Public Utility Jeepney Modernization Health Impact/Benefit Assessment

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1 Introduction

The Philippine public utility jeepney (PUJ) is a dominant, informal public transport mode that services routes ranging from 0.4-km to 37.8-km or mostly about 12-km-long.[1] Jeepneys meet a significant proportion of public transport demand in the country. Recent available estimates indicate that jeepneys account for 75.8 million passenger-km trips of Mega Manila annually in 2015[2]. Outdated design and technology, inadequate maintenance, uncoordinated operations, and poor driving behavior have made jeepneys a major contributor of air pollution and a source of safety, travel comfort, service reliability, and efficiency issues.

In 2017, the Public Utility Vehicle Modernization Program (PUVMP) was launched to reform the public transport industry through the replacement of old units with more efficient, modern units, and fleet consolidation and management to formalize operations. A total of 820 modern jeepney units have been rolled out in February 2020.[3]

Modern jeepneys are classified as Class 1 or Class 2 units, which mainly differ in passenger capacity. Class 1 jeepneys can accommodate 9-12 seated passengers and would mostly service low-demand areas and shorter routes. Class 2 units are designed with a maximum seating capacity of 23 passengers, allow standing passengers, and are the main replacement for old jeepneys. The table below outlines the more popularly adopted units currently.

Table 1 Modern PUJs in the Local Market

Brand and Model	Technology	Passenger Capacity	
Hino XU343	Euro 4 Diesel	23 seated + 6 standing	
Isuzu - Centro	Euro 4 Diesel	23 seated + 7 standing	
Yutong	Euro 4[4] Diesel	21 seated + 9 standing	

[1] LTFRB 2015 Franchise and Route Database

[2] Mejia A., Guillen M.D., Villaraza C.M., and Dematera, K. 2017. The Philippine Stocktaking Report on Sustainable Transport and Climate Change. Data, Policy and Methodology. Mandaluyong City: Deutsche Gesellschaft fuer Internationale Zusammenarbeit (GIZ) GmbH.

[3] DOTr 2020 data provided

[4] Unclear if Euro 2 or Euro 4

Brand and Model	Technology	Passenger Capacity	
Mahindra T20	Euro 4 Diesel	22 seated + 8 standing	
Isuzu - Almazora	Euro 4 Diesel	23 seated + 8 standing	
Tojo Motors E-Jeep	Electric	23 seated + 8 standing	
Star 8 E-Jeep	Electric	22 seated + 8 standing	

The PUVMP is anchored on improving air quality and energy efficiency and providing a decent and efficient public transport system. This report provides an evaluation of potential air quality and health impact benefits from the full adoption of the programme in Metro Manila.

2 Objectives

The study aimed to project the air quality and health benefits arising from the PUVMP in Metro Manila. Specifically, the project quantified the following:

- Amount of pollutant releases avoided;
- Effect on the ambient pollutant concentration;
- Avoided mortality and morbidity; and
- Monetary benefits from the avoided mortality and morbidity.

3 Scope, Assumptions and Methodology

This study covers jeepneys in Metro Manila based on routes provided in the LTFRB 2015 database (**Appendix A**). It is noted that the PUVMP includes the rationalization of routes and services, which remains to be an ongoing effort. This study therefore considered adjustments in fleet size based on the ratio of vehicle capacities of old and modern jeepneys. The study modelled the following technology scenarios:

- Scenario 1 – Replacement with Euro 4 diesel modern jeepneys
- Scenario 2 – Replacement with electric modern jeepneys (E-Jeepneys)
- Scenario 3 – Replacement with combined Euro 4 and electric modern jeepneys

Scenario 3 assumed that central business district routes will be served by E-Jeepneys, while Euro 4 units will service the remaining network. This translates to a 91% veh-km share for Euro 4 units and 9% for electric jeepneys. The LTFRB 2015 database indicates 50,073 jeepney units are operating in Metro Manila. Considering the higher capacity of modern units, the number of units to replace existing services was assumed to be reduced to a factor of 1.5. Emission reduction benefits are therefore traced to the combined effect of lower emission factors and reduced mileage needed. The health impact component covered the benefits and/or impact of changes in PM_{10}, $PM_{2.5}$, NO_x, and SO_x emission generation. There has been limited information on the concentration- response relationship of CO. VOC impacts is normally associated with ground level ozone. Ozone formation simulations however was not activated in the dispersion model due to the absence of speciation information on the VOC's released locally.
The determination of air quality and health benefits involved three main phases, discussed in the sub-sections below.

3.1 Source Emission Modeling

A spreadsheet model was developed to determine the amount of emissions generated and point of release. For conventional technologies, emissions generated were calculated for each route, assuming that emissions are equally distributed throughout the service line. Emissions generated in each route (*E*) were computed by multiplying the emission factor (*EF*) by the distance traveled (*D*) and by the corresponding fleet size (*FS*), indicated below:

$$E = EF \times D \times FS \qquad \text{Equation 1}$$

Emission factors (EF) for each technology variant were generated by multiplying specific emission factors (SFC) with the corresponding fuel consumption (FC), as shown below:

$$EF = SFC \times FC \qquad \text{Equation 2}$$

Specific emission factors for pre-Euro (baseline) and Euro 4 units were derived and calibrated from the EMEP/EEA Emissions Inventory Guidebook (Ntziachristos and Samaras, 2019[5]) specific emission factors shown in the table below. PM_{10} emission factors are not provided in the guidebook and were determined through the $PM_{2.5}$-PM_{10} ratio derived from the Argonne National Laboratory GREET Model (Wang, 2018).[6]

Table 2 Vehicle Specific Emission Factors (g/kg)

Technology	CO	NMVOC	SO_X	NO_X	PM_{10}	$PM_{2.5}$
Baseline Jeepney	9.17	2.12	0.10	11.60	3.69	2.95
Euro 4 Diesel	1.26	0.19	0.10	7.95	0.54	0.43

Fuel economy of baseline units adopted varied with route lengths, as lifted from Biona (2015).[7] Estimated daily distance traveled by units in each route was also drawn from Biona (2015). GIZ (2020) indicated modern Euro 4 units consumed 13.5% more fuel than old units locally. Higher fuel consumption is attributed to the larger capacities of modern units and the added load from the

[5] Ntziachristos L. and Z. Samaras (2019). EMEP/EEA air pollutant emission inventory guidebook 2019. European Environment Agency.

[6] Wang M. (2018). Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model 2018. Argonne National Laboratory.

[7] Biona. 2015. Jeepney Market Transformation Study. Metro Manila: Deutsche Gesellschaft fuer Internationale Zusammenarbeit (GIZ) GmbH and Department of Transportation.

air conditioning system. This was applied to baseline values to project Euro 4 fuel consumption. The table below shows the estimated fuel economies of baseline and Euro 4 jeepneys in varying route lengths.

Table 3 Fuel Economy of Baseline and Euro 4 Jeepneys by Route Length (km/l)

Technology	< 5 km	5 - 10 km	10-20 km	> 20 km
Baseline Jeepney	4.2	5.7	7.2	7.8
Euro 4 Jeepneys	3.7	5.0	6.3	6.8

Energy economy of electric jeepneys was based on industry data provided by a major E-Jeepney manufacturer in the country. An energy economy of 2 km/kWh was assumed across all route lengths considering power is not consumed while idling and therefore effects on the drive cycle is limited compared to conventional units. Grid emissions generated to power E-Jeepneys were determined by quantifying total energy consumption multiplied to the grid emission factor. **Table 4** shows electricity grid emission factors based on the Luzon power dependable capacity mix using the power plant emission factors provided by EPA (1995)[8]. $PM_{2.5}$ emission factors were not covered in the EPA (1995) database and were derived by multiplying PM_{10} values with the $PM_{2.5}$- PM_{10} emission factor ratios provided in Wang (2018). A summary of emission factors used are provided in **Appendix B**.

