollution, municipal waste, and air pollution. Vietnam's real gross domestic product (GDP) has been experiencing positive growth for the past five years since 2016. And in 2019, Vietnam's real GDP increased by 7.02% compared to the previous year. To maintain the growth rate, there is a huge amount of electricity required, not accounting for the other sectors. Thermal power plants generate more than 50% of total electricity in Vietnam, therefore, it is said that coal-fired power plants have been the major sources of air emissions and caused a serious impact on the environment. Recently air pollution is a hot issue in Ho Chi Minh City (HCMC), the air quality is being polluted by PM2.5, O3, CO, NO2, and TSP. Despite that, the neighboring areas of the city will install more coal-fired power plants, threatening to degrade the quality of the environment. Therefore, the objectives of this study are (i) Modeling the impacts of thermal power plants in SouthEast and SouthWest areas on the air quality of HCMC for two scenarios (current status in 2019 and future according to Power planning VII (adjusted) toward 2030); And (ii) Develop interprovincial air quality protection solutions. The research applied the TAPM model for meteorological modeling and AERMOD model for air pollution dispersion. The annual average PM2.5 concentration in the study area was approximately 0.121 μg/m3 and the highest concentration at a location close to Vinh Tan thermal power center with 8.61 μg/m3. NO2 the annual average concentration from power plants in 2020 and 2030 blows to HCMC and contributes to HCMC’ air quality only 0.01 and 0.03 μg/m3, respectively. The 24 hours average SO2 levels of HCMC in 2030 is 39.2 μg/m3, higher than WHO’s guideline (20 μg/m3). Currently, air pollution in HCMC is polluted by PM2.5, SO2, and NO2 and cause bad effect to public health. However, in the future with the contribution of 33 thermal power plants under intercity/provinces air pollution dispersion, air pollution HCMC will be worse and affect public health. Air pollution HCMC will be a huge impact on HCM’s public health in the future due to the contribution of 33 thermal power plants under intercity/provinces air pollution dispersion. The paper developed 7 main mitigation measures to reduce the impacts of air pollution from the power plan and reduce the impacts of air pollution on HCM’s public health. The measures are focused on using clean fuel, advanced technology, and controlling trans-provincial air pollution.
Keywords: TAPM–AERMOD; Thermal power plants; Air quality modeling; SouthEast and SouthWest; Ho Chi Minh city; Vietnam

1. Introduction

Ho Chi Minh City (HCMC) is located in the Southeastern region of Vietnam, a contiguous area of two regions SouthEast and SouthWest. There are 20 districts and 1 city in HCMC, with a population of 8.6 million people, and about nine million private vehicles. The city's economic growth rate has been skyrocketing in recent years. Currently, there are 19 manufacturing and industrial zones, 30 industrial clusters on an area of 1,900 ha, and numerous factories and enterprises located separately in HCMC [1]. The huge volume of household cooking fuels, private traffic in the area, and industrial units in and around the city release significant amounts of pollutants into the atmosphere. The results show that the highest concentrations of TSP, PM$_{2.5}$, CO, NO$_2$ and O$_3$ in 2017 exceeded the National technical regulation in ambient air quality (QCVN 05:2013/BTNMT) 1.5, 1.5, and 1.1 times [2]. There is 93.8% of PM data recorded from the 19 traffic locations have exceeded The National Technical Regulation on Ambient Air Quality (QCVN 05: 2013/BTNMT). These high pollutant concentrations were associated with an increase in the risk of human health in HCMC [3-5]. The research of our research team in the year 2017 about the impact of air pollution on human health, showed that air pollution in HCMC was seriously affecting public health by the previous study of us [6]. The air pollution levels (PM$_{2.5}$, SO$_2$, and NO$_2$) were responsible for 1,396 deaths related to three diseases (lung cancer, cardio-pulmonary, and Ischemic Heart Disease (IHD)). In which, levels of PM$_{2.5}$ were associated with 1.136 deaths, followed by NO$_2$ with 172 cases and 89 cases by SO$_2$. Moreover, the air pollution level in HCMC is forecasted to be increased in the future under the pressure of economic development due to the National Power Development Plan (Power Master Plan VII revised) for the 2011 – 2020 period with the vision to 2030.