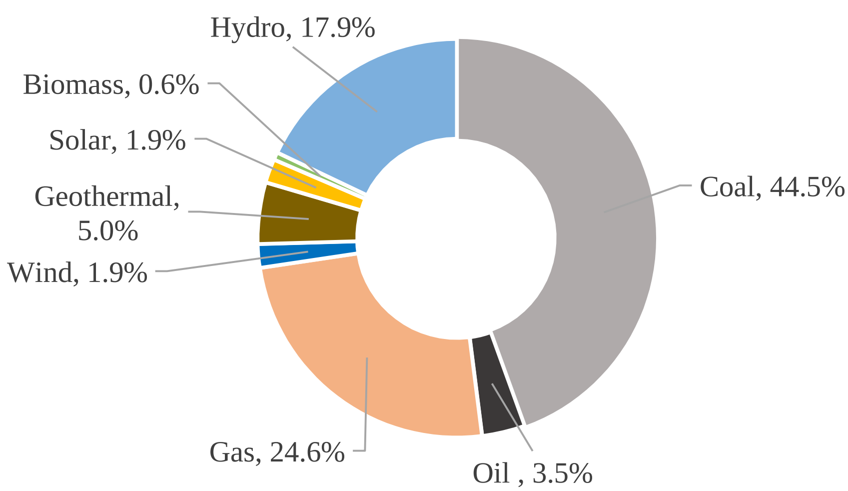


Figure 1 Grid Power Mix

Table 4 Grid Emission Factors (g/kWh)

Reference	CO	NMVOC	SO_X	NO_X	PM_{10}	$PM_{2.5}$
Luzon Grid	0.037	0.002	1.447	0.144	0.022	0.017

[8] EPA (1995). AP-42 : Compilation of Air Emissions Factors. United States Environment Protection Agency.

The electricity grid emissions generated were geographically disaggregated based on the DOE (2019)[9] power generation share of power plants in Luzon (detailed in **Appendix C**). The figure below illustrates the locations and dependable capacities (MW) of power plants connected to the Luzon Grid.

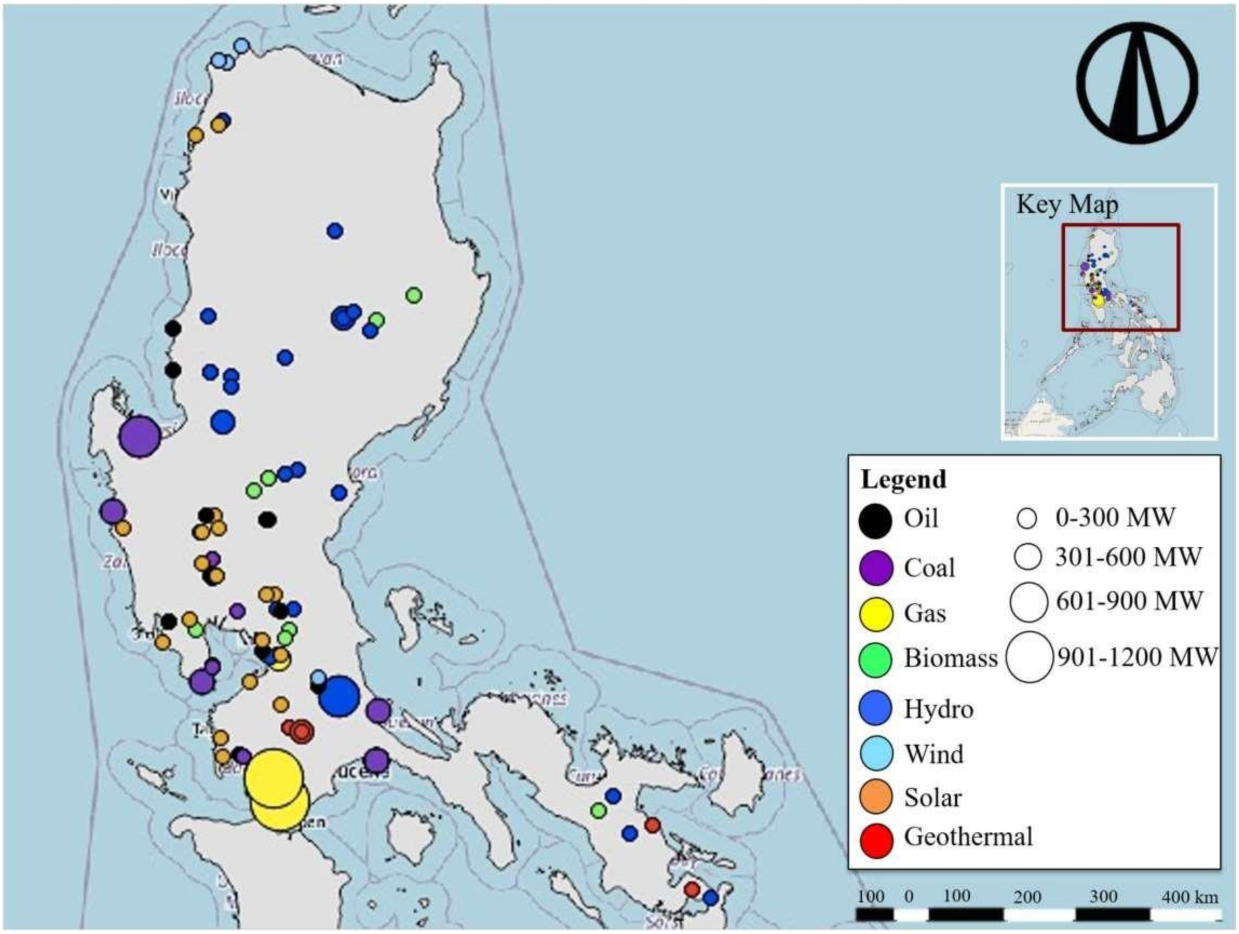


Figure 2 Luzon Grid-Dependent Power Plants by Fuel Type and Dependable Capacity (Source: Own work, based on DOE, 2019)

Coal power plants are concentrated in Pangasinan, Bataan, Batangas, and Quezon provinces, with some located in Pampanga and Bulacan. Oil-fired power plants are mostly in La Union, with some distributed in Central Luzon provinces, including Pampanga, Nueva Ecija, Bulacan, and Bataan, and smaller variants in Rizal. Lower-capacity biomass power plants operate in Nueva Ecija, Bataan, and Isabela. **Table 5** summarizes the emission factors generated for CO, NMVOC, SO_X, NO_X, and PM.

[9] DOE (2019). List of existing (Grid Connected) power plants. Philippine Department of Energy.

Table 5 Summary of Emission Factors Estimated (g/km)

Carbon Monoxide				
Technology	**< 5 km**	**5 - 10 km**	**10-20 km**	**> 20 km**
Baseline Jeepney	1.857	1.368	1.086	1.004
Euro 4 Diesel Jeepneys	0.289	0.213	0.169	0.157
Electric Jeepney	0.017	0.017	0.017	0.017
Volatile Organic Compounds				
Technology	**< 5 km**	**5 - 10 km**	**10-20 km**	**> 20 km**
Baseline Jeepney	0.429	0.316	0.251	0.232
Euro 4 Diesel Jeepneys	0.044	0.032	0.026	0.024
Electric Jeepney	0.001	0.001	0.001	0.001
Nitrogen Oxide				
Technology	**< 5 km**	**5 - 10 km**	**10-20 km**	**> 20 km**
Baseline Jeepney	2.348	1.730	1.373	1.270
Euro 4 Diesel Jeepneys	1.824	1.344	1.067	0.987
Electric Jeepney	0.065	0.065	0.065	0.065
Particulate Matter 10				
Technology	**< 5 km**	**5 - 10 km**	**10-20 km**	**> 20 km**
Baseline Jeepney	0.596	0.439	0.349	0.322
Euro 4 Diesel Jeepneys	0.099	0.073	0.058	0.053
Electric Jeepney	0.008	0.008	0.008	0.008
Particulate Matter				
Technology	**< 5 km**	**5 - 10 km**	**10-20 km**	**> 20 km**
Baseline Jeepney	0.596	0.439	0.349	0.322
Euro 4 Diesel Jeepneys	0.099	0.073	0.058	0.053
Electric Jeepney	0.010	0.010	0.010	0.010
Sulfur Oxide				
Technology	**< 5 km**	**5 - 10 km**	**10-20 km**	**> 20 km**
Baseline Jeepney	0.020	0.015	0.012	0.011
Euro 4 Diesel Jeepneys	0.023	0.017	0.013	0.012
Electric Jeepney	0.658	0.658	0.658	0.658

3.2 Pollution Dispersion Modeling

Pollution dispersion modelling was undertaken using the Weather and Research and Forecasting with Chemistry (WRF-Chem) v. 4.0.1 modelling system to simulate pollutant dispersion and predict ground level concentrations. Bottom-up emissions inventories are ideally loaded on a baseline dispersion model and calibrated using air quality readings. This approach would easily allow baseline jeepney emissions to be removed from the emissions map and replaced with scenario emissions, which will be loaded into the dispersion model. However, in the absence of bottom-up emissions inventory assessments, only jeepney emissions were mapped and loaded into the model to determine the difference in pollution concentration.

Despite the study scope covering Metro Manila, simulations undertaken covered impacts in the entire Luzon region considering that pollution is expected to flow to nearby provinces and most power plants are situated outside Metro Manila.

Jeepney fleet emissions for each route was quantified and assumed as equally distributed within a given route. The estimated set of transit line emissions were overlain on a 1-km x 1-km grid map of Metro Manila, using intersect geoprocessing in the QGIS software. Power plant emissions were also assigned to similar grids. Gridded emissions were then loaded into WRF-Chem v. 4.0.1 dispersion modelling system.

The model was configured to have multiple nest levels (telescoping). Telescoping with multiple nest grids allow high-resolution modeling. A ratio of 1:5 was determined as most effective. The figure below illustrates the domain configuration for the experiments, having 3 domains with resolutions of 25 km, 5 km, and 1 km from the outermost to the innermost domain, respectively. **Table 6** provides the model settings for the different domains. Four sets of simulations were performed covering January to December 2019.

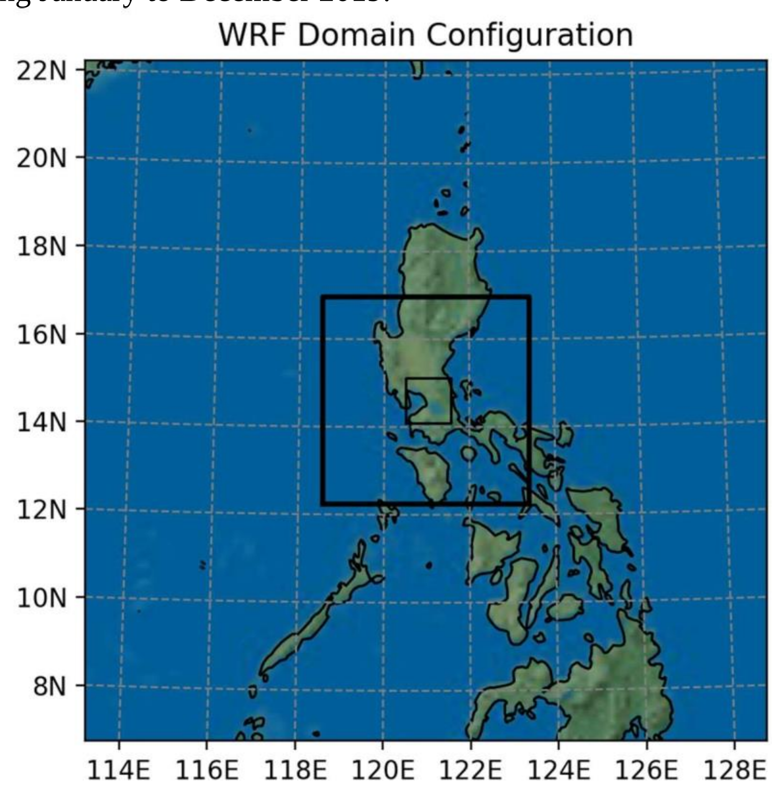


Figure 3 Domain Configuration of the Model

Table 6 Model Domain Settings

Domains	Domain 1	Domain 2	Domain 3
Horizontal Resolution	25 km	5 km	1 km
Vertical Resolution	51 levels	51 levels	51 levels
Grid Points West-East	70	106	116
Grid Points South-North	70	106	116
Domains Of Integration	Latitude 6.3° N- 22.4° N	Latitude 12.2° N - 17.0° N	Latitude 14.1° N - 15.1° N
	Longitude 114.1° E-128.9° E	Longitude 118.4° E – 123.7° E	Longitude 120.5° E - 121.6° E

The model was configured with the physical and chemical parameterization schemes outlined in **Table 7**. The main physical parameterizations set within the model were the Goddard shortwave radiation scheme (Chou et al, 1998)[10] and the Rapid Radiative Transfer Model (RRTM) long wave radiation scheme (Mlawer et al., 1997)[11]. For the land surface model, the Unified Noah model was selected based on Chen and Dudhia (2001)[12] to describe land surface processes. For microphysical processes in cloud droplet formation, the WRF Single Moment 6 Class (WSM6) scheme was selected, adopted from Hong (2006)[13]. This scheme was determined appropriate for high-resolution simulations based on Wang et al (2009)[14].
The Planetary Boundary Layer (PBL) process adopted was based on the Yonsei University (YSU) scheme, which allows for an explicit treatment of entrainment, generating warmer PBLs (Yerramilli et al., 2012)[15]. Most studies also show that the YSU PBL scheme closely simulates approximated atmospheric conditions and proper chemistry.

Table 7 Model Physical and Chemical Parameterizations

Physical and chemical assumptions	
Shortwave Radiation	Dudhia scheme
Longwave Radiation	Rapid Radiative Transfer Model
Land-Surface Model	Unified Noah land-surface model

[10] Chou, M. D., Suarez, M. J., Ho, C. H., Yan, M. M. H., & Lee, K. T. (1998). "Parameterizations for cloud overlapping and shortwave single-scattering properties for use in general circulation and cloud ensemble models." Journal of Climate, Volume 11, Issue 2, Pages 202–214.

[11] Mlawer, E. J., Taubman, J., Brown, P. D., Iacono, M. J., & Clough, S. A. (1997). "Radiative transfer for inhomogeneous atmospheres: RRTM, a validated correlated k model for the longwave." Journal of Geophysical Research: Atmospheres, Volume 102, Issue D14, Pages 16663–16682.

[12] Chen, F., & Dudhia, J. (2001). "Coupling an Advanced Land Surface – Hydrology Model with the Penn State – NCAR MM5 Modeling System. Part I: Model Implementation and Sensitivity." Monthly Weather Review, Volume 129, Issue 4, Pages 569-585.