![Figure 1. Proportion of fuel type to generate electricity in Vietnam from 2010 to 2020](image)

From 1985 to 2020, the amount of electricity in Vietnam has rapidly increased 50 times from 5 TWh to 234 TWh. The average increase was 11% per year [7]. In Figure 1 shown the proportion of fuel type to generate electricity in Vietnam from 2010 to 2020, In the beginning hydroelectric was the main source (accounting for 53%) and strongly increased, fluctuating around 60% and 70% from 2012 to 2017 and then gradually decreased from 2018, then stopped at 50% in 2020. Witness the same trend, electricity from natural gas was dropped from 31% in 2010 to 10% in 2020. On the other hand, coal power plants increased quickly from 12% to 37% in 10 years, replacing the proportion of hydroelectricity. Electricity
from renewable energy and Diesel Oil (DO) was negligible. Only in recent years, renewable energy has been concerned and developed, thanks to the new policy and support from the government. Resulting in the growth from 2% in 2019 to 4% in 2020.

According to the Power Master Plan VII revised, the total electricity generation will reach: 235 - 245 billion kWh in 2020, 352 - 379 billion kWh in 2025, and 506 - 559 billion kWh in 2030 [7], and the two major of energy use is hydropower and coal power. The proportion of each fuel used to generate energy is 16.9% from big and medium hydroelectric, 42.6% from coal, and 14.7% from natural gas (including Liquefied Natural Gas (LNG)), 21% from renewable energy, and 3.6% from nuclear, 1.2% from import.

Coal is the popular fuel for electricity generation in countries like India and China. The cheap and abundant supply of coal locally, together with the high prices of imported natural gas and oil, make the coal-fired generation of electricity more attractive economically [8]. Therefore, many studies on coal-fired power have been carried out in India and China. Thermal power emissions are usually calculated using the emission factor and material balance method [8-10]. The meteorological and air quality modeling system is applied to simulate the spread of air pollutants from the thermal power plants.

Vietnam has a lot of potential for renewable energy development and clean energy such as solar energy, wind energy, biomass energy, and hydroelectricity. However, there has not been any research to evaluate the overall assessment of all plants in this master plan on air pollution and the public health of HCMC. Therefore, the management agencies have not seen the impact of serious thermal power plants on air pollution and public health, therefore it is necessary to carry out this study to provide scientific data to convince the management agencies to adjustment the master plan and for inter-provincial coordination to develop an energy plan for the whole region without affecting neighboring provinces. Because the problem of air pollution is an inter-provincial issue. Therefore, the objectives of this study are (i) Modeling the impacts of thermal power plants in SouthEast and SouthWest areas on the air quality of HCMC for two scenarios (current status in 2019 and in future according to Power planning VII (adjusted) toward 2030); And (ii) Develop interprovincial air quality protection solutions. The research applied the TAPM (The Air Pollution Model) model for meteorological modeling and the AERMOD model for air pollution dispersion.

In Vietnam, there have also been studies simulating the air pollution of thermal power plants. Research by Ho Quoc Bang et al, 2019 with research on impact assessment of Duyen Hai thermal power plants. The study applied the meteorological and air quality modeling system (TAPM-CALPUFF). The study of Duong Ngoc Bach in 2017 about the simulation of pollution from Na Duong I & II thermal power plants to ambient air quality in Lang Son province. Research and apply AERMOD VIEW 8.2 software to simulate the dispersion of TSP, SO$_2$, and NO$_2$ pollutants from the chimneys of Na Duong I & II thermal power plants.

2. Materials and Methods

This research contains three main stages: air pollution emission inventory; meteorology simulation, air quality modeling, and proposed mitigation measures based on the results. Step by step process of the research is described in Figure 2.