[13] Hong, S. (2006). "The WRF Single-Moment 6-Class Microphysics Scheme (WSM6)". Journal of Korean Meteorological Society, Volume 42, Issue 2, Pages 129–151.

[14] W. Wang, C. Bruyère, M. Duda, J. Dudhia, D. Gill, M. Kavulich, K. Werner, M. Chen, L. Hui-Chuan, J. Michalakes, S. Rizvi, X. Zhang, J. Berner, D. Munoz-Esparza, B. Reen, S. Ha & K. Fossell, "WRF ARW Version 4 Modeling System User's Guide," January 2019.

[15] Yerramilli, A., Vogel, C. A., Baham, J. M., Pendergrass, W. R., Patrick, C., Dodla, V. B. R., Challa, V. S., et. al., (2012). "Simulation of surface ozone pollution in the Central Gulf Coast region during summer synoptic condition using WRF/Chem air quality model." Atmospheric Pollution Research, Volume 3, Issue 1, Pages 55-71.

PBL Process	Yonsei University scheme
Cumulus Convection	Grell-Freitas scheme except on the fine nest
Cloud Microphysics	Kain-Fritsch scheme
Photolysis Scheme	Madronich F-TUV Photolysis
Gas-Phase Mechanism	Regional Acid Deposition Model Version 2
Aerosol Module	Go-cart simple aerosol treatment

3.3 Ambient Air Pollutant Concentration Effects

The resulting ambient air pollutant concentration estimates generated for the control scenarios were limited to pollutants measured at air quality monitoring sites in Metro Manila. This only include $PM_{2.5}$ and PM_{10}. Likewise, only annual average concentrations were generated due to limitations in available data. A listing of the available stations is provided in **Table 8**.

Table 8 Air Quality Monitoring Stations in Metro Manila

Station ID	Location	LGU
1	Rohm and Hass Warehouse Compound, CAA Road, Las Pinas City	Las Pinas
2	Makati Park and Garden, Dr. Jose P. Rizal Extension	Makati
3	Malabon Polytechnic Institute Cmpd., Gov. A. Pascual	Malabon
4	Plaza Hardin, Martinez Highway, Addition Hill, Mandaluyong City	Mandaluyong
5	Hall of Justice, Open Ground, Marikina City Hall, Marikina City	Marikina
6	Muntinlupa Bilibid Prison open ground, Muntinlupa City	Muntinlupa
7	Navotas City Hall Cmpd., M. Naval Street, Navotas City	Navotas
8	Caloocan City Hall Annex Cmpd., Caloocan City	Caloocan
9	Don Bosco Barangay Hall, Paranaque City	Paranaque
10	PAL Cmpd., Andrews Ave., Brgy. 184, Zone 19, Pasay City	Pasay
11	Country Lodge Cpd., 18 Danny Floro Street, Oranbo, Pasig City	Pasig
12	Pateros Elementary School, P. Herrera St., San Pedro, Municipality of Pateros	Pateros
13	Pinaglabanan Shrine along Pinaglabanan St., San Juan City	San Juan
14	TUP Taguig Campus, East Service Road, Western Bicutan, Taguig City	Taguig

15	University of the East, 105 Samson Road, Caloocan City	Caloocan
16	National Printing Office Cmpd. EDSA Diliman, Quezon City	Quezon
17	Marikina Sports Complex Cmpd. Sumulong Highway Brgy. Sto Nino, Marikina City	Marikina
18	DOH Cmpd. Rizal Avenue Sta Cruz, Manila	Manila
19	MMDA Building Cmpd. Orense St. cor. EDSA Guadalupe, Makati City	Makati

3.4 Health Impact and Valuation Modeling

Air pollution endpoints are expressed in various forms (e.g., incidences of mortality, morbidity, and hospitalization, and loss of productive days). A main consideration in selecting endpoints to adopt is the availability of corresponding baseline data. Local data is limited to mortality and morbidity, which were therefore adopted as the endpoints in the analysis. PSA (2020)[16] provides a long list of mortality causes. The study identified and adopted cardio-, respiratory-, and circulatory- air pollution-related illnesses leading to mortality, as provided in the table below.

Table 9 Baseline Annual Incidence by Region and Relevant Disease

Disease	Region							Total
	CAR	NCR	I	II	III	IVA	V	
Acute rheumatic fever and chronic rheumatic heart diseases	34	255	34	84	280	266	129	1,082
Cerebrovascular diseases	1,061	6,265	1,061	2,076	7,549	8,072	4,413	30,497
Chronic lower respiratory diseases (COPD, Emphysema, etc.)	310	2,788	310	1,109	3,571	3,199	1,610	12,897
Hypertensive diseases	330	5,261	330	1,395	3,600	4,562	1,862	17,340
Ischemic heart diseases	948	12,951	948	2,266	9,653	11,847	4,562	43,175
Other acute lower	No Data	4	No Data	2	7	16	7	36

[16] Philippine Statistics Authority (2020). Number of Deaths by Cause, by Age Group and by Sex, Philippines 2006-2015. Accessed from https://psa.gov.ph/vital-statistics/table

Disease	Region							Total
	CAR	NCR	I	II	III	IVA	V	
respiratory infections								
Other heart diseases	354	3,257	354	1,156	4,329	4,066	2,235	15,751
Other respiratory conditions of newborn	15	249	15	22	136	250	65	752
Pneumonia	764	5,886	764	2,299	4,090	5,665	3,432	22,900
Remainder of diseases of the circulatory system	31	332	31	61	193	279	86	1,014
Remainder of diseases of the respiratory system	60	831	60	115	587	863	334	2,850
Respiratory distress of newborn	29	382	29	57	334	438	124	1,392
Respiratory tuberculosis	165	3,583	165	640	2,252	3,672	1,884	12,361

The table below provides the adopted coverage for morbidity, which was not as exhaustive as only the leading ten causes of morbidity could be accessed in PSA (2015).

Table 10 Baseline Old Jeepneys Morbidity Annual Incidence by Disease and Region

Disease	Region							Total
	CAR	NCR	1	2	3	4A	5	
Acute Respiratory Infection	137,711	717,356	536,402	184,421	31,943	515,691	223,554	2,347,078
Acute Lower Respiratory Infection and Pneumonia	18,148	161,689	10,296	135,669	16,620	105,022	40,055	487,499
Bronchitis	20,494	39,054	32,892	5,538	1,751	10,415	15,596	125,740
Tuberculosis	No Data	23,390	10,642	5,884	3,541	2,818	11,733	58,008
Hypertension	29,658	128,825	135,216	50,777	10,407	116,004	71,285	542,172

The changes in mortality and morbidity in each cell of the gridded map for each control scenario were quantified using log-linear health impact functions (HIF) provided in Equation 3.

$$\Delta I = (1 - e^{-\beta \Delta \mathrm{Conc}}) IR_{\mathrm{Base}} Pop \qquad \text{Equation 3}$$

The health impact functions estimate the change of incidence of an endpoint (ΔI) resulting from changes in pollution concentration ($\Delta Conc$) considering baseline incidence rate (IR_{Base}), population (Pop) and a concentration-response calibration coefficient, beta (β) in the case of the log-linear HIF. The log-linear form is one of the most commonly used HIF and normally serves as the default function for most air pollution health impact tools such as BENMAP (EPA, 2018[17]). The incidence changes and their corresponding monetary equivalents were implemented using the said tool. HIFs were collated for the endpoints listed earlier. In cases where beta values are not directly available, relative risk (RR) values were sourced and converted to beta using Equation 4 (EPA, 2018). The HIFs and RR values were collated from various sources including EPA (2018), WHO (2013)[18], Industrial Economics Inc and Thurston G. (2015)[19] and Jalaludin N. and C. Christie (2010)[20].

In cases where no morbidity RR values are available for a pollutant and illness pair, RR values for hospitalization were adopted instead. The practice assumes that hospitalization incidence is directly proportional with morbidity. A summary of the beta's adopted are provided in **Tables 11 and 12**.

$$\beta = -\frac{\ln RR}{\Delta I} \qquad \text{Equation 4}$$

Table 11 Modeling Mortality and Cost Parameters

Pollutant, Averaging	Cause of Mortality	Incidence Modeling Parameters	
		Beta	**Notes**
$PM_{2.5}$, Annual Average	Respiratory tuberculosis	0.013103	Cardiopulmonary
	Whooping cough	0.005827	All causes
	Acute rheumatic fever and chronic rheumatic heart diseases	0.013103	Cardiopulmonary
	Hypertensive diseases	0.013103	Cardiopulmonary
	Ischaemic heart diseases	0.021511	Disease specific
	Other heart diseases	0.013103	Cardiopulmonary
	Cerebrovascular diseases	0.013103	Cardiopulmonary

[17] EPA (2018). BENMAP: Environmental Benefits Mapping and Analysis Program – Community Edition User's Manual. United States-Environment Protection Agency.

[18] WHO (2013). Health risks of air pollution in Europe – HRAPIE project Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone, and nitrogen dioxide. World Health Organization

[19] Industrial Economics, Inc., and Thurston G. (2015). Industrial Economics Literature Review of Air Pollution-Related Health Endpoints and Concentration-Response Functions for Ozone, Nitrogen Dioxide, and Sulfur Dioxide: Results and Recommendations. Draft Report Submitted to the South Coast Air Quality Management District.

[20] Jalaludin N. and C. Christie (2010). Health Risk Assessment – Preliminary Work to Identify Concentration-Response Functions for Selected Ambient Air Pollutants. Respiratory and Environmental Epidemiology Woolcock Institute of Medical Research. Report prepared for EPA Victoria.

Pollutant, Averaging	Cause of Mortality	Incidence Modeling Parameters	
		Beta	Notes
	Remainder of diseases of the circulatory system	0.013103	Cardiopulmonary
	Pneumonia	0.013103	Cardiopulmonary
	Other acute lower respiratory infections	0.005827	All causes
	Chronic lower respiratory diseases (COPD, Emphysema, etc.)	0.013103	Cardiopulmonary
	Remainder of diseases of the respiratory system	0.005827	All causes
	Respiratory distress of newborn	0.006766	Infant deaths
	Other respiratory conditions of newborn	0.006766	Infant deaths
$PM_{2.5}$, Daily Average	Respiratory tuberculosis	0.000678	Respiratory
	Whooping cough	0.000678	Respiratory
	Acute rheumatic fever and chronic rheumatic heart diseases	0.000846	Cardiovascular
	Hypertensive diseases	0.000846	Cardiovascular
	Ischaemic heart diseases	0.000846	Cardiovascular
	Other heart diseases	0.000846	Cardiovascular
	Cerebrovascular diseases	0.000846	Cardiovascular
	Remainder of diseases of the circulatory system	0.000846	Cardiovascular
	Pneumonia	0.000846	Cardiopulmonary
	Other acute lower respiratory infections	0.000678	Respiratory
	Chronic lower respiratory diseases (COPD, Emphysema, etc.)	0.000678	Respiratory
	Remainder of diseases of the respiratory system	0.000678	Respiratory
	Respiratory distress of newborn	0.000678	Respiratory
	Other respiratory conditions of newborn	0.000678	Respiratory
PM_{10}, Annual Average	Respiratory tuberculosis	0.000385	All causes
	Whooping cough	No C-R obs.	
	Acute rheumatic fever and chronic rheumatic heart diseases	No C-R obs.	
	Hypertensive diseases	No C-R obs.	
	Ischaemic heart diseases	No C-R obs.	
	Other heart diseases	No C-R obs.	
	Cerebrovascular diseases	No C-R obs.	

Pollutant, Averaging	Cause of Mortality	Incidence Modeling Parameters	
		Beta	Notes
	Remainder of diseases of the circulatory system	No C-R obs.	
	Pneumonia	0.000385	All causes
	Other acute lower respiratory infections	0.000385	All causes
	Chronic lower respiratory diseases (COPD, Emphysema, etc.)	0.000385	All causes
	Remainder of diseases of the respiratory system	0.000385	All causes
	Respiratory distress of newborn	0.003922	Infant deaths
	Other respiratory conditions of newborn	0.003922	Infant deaths
PM_{10}, Daily Average	Respiratory tuberculosis	0.001292	Respiratory
	Whooping cough	0.001292	Respiratory
	Acute rheumatic fever and chronic rheumatic heart diseases	0.000896	Cardiovascular
	Hypertensive diseases	0.000896	Cardiovascular
	Ischaemic heart diseases	0.000896	Cardiovascular
	Other heart diseases	0.000896	Cardiovascular
	Cerebrovascular diseases	0.000896	Cardiovascular
	Remainder of diseases of the circulatory system	0.000896	Cardiovascular
	Pneumonia	0.001292	Respiratory
	Other acute lower respiratory infections	0.001292	Respiratory
	Chronic lower respiratory diseases (COPD, Emphysema, etc.)	0.001292	Respiratory
	Remainder of diseases of the respiratory system	0.001292	Respiratory
	Respiratory distress of newborn	0.001292	Respiratory
	Other respiratory conditions of newborn	0.001292	Respiratory
NO_2, Annual Average	Respiratory tuberculosis	No C-R obs.	Respiratory
	Whooping cough	No C-R obs.	Respiratory
	Acute rheumatic fever and chronic rheumatic heart diseases	No C-R obs.	
	Hypertensive diseases	No C-R obs.	
	Ischaemic heart diseases	No C-R obs.	
	Other heart diseases	No C-R obs.	
	Cerebrovascular diseases	No C-R obs.	

Pollutant, Averaging	Cause of Mortality	Incidence Modeling Parameters	
		Beta	Notes
	Remainder of diseases of the circulatory system	No C-R obs.	
	Pneumonia	No C-R obs.	
	Other acute lower respiratory infections	No C-R obs.	
	Chronic lower respiratory diseases (COPD, Emphysema, etc.)	No C-R obs.	
	Remainder of diseases of the respiratory system	No C-R obs.	
	Respiratory distress of newborn	No C-R obs.	
	Other respiratory conditions of newborn	No C-R obs.	
NO_2, Daily Average	Respiratory tuberculosis	0.002093	Respiratory
	Whooping cough	0.002093	Respiratory
	Acute rheumatic fever and chronic rheumatic heart diseases	0.000866	Cardiovascular
	Hypertensive diseases	0.000866	Cardiovascular
	Ischaemic heart diseases	0.000866	Cardiovascular
	Other heart diseases	0.000866	Cardiovascular
	Cerebrovascular diseases	0.000866	Cardiovascular
	Remainder of diseases of the circulatory system	0.000866	Cardiovascular
	Pneumonia	0.002093	Respiratory
	Other acute lower respiratory infections	0.002093	Respiratory
	Chronic lower respiratory diseases (COPD, Emphysema, etc.)	0.002093	Respiratory
	Remainder of diseases of the respiratory system	0.002093	Respiratory
	Respiratory distress of newborn	0.002093	Respiratory
	Other respiratory conditions of newborn	0.002093	Respiratory
SO_2, Annual Average	Respiratory tuberculosis	No C-R obs.	
	Whooping cough	No C-R obs.	
	Acute rheumatic fever and chronic rheumatic heart diseases	No C-R obs.	
	Hypertensive diseases	No C-R obs.	
	Ischaemic heart diseases	No C-R obs.	
	Other heart diseases	No C-R obs.	
	Cerebrovascular diseases	No C-R obs.	