The first step is to make a comprehensive list of power plants in the research area with detailed information such as name, fuel used, location, time in operation. Then collect all the information related to these plants including chimneys height, gas temperature, amount of fuel used, type of fuel, abatement technology, combustion system… from EIA reports, Decision of Power Master plan VII revised, all the Decision and report relating to the implementing progress the Power Master plan, etc. After that,
emission factors for each type of power plant need to gathering from AP-42, WHO, and EMEP/EEA guidelines and put into calculations, taking into consideration the effectiveness of the treatment system. The second step, meteorology, and air quality dispersion model should be set up for the research area with calibration process, detailed will be discussed after. Then, the meteorology in the year 2019 was prepared with hourly data for 365 days, presented in the surface and upper files. Finally, input emission data and meteorology data into AERMOD model, air pollution map will be generated after finishing the calibration and validation steps. Based on these maps, inter-provinces pollution levels will be defined, and mitigation measures will be defined.

Figure 2. Research diagram of this study

2.1 Meteorological model

The Air Pollution Model (TAPM) was developed by the Commonwealth Scientific and Industrial Research Organization - Commonwealth Scientific and Industrial Research Organization (CSIRO) of Australia. TAPM is a three-dimensional Eulerian meteorological model for simulating meteorology. Detailed descriptions of the model were described by [2]. The model is non-hydrostatic and anelastic using terrain following grid with finite volume discretization [2]. The TAPM model was run for 3 domains, covering the whole study area, the smallest domain is covering the central region that focused on HCMC and surrounding provinces. Since the study aims to define the levels of pollution of thermal power plants from the outside travel to HCMC, a meteorology point in Dong Nai province (next to Formosa power plant) was adopted as the input for the AERMOD model. The model manages meteorological data on the surface and on different levels of height, allowing the calculation of atmospheric characteristics. The meteorology file consists of the following two types: surface met data file (*.sfc) contains the 1-hour observed data including wind direction, wind speed, humidity, atmospheric pressure, precipitation, cloud cover, solar radiation; and the upper air data file (*.pfl) including similar parameter but in many levels of height.

2.2 Air quality model
The AERMOD Model - The AMS/EPA Regulatory Model (AERMOD) is designed to support the US Environmental Protection Agency (EPA) management program. The model consists of three components: AERMOD (AERMIC Scattering Model), AERMOD (AERMOD Terrain Tool), and AERMOD (AERMOD Meteorological Tool). Since 1991, the AERMOD model has been developed by the Meteorological Agency and the US Environmental Protection Agency (US EPA). A team of scientists (AERMIC) has teamed up to build the AERMOD model. AERMOD was officially used on December 9, 2005, after 14 years of research and development [11]. AERMOD will produce simulation results in the form of 2-dimensional, three-dimensional images and export them through Google Earth, making it easy for users to see the effects of emissions to the survey area. The grids domain was set 459 km by 459 km with 153 cells x 153 cells and the grid resolution was 3.0 km x 3.0 km, covering the study areas from Binh Thuan province to Ca Mau province.

2.3 Model Evaluation

Similar to other models, TAPM and AERMOD models also need to be evaluated before using. This approach was used by comparing the observations from the field with the modeled data. In which meteorological data at Bien Hoa station and air quality data monitored at 4 stations in Duyen Hai district of Tra Vinh Province were used to assess the TAPM and AERMOD model, respectively. More specifically, statistical parameters including Pearson correlation coefficient (R) between observed (O) and predicted (P) values, mean value, standard deviation, minimum value (min), and maximum value (max) were used in this study. It is imperative to evaluate the air dispersion model with observation data before using the simulated results, to check the input data and options for the research area and the uncertainty of the model. The following criteria are used to evaluate model performance. The equation below is the requirement of these indices to consider the performance of the model (table 1) [9]. Mean Normalized Bias Error (MNBE):

\[ MNBE = \frac{1}{N} \sum_{i=1}^{N} \frac{C_{mod}(x_{i,t}) - C_{obs}(x_{i,t})}{C_{obs}(x_{i,t})} \times 100 \]  

Where

- \( C_{mod}(x_{i,t}) \): modeling value at site i, time t
- \( C_{obs}(x_{i,t}) \): observed value at site i, time t

| Indicator                          | Standard |
|------------------------------------|----------|
| Mean Normalized Bias Error (MNBE)  | ± 15%    |