Pollutant, Averaging	Cause of Mortality	Incidence Modeling Parameters	
		Beta	Notes
	Remainder of diseases of the circulatory system	No C-R obs.	
	Pneumonia	No C-R obs.	
	Other acute lower respiratory infections	No C-R obs.	
	Chronic lower respiratory diseases (COPD, Emphysema, etc.)	No C-R obs.	
	Remainder of diseases of the respiratory system	No C-R obs.	
	Respiratory distress of newborn	No C-R obs.	
	Other respiratory conditions of newborn	No C-R obs.	
SO_2, Daily Average	Respiratory tuberculosis	No C-R obs.	
	Whooping cough	No C-R obs.	
	Acute rheumatic fever and chronic rheumatic heart diseases	No C-R obs.	
	Hypertensive diseases	No C-R obs.	
	Ischaemic heart diseases	No C-R obs.	
	Other heart diseases	No C-R obs.	
	Cerebrovascular diseases	No C-R obs.	
	Remainder of diseases of the circulatory system	No C-R obs.	
	Pneumonia	No C-R obs.	
	Other acute lower respiratory infections	No C-R obs.	
	Chronic lower respiratory diseases (COPD, Emphysema, etc.)	No C-R obs.	
	Remainder of diseases of the respiratory system	No C-R obs.	
	Respiratory distress of newborn	No C-R obs.	
	Other respiratory conditions of newborn	No C-R obs.	

Note: "No C-R Obs" indicates that there has not been observed relationship between the pollutant concentration and the end point.

Table 12 Modeling Morbidity and Cost Parameters

Pollutant, Averaging	Cause of Morbidity	Incidence Modeling Parameters	
		Beta	Notes
$PM_{2.5}$, Annual Average	Acute Respiratory Infection	0.002664	Respiratory, Hospitalization
	Acute Lower Respiratory Infection	0.002664	Respiratory, Hospitalization

Pollutant, Averaging	Cause of Morbidity	Incidence Modeling Parameters	
		Beta	Notes
	Pneumonia	0.002664	Respiratory, Hospitalization
	Hypertension	0.003343	Cardiovascular, Hospitalization
	Tuberculosis	0.002664	Respiratory, Hospitalization
	Bronchitis	0.059333	COPB/Bronchitis
$PM_{2.5}$, Daily Average	Acute Respiratory Infection	0.002049	Respiratory, Hospitalization
	Acute Lower Respiratory Infection	0.002049	Respiratory, Hospitalization
	Pneumonia	0.002049	Respiratory, Hospitalization
	Hypertension	0.003343	Cardiovascular, Hospitalization
	Tuberculosis	0.002049	Respiratory, Hospitalization
	Bronchitis	0.002049	Respiratory, Hospitalization
PM_{10}, Annual Average	Acute Respiratory Infection	No C-R obs.	
	Acute Lower Respiratory Infection	No C-R obs.	
	Pneumonia	No C-R obs.	
	Hypertension	No C-R obs.	
	Tuberculosis	No C-R obs.	
	Bronchitis	0.007232	COPD/Bronchitis
PM_{10}, Daily Average	Acute Respiratory Infection	0.001134	Respiratory, Hospitalization
	Acute Lower Respiratory Infection	0.001134	Respiratory, Hospitalization
	Pneumonia	0.001134	Respiratory, Hospitalization
	Hypertension	No C-R obs.	
	Tuberculosis	0.001134	Respiratory, Hospitalization
	Bronchitis	0.001134	Respiratory, Hospitalization
	Acute Respiratory Infection	No C-R obs.	

Pollutant, Averaging	Cause of Morbidity	Incidence Modeling Parameters	
		Beta	Notes
NO_2, Annual Average	Acute Lower Respiratory Infection	No C-R obs.	
	Pneumonia	No C-R obs.	
	Hypertension	No C-R obs.	
	Tuberculosis	No C-R obs.	
	Bronchitis	No C-R obs.	
NO_2, Daily Average	Acute Respiratory Infection	0.000827	Respiratory, Hospitalization
	Acute Lower Respiratory Infection	0.000827	Respiratory, Hospitalization
	Pneumonia	0.000827	Respiratory, Hospitalization
	Hypertension	0.000678	Cardiovascular, Hospitalization
	Tuberculosis	0.000827	Respiratory, Hospitalization
	Bronchitis	0.000827	Respiratory, Hospitalization
SO_2, Annual Average	Acute Respiratory Infection	No C-R obs.	
	Acute Lower Respiratory Infection	No C-R obs.	
	Pneumonia	No C-R obs.	
	Hypertension	No C-R obs.	
	Tuberculosis	No C-R obs.	
	Bronchitis	No C-R obs.	
SO_2, Daily Average	Acute Respiratory Infection	0.000499	Respiratory, Hospitalization
	Acute Lower Respiratory Infection	0.000499	Respiratory, Hospitalization
	Pneumonia	0.000499	Respiratory, Hospitalization
	Hypertension	No C-R obs.	
	Tuberculosis	0.000499	Respiratory, Hospitalization
	Bronchitis	0.000499	Respiratory, Hospitalization

Note: “No C-R Obs” indicates that there has not been observed relationship between the pollutant concentration and the end point.

Changes in morbidity and mortality were respectively monetized using estimated treatment costs based on physician interviews (See **Table 13**) and locally calibrated value of a statistical life (VSL).

Table 13 Estimated Treatment Cost by Illness

Illness	Treatment Cost (PHP)
Respiratory tuberculosis	10,000.00
Whooping cough	11,000.00
Acute rheumatic fever and chronic rheumatic heart diseases	16,000.00
Hypertensive diseases	10,000.00
Ischemic heart diseases	660,000.00
Other heart diseases	19,000.00
Cerebrovascular diseases	1,615,000.00
Remainder of diseases of the circulatory system	15,200.00
Acute Lower Respiratory Infection and Pneumonia	26,000.00
Other acute lower respiratory infections	32,000.00
Chronic lower respiratory diseases (COPD, Emphysema, etc.)	129,000.00
Remainder of diseases of the respiratory system	12,000.00
Respiratory distress of newborn	235,000.00
Other respiratory conditions of newborn	11,000.00
Bronchitis	15,300.00
Acute Respiratory Infection	1,600.00

The VSL is the marginal rate of substitution between income and mortality risk and indicates how much individuals are willing to pay (WTP) to reduce the risk of death. The VSL is an applicable approach in benefit-cost analyses to evaluate the design efficiency of government policies in reducing risk. No local VSL data exists. U.S. VSL 1990 figures were therefore locally adjusted to consider inflationary effects, purchasing power parity, and GDP differences, as shown in Equation 5. It is noted that due to wide income gaps in the country, median household income was adopted rather than GDP per capita as typically used in the Environmental Benefits Mapping and Analysis Program (BENMAP) process. The approach adopted however, conforms in principle with the BENMAP process.

$$\begin{aligned} VSL_{Philippines,2019} \\ &= VSL_{US,1990} * \left(\frac{Y_{Philippines,2019}}{Y_{US,2019}}\right)^{\varepsilon} * PPP_{1990} * \frac{CPI_{Philippines,2019}}{CPI_{Philippines,1990}} \\ &= A * B * C * D \end{aligned}$$

Equation 5

Where :

- $VSL_{Philippines,2019}$ is the VSL value in the Philippines in 2019 PHP
- $VSL_{US,1990}$ is the VSL value for the US in 1990 USD
- $Y_{Philippines,2019}$ is the median household income in the Philippines in 2019
- $Y_{US,1990}$ is the median household income in the US in 1990
- ε is the income elasticity of the VSL
- PPP_{1990} is the purchasing power parity index in the Philippines in 1990
- $CPI_{Philippines,2019}$ is the consumer price index in the Philippines in 2019
- $CPI_{Philippines,1990}$ is the consumer price index in the Philippines in 1990

The tables below provide the assumptions adopted in deriving the VSL and the VSL values adopted.

Table 14 VSL Assumptions

Parameter	Value	Source
$Y_{Philippines,2019}$	USD 5,906.66	PSA (2019)[21]
$Y_{US,1990}$	USD 54,621.00	Statista (2019)[22]
ε	1.2[23]	EPA (2018)
$CPI_{Philippines,2019}$	122.6	World Bank (2020)[24]
$CPI_{Philippines,1990}$	28.58	Index Mundi (2019)[25]

Table 15 VSL Equation Parameter Values

ID	Parameter	Value
A	$VSL_{US,1990}$	$ 4,800,000
B	$\left(\frac{Y_{Philippines,2019}}{Y_{US,1990}}\right)^{\varepsilon}$	0.069
C	PPP_{1990}	6.7[26]
D	$\frac{CPI_{Philippines,2019}}{CPI_{Philippines,1990}}$	4.29

[21] Philippine Statistics Authority. 2019. Annual Family Income is Estimated at PhP 313 thousand, on Average, in 2018. [Online]. Manila: PSA. Available in: https://psa.gov.ph/content/annual-family-income-estimated-php-313-thousand-average-2018

[22] Statista. 2019. Average (median) household income in the United States from 1990 to 2018. [Online]. Duffin. Available in https://www.statista.com/statistics/200838/median-household-income-in-the-united-states/

[23] Assumed for low- and middle-income countries

[24] World Bank. 2020. Data Bank: World Development Indicators. [Online]. The World Bank Group. Available in: https://databank.worldbank.org/reports.aspx?source=world-development-indicators

[25] Index Mundi. 2019. Philippines – Consumer price index. [Online]. Available in https://www.indexmundi.com/facts/philippines/consumer-price-index

[26] World Bank. 2020. Data Bank: World Development Indicators. [Online]. The World Bank Group. Available in: https://databank.worldbank.org/reports.aspx?source=world-development-indicators

The VSL for the Philippines was determined to be PHP 9,519,681.60 per mortality incidence. The present value of monetized benefits resulting from changes in morbidity and mortality throughout the service life of the vehicles were determined using standard annuity equations, assuming a 3.5% discount rate and projections on consumer price index.

4 Results and Discussions

4.1 Emission Generation

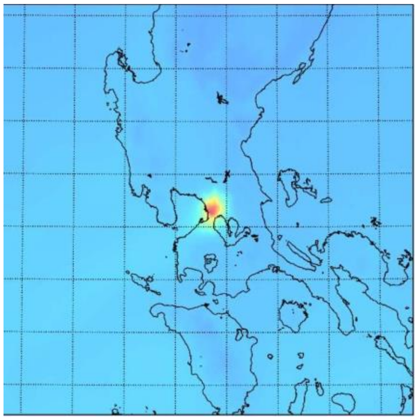
Except for SO_x releases of Scenario 2, all controls scenarios are expected to cut-down emission releases from the use of jeepneys in Metro Manila. Scenario 1 or the Euro 4 case is expected to cut-down CO, VOC, and PM emissions by at least 90%. Reductions in SO_x and NO_x emissions are also significant but lower compared to the other pollutants. The E-Jeep scenario on the other hand is expected to cut down releases of pollutants by at least 96% except for SO_x which could increase significantly. It could be noted the Coal comprise almost 45% of the Luzon grid mix with some oil share. This is expected to push-up SO_x releases relative to emissions from the old jeepneys considering that sulfur content limits of automotive diesel have been decreased to 50 ppm with the adoption of Euro 4 fuel standards.

Table 16 Annual Emissions Generated in Tons

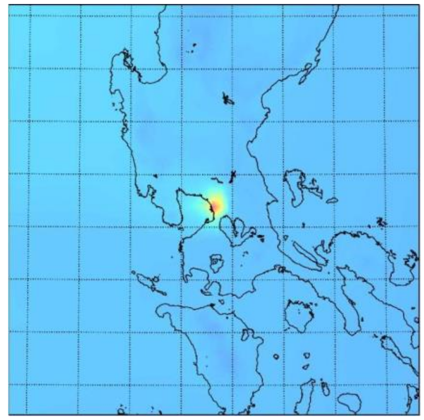
Case	CO	NMVOC	SO_x	NO_x	PM_{10}	$PM_{2.5}$
Baseline : Old Jeepneys	2826.25	653.16	30.74	3573.90	1134.30	907.44
Scenario 1 : Euro 4 Jeepneys	276.82	42.12	21.96	1745.20	118.10	94.48
Scenario 2 : E-Jeepneys	352.16	3.24	1528.59	1355.27	35.48	20.67

4.2 Dispersion Modeling

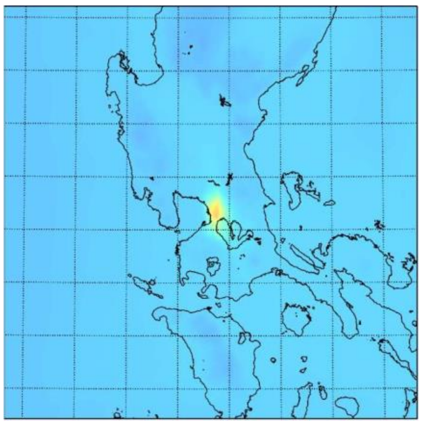
Average wind speed and direction for all months in the simulations are representative of the 3 seasonal patterns that prevail during these months: easterly (May), south-westerly (July), and north-easterly (October and December) wind flows. Overall, during the months of October and December, North-easterly wind flows are hindered because of the Sierra Madre Mountain Ranges to the east of Metro Manila. In effect, this allows low wind speed in the downwind area towards Metro Manila causing a stagnation of particulate and gaseous pollutants. However, it is to be noted that on some occasions, during the surge of the north-east monsoon, strong winds may also push pollutants towards areas of southern Luzon, more particularly Cavite, Batangas, and Laguna. On the other hand, during the months of July, strong south-westerly wind flow patterns greatly affect pollutants towards the north of Luzon, thus slightly affecting these areas particularly Bulacan and Pampanga provinces. Being across Metro Manila, Bataan was also seen to receive high amounts of pollutants during the surge of the north-east monsoon blowing in from the Pacific. Moreover, increased humidity due to the southwest monsoon greatly affects the presence of particulate emissions. **Figure 5** shows graphically pollutant flow during the three seasons discussed earlier.



North-Easterly



Easterly



South Easterly

Figure 4 Baseline $PM_{2.5}$ by Season

Local wind patterns in Metro Manila also greatly affect pollutant concentrations throughout the day. Diurnal variations in temperature allow the heating of Metro Manila along with Manila Bay. Due to this, during noon time, the development of a strong temperature gradient between Metro Manila and Manila Bay creates a local circulation of wind flow pointing from Manila Bay towards Metro Manila. This effect is also known as a sea breeze, and it directly cancels out the outflow of air within the Metro, thus the increase in pollutant concentrations. This effect is more pronounced during the north-east monsoon, when the development of this type of circulation goes against the prevailing winds.