3. Results

3.1. Air emission inventory

|                  | NO\textsubscript{X} (ton/year) | CO (ton/year) | SO\textsubscript{X} (ton/year) | PM\textsubscript{10} (ton/year) | PM\textsubscript{2.5} (ton/year) | TSP (ton/year) |
|------------------|---------------------------------|---------------|-------------------------------|-------------------------------|-------------------------------|---------------|
| **In 2020**      |                                 |               |                               |                               |                               |               |
| Coal             | 15.948,57                       | 4.425,92      | 41.715,57                     | 609,36                        | 423,69                        | 1.324,70      |
| Natural Gas      | 4.882,03                        | 14.262,12     | 10,28                         | 0,65                          | 1,30                          | 0,33          |
| DO               | 1,05                            | 0,74          | 2,43                          | 0,00                          | 0,00                          | 0,00          |
| **Total**        | **20.831,65**                   | **18.688,78** | **41.728,28**                 | **610,02**                    | **424,99**                    | **1.325,03**  |
The air emission inventory is the main data input for AERMOD air quality model. The air emission inventory is described in Table 2 for 2020 and 2030. This result includes whole thermal power plants in SouthEast and SouthWest of Vietnam with 5 coal power plants in Vinh Tan and two gases power plants in Son My of Binh Thuan province. These seven thermal power plants in Binh Thuan province are located about 218 km far from HCMC, having stacks in 210m (height) and 6m (diameter), air pollution from these stacks can disperse to HCMC (Figure 3). Therefore, this paper simulates for whole thermal power plants in SouthEast and SouthWest of Vietnam and seven power plants in Binh Thuan province. Emission calculation results is referred from other study [13] and additional calculations for seven power plants in Binh Thuan province.

![Figure 3. Distribution of Thermal power plants in study area (South-East, South-West and Vinh Tan power center)](image)

The results of air emission inventory in Table 2 shows that air emission load in 2030 is higher than emission in 2020 more than 2 times for NOx, CO and SOx. This is because the electric production in 2030 is higher than 2020.

However, air emission inventory in Table 2 shows that air emission load in 2030 is lower than emission in 2020 for dust (TSP, PM$_{10}$ and PM$_{2.5}$) NOx, CO and SOx. This is because the electric production in 2030 is higher than in 2020. This can be explained because in the future all plants using domestic coal will switch to using imported coal, the amount of ash in imported coal is much lower than domestic coal. Domestic coal of Quang Ninh 6A anthracite coal has 33.12% of ash, while imported coal such as from Indonesia has 5.88% of ash. Therefore, the emission load of PM$_{10}$, PM$_{2.5}$, and TSP for coal imported from Indonesia is lower than Quang Ninh 6A anthracite coal about 5 times.
3.2. Modeling results

3.2.1. Calibration and validation model

The TAPM meteorological model was calibrated from January 31, 2015, to February 4, 2015, for meteorology modeling at Tan Son Hoa station, and found the amplification coefficient was equal to 0.8 [2]. For validation of the TAPM model, two important parameters are surface temperature and wind speed. The model was validated from 01/01/2019 to 31/1/2019 for meteorology modeling at Bien Hoa station (Dong Nai Province). The model gives the results closest to reality with the observed and simulation temperature having R² coefficient = 0.86 (Figure 4). For validation of the TAPM model, two important parameters are surface temperature and wind speed. Results of the validation of the TAPM model at Bien Hoa station show that the simulation model generated reliable data with the correlation coefficient (R²) not less than 0.7. The average temperature difference between the simulated temperature and the observed temperature in Jan 2019 is 1.4°C, in December 2019 is 0.75°C.

![Figure 4. Calibration and validation model TAPM model](image)

Air quality simulation results from AERMOD model have been calibrated and validated with observed value at 4 sites in Duyen Hai thermal power plant center, Tra Vinh province (Figure 5). The monitoring parameters are PM$_{2.5}$, TSP, CO, SO$_2$, and NO$_2$ hourly data from 7 am to 18 pm on 10 Jan 2018 (Table 3). The results of the MNBE error calculation between the simulated value and the average air quality monitoring value were 9.98% (ranging from 8.33% to 13.3%). This error is in the range of ± 15%. Therefore, the AERMOD model is capable of simulating the spread of air pollution by the region. The next step is to use this model to simulate air pollution for different scenarios.

**Table 3. The observation sites of meteorological**

| Site | Coordinate       |
|------|------------------|
|      | Lat      | Long      |
| 1    | 9.5860960 | 106.5145031 |
| 2    | 9.575617  | 106.520684  |
| 3    | 9.591916  | 106.534223  |
| 4    | 9.5611659 | 106.513961  |
3.2.2. Modeling of air pollution for current situation

After calibration and validation, simulation of the air quality for each hour in 2019 (8,760 hours) was conducted to determine the impacts of thermal power plants on air quality in HCMC. The simulation results included all of one-hour, average of 24-hour and annual average concentration.

The simulation results show that the PM$_{2.5}$ concentration pollution in the study area has the highest 1 hour with a concentration of 8.61 μg/m$^3$ close to Vinh Tan thermal power plant center (Northeast of the Figure 6).
The simulation results show that the PM$_{2.5}$ concentration pollution in the study area has the highest average 24 hours with a concentration of 2.78 $\mu$g/m$^3$ (Figure 7). The highest 24-hour average concentration of PM$_{2.5}$ is lower than QCVN 05: 2013/BTNMT (average 24 hours for PM$_{2.5}$ is 50 $\mu$g/m$^3$) or WHO’s guide (average 24 hours for PM$_{2.5}$ it is 25 $\mu$g/m$^3$).

The annual average PM$_{2.5}$ levels map was generated in Google Earth (Figure 8), after simulating for 365 days in the year 2020. The annual average concentration in this area is about 0.121 $\mu$g/m$^3$. However, the annual average concentration of PM$_{2.5}$ from power plants in 2020 flows to HCMC and contributes to HCMC’ air quality only 0.005 $\mu$g/m$^3$. The average annual PM$_{2.5}$ concentration from power plants does not exceed QCVN 05:2013/BTNMT and WHO’s guideline.

However, in the previous study only for HCMC by Khue [6] in Figure 9 annual average PM$_{2.5}$ concentration is 23 $\mu$g/m$^3$ which was higher than WHO’s guideline (annual average PM$_{2.5}$ concentration is 10 $\mu$g/m$^3$). The PM$_{2.5}$ in HCMC is from two sources (local emission of HCMC (23 $\mu$g/m$^3$) and from
power plants (0.005 μg/m³). Therefore, PM₂.⁵ impacts on public health of HCMC. To control and manage the air’s quality and minimize the impacts from power plants to PM₂.⁵ in HCMC, the paper suggested many possible solutions in the next section.

![Figure 9. Annual average PM₂.⁵ concentration of HCMC [6]](image)

The annual average concentration of PM₂.⁵ due to thermal power plants for the case of 2030 in this area is about 0.055 μg/m³ (Figure 10) However, the annual average concentration of PM₂.⁵ from power plants in 2030 flows to HCMC and contributes to HCMC’ air quality only 0.003 μg/m³ which is less
than the case of 2020. This can be explained by two reasons: (i) the PM$_{2.5}$ emissions in 2030 are lower than 2020 about 59.12% due to the change of domestic coal into imported coal (Table 2), (ii) the second is that the number of thermal power plants in 2030 increases much compared to 2020, these plants located spread out the study area - quite close to HCMC. However, other pollutants such as NO$_2$ and SO$_2$ are different from PM$_{2.5}$ which will be discussed in detail in Table 4.

Table 4. Summary current situation 2020 and plan 2030 of pollutants

| Sources | NO$_2$  | SO$_2$  | PM$_{2.5}$ |
|---------|---------|---------|------------|
| Emission in 2020 (ton/year) | 20,831.65 | 41,728.28 | 424.99 |
| Emission in 2030 (ton/year) | 47,713.86 | 97,371.09 | 304.82 |
| Background of HCMC 2020 (µg/m$^3$) annual average$^*$ | 67.1 | 19.2 | 23.0 |
| Power plants contribute to HCMC 2020 (µg/m$^3$) annual average | 0.01 | 0.17 | 0.005 |
| Power plants contribute to HCMC 2030 (µg/m$^3$) annual average | 0.03 | 0.40 | 0.003 |
| QCVN 05:2013 (annual average) (µg/m$^3$) [17] | 40 | 50 | 25 |
| WHO guideline (µg/m$^3$) [18] | 40 | 20$^{**}$ | 10 |

Note: ($^*$) is referred from Khue’s study [6]; ($^{**}$) is 24 hours average concentration

Table 3 shows that the annual average concentration of PM$_{2.5}$, SO$_2$ and NO$_2$ due to thermal power plants for the case of 2020 and 2030 contribute to HCMC’s air pollution. For the case of NO$_2$ the annual average concentration from power plants in 2020 and 2030 flows to HCMC and contributes to HCMC’ air quality only 0.01 and 0.03 µg/m$^3$, respectively; in the previous study only for HCMC by Khue [6] in the annual average NO$_2$ concentration is 67.1 µg/m$^3$ which was higher than WHO’s guideline (annual average NO$_2$ concentration is 40 µg/m$^3$). The NO$_2$ in HCMC is from two sources (local emission of HCMC (67.1 µg/m$^3$) and from power plants (0.03 µg/m$^3$). Therefore, NO$_2$ impacts on public health of HCMC.

For the case of SO$_2$ the 24 hours average concentration from power plants in 2030 flows to HCMC and contributes to HCMC’ air quality only 10 µg/m$^3$; in the previous study only for HCMC by Khue [6] in the annual average SO$_2$ concentration is 19.2 µg/m$^3$ (WHO’s guideline doesn’t have annual average SO$_2$ guideline). If HCMC has the annual average SO$_2$ concentration is 19.2 µg/m$^3$, then 24 hours average concentration SO$_2$ of HCMC should be higher than 19.2 µg/m$^3$. That’s the reason why the 24 hours average SO$_2$ of HCMC in 2030 is higher than 39.2 µg/m$^3$ which is higher than WHO’s guideline (24 hours average SO$_2$ concentration is 20 µg/m$^3$). Therefore, SO$_2$ impacts on public health of HCMC.

With the above discussion, currently air pollution in HCMC is already polluted by PM$_{2.5}$, SO$_2$ and NO$_2$ and impacts on public health. However, in the future with the contribution of 33 thermal power plants under intercity/provinces air pollution dispersion, air pollution HCMC will be a huge impact on HCMC’s public health. It’s necessary to develop measures to reduce these impacts.

3.3. Abatement strategies

Thermal power plants with high chimneys up to 150 – 210 meters in height (4 – 6 meters in diameter) will be able to spread the pollution plum to inter-provincial areas, especially the neighbor. Therefore, in the stage of appraisal and investment of new projects, it is necessary to consider the background contaminated concentration of surrounding thermal power plants in the Environment Impact Assessment (EIA).
In recent years, several cities/areas in the Southeast and Southwest regions have had the air polluted by TSP, PM$_{10}$, and PM$_{2.5}$ such as HCMC, Dong Nai, Binh Duong, Ba Ria Vung Tau, and Can Tho. Therefore, constructing more thermal power plants using dirty fuels will worsen the air quality. Meanwhile, other clean and renewable energy such as wind, solar, gas, biomass, and garbage should be considered to develop in the local area, to address energy needs and co-benefits solutions for waste treatment. Thus, more policies and programs to support the development of clean energy and renewable energy (to replace the role of the coal power plant) should be issued by the government, in similar circumstances to achieve the rapid growth of solar power nationwide.

The air quality management plan in the 5-year period of each province must consult with neighboring provinces to mitigate the impact of trans-provincial air pollution.

The competent person who decides on investment projects, selects power generation plans, technology, investment locations ..., it is necessary to conduct a strategic environmental assessment of energy at the regional level. The strategic environmental assessment should be conducted before approving the project investment policy. It is necessary to assess the cumulative impact of all projects at the same time to make strategic decisions to minimize the wide-ranging negative impact and severity.

In the overview, the current status and in the future plan, coal power plants account for a very large proportion of 42.6% of total energy. Meanwhile, particulate matter such as TSP, PM$_{10}$, and PM$_{2.5}$ was estimated using the emission factor based on fuel type consumption and technology of the abatement system. It shows that emissions strongly depend on the quality of input fuels and the effectiveness of the treatment system. For example, Duyen Hai I has unit 1 using Anthracite 6A Quang Ninh coal-bran fuel, so the ash level A = 33.12%. Meanwhile, Duyen Hai III Expanded at the same capacity as Duyen Hai I, mainly using Bituminous coal and Sub-Bituminous coal imported from Indonesia with ash level A = 5.88%. In the results, the emissions of TSP, PM$_{10}$, and PM$_{2.5}$ of Duyen Hai I are greater than Duyen Hai III Expanded up to 2.98, 2.0, and 2.0 times, respectively. Therefore, one of the main solutions to reduce dust pollution TSP, PM$_{10}$, and PM$_{2.5}$ is to use clean coal fuel with a low ash ratio.

According to the calculation results, based on the amount of emissions per unit of electricity (Ex. ton PM2.5/MW.year), The suggested order of precedence is as follows: gas power, oil, biomass, imported coal, domestic coal.

In spatial planning of power plants, to ensure environmental safety, sustainable ecosystem, and protecting public health, the application of advanced technologies (SC, USC) is very essential. Especially for coal-fired power, as an important step forward, this technology will increase power generation efficiency, reduce fuel use, thus, reduce the emissions and slag ash with the same amount of electricity generated. But, the ratio of emissions per ton of fuel does not change, so does the amount of slag ash and the amount of cooling heat. As a result, many factories are concentrated in one geographic area, and total emissions can still exceed public health safety.

4. Conclusions

The paper studied the impacts of thermal power plants in SouthEast, SouthWest, and 7 power plants in Binh Thuan province on the air quality of HCMC for two scenarios (current status of 2020 and according to Power planning VII (adjusted) toward 2030) by using the TAPM-AERMOD system model.

The results show that the simulation results of PM$_{2.5}$ concentration pollution in the study area has the highest 1 hour with a concentration of 8.61 $\mu$g/m$^3$ close to Vinh Tan thermal power plant center. The PM$_{2.5}$ concentration pollution in the study area has the 24-hour average with a concentration of 2.78 $\mu$g/m$^3$. A map of simulating annual average PM$_{2.5}$ was generated by extracting the results from these
8,760 hours of the year with the average concentration in this area is about 0.121 μg/m³. NO₂ the annual average concentration from power plants in 2020 and 2030 flows to HCMC and contributes to HCMC’ air quality only 0.01 and 0.03 μg/m³, respectively. The 24 hours average concentration of SO₂ from power plants in 2030 flows to HCMC and contributes to HCMC’ air quality of 10 μg/m³. The 24 hours average SO₂ of HCMC in 2030 is higher than 39.2 μg/m³ which is higher than WHO’s guideline (24 hours average SO₂ concentration is 20 μg/m³). Therefore, SO₂ impacts on public health of HCMC. Currently, air pollution in HCMC is already polluted by PM₂.Ş, SO₂ and NO₂ and impacts public health. However, in the future with the contribution of 33 thermal power plants under intercity/provinces air pollution dispersion, air pollution HCMC will be worse and have impacts on HCMC’s public health. The paper developed 7 main mitigation measures to reduce impacts of air pollution from the master plan of Power planning VII (adjusted) toward 2030 and reduce the impact of air pollution on HCM’s public health. The measures are focused on using clean fuel, advanced technology and controlling trans-provincial air pollution.

Author Contributions:
Khue Vu contributes as coordinator for whole research, air quality modeling and develop abatement strategies. While H.T.T.N. were responsible for calculating emissions. Bang Q. HO is in charge of running the TAPM-AERMOD model. T.T.N. contributed to the overview and discussion tasks. The manuscript was developed, revised, and edited by Bang Q. HO and Khue Vu.

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