Figures 5 to **8** provides the annual average pollutant contribution of Metro Manila jeepneys in the whole of Luzon for the baseline and the three control scenarios. Expectedly, the reduction of tail pipes emissions in Metro are expected to benefit not only Metro Manila but the nearby provinces mentioned previously at various seasons of the year. Only about 40% of the particulate matter emitted by old units stays within with metropolis. The rest are blown off to nearby provinces and some portions even reach the uppermost and lower most regions of Luzon. The adoption of Euro 4 units is projected to bring down ambient $PM_{2.5}$ concentration effects from jeepneys by around 78% in Metro Manila and about 20% in Region 4A. Pollution concentration improvements in Central Luzon may also be realized but to a lesser degree. The complete replacement of all units with E-Jeepneys pulls down effects of jeepneys to Metro Manila's $PM_{2.5}$ pollution concentration to negligible levels. $PM_{2.5}$ production from the added production of power plants within the City and nearby provinces are negligible compared to the amount emitted by old jeepneys in the metropolis. It will however impact negatively to some degree $PM_{2.5}$ ambient concentrations in the vicinity of combustion-based power plants. This is particularly true in the locations of major coal power plants such as in Sual, Pangasinan in Region 1, Zambales and Bataan in the Central Luzon region and the provinces of Batangas and Quezon in Region 4A. Region 1 is projected to have the biggest increase in $PM_{2.5}$ concentration from the added power production at around 7% on the average. Expectedly. These effects are less significant in scenario 3 where only about 10% of the jeepneys are converted to E-Jeepneys. Concentration effects within Metro Manila and nearby provinces though approximate that of scenario 1 considering the dominance of Euro 4 units. The same trend is true for PM_{10} ambient concentration effects. Their spillover positive effect in nearby provinces however is slightly lower considering their shorter suspension time in the atmosphere. This is also true for PM_{10} from power plants wherein the area affected are slightly smaller than those in $PM_{2.5}$.

A larger portion, around 90%, of NO_X emitted by the old jeepney units stay within the metropolis. This could be attributed to the shorter residence time of the gas compared to particulate matter. They are normally converted to ozone within a day or less and are not able to travel far. It affects adjacent provinces to a very small degree and hardly affects farther regions. Scenario 1 is expected to lower jeepney contributions to NO_X atmospheric concentrations in Metro Manila by around 60% while bring down concentration effects in region 4A and Central Luzon to negligible levels. Unlike in PM, the effect of the added power generation as required by E-Jeepneys in scenario 2 on NO_X concentrations in the vicinity of power plants are negligible. Expectedly, effect of scenario 3 on NO_X concentration in Metro Manila and nearby provinces approximates that of scenario 1.

Studies shows that up to 50% of the SO_X released to the atmosphere could undergo oxidation or absorption in 20 minutes while being transported in the atmosphere. This prevents the gas from travelling far from the point of release. This effect is reflected in the dispersion simulations where almost 98% of SO_X emitted by old jeepneys are not able to make it pass the boundaries of the metropolis. The adoption of scenario 1 is expected to reduce SO_X concentration contributions of jeepney in Metro Manila while rendering effects in nearby provinces to negligible levels. It could be recalled that E-Jeepney SO_X emission factors are significantly higher than diesel units due to the high share of coal and presence of some oil-fired plants in the grid. Scenario 2 could therefore possibly worsen SO_X concentrations in Metro Manila due to releases from some fossil fired power plants in nearby provinces. More specifically, emissions from coal and oil-fired power plants in Pampanga and Bulacan and the peaking generator set in Navotas are expected to increase concentrations in Metro Manila. Increased SO_X concentration levels in the vicinity of coal power plants elsewhere are also expected. This however may be addressed if stricter stationary emission standards are crafted and implemented. The increase in SO_X emission can be reduced if the Emission Factor used considered Air Pollution Control such as Flue Gas Desulfurizer or the use of Clean Technologies such as Fluidized Bed Boilers used in Coal Fired Power Plants or the shift to low sulfur fuel oil in Oil Fired Power Plants.

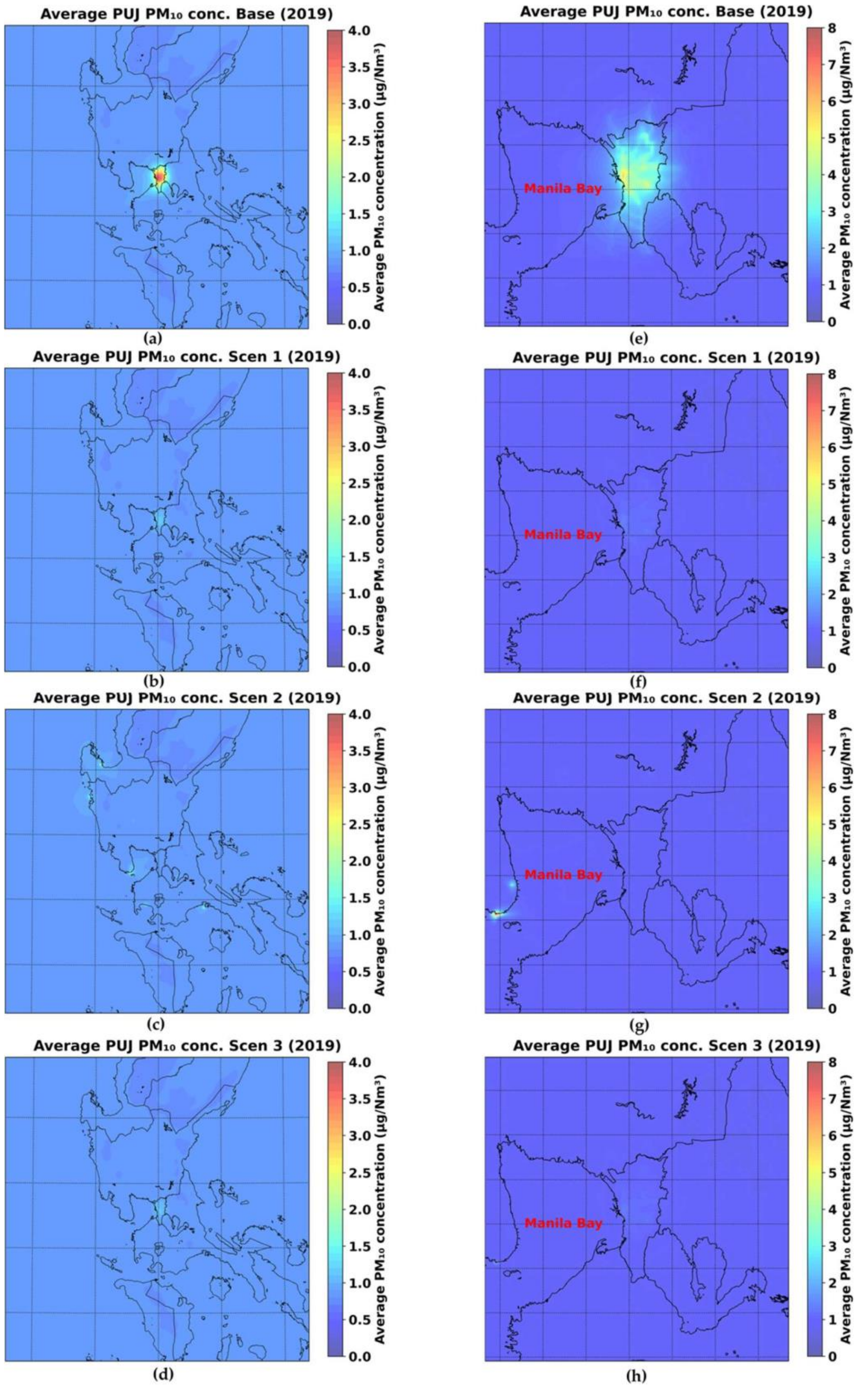


Figure 5 PM_{10} for the Various Control Scenarios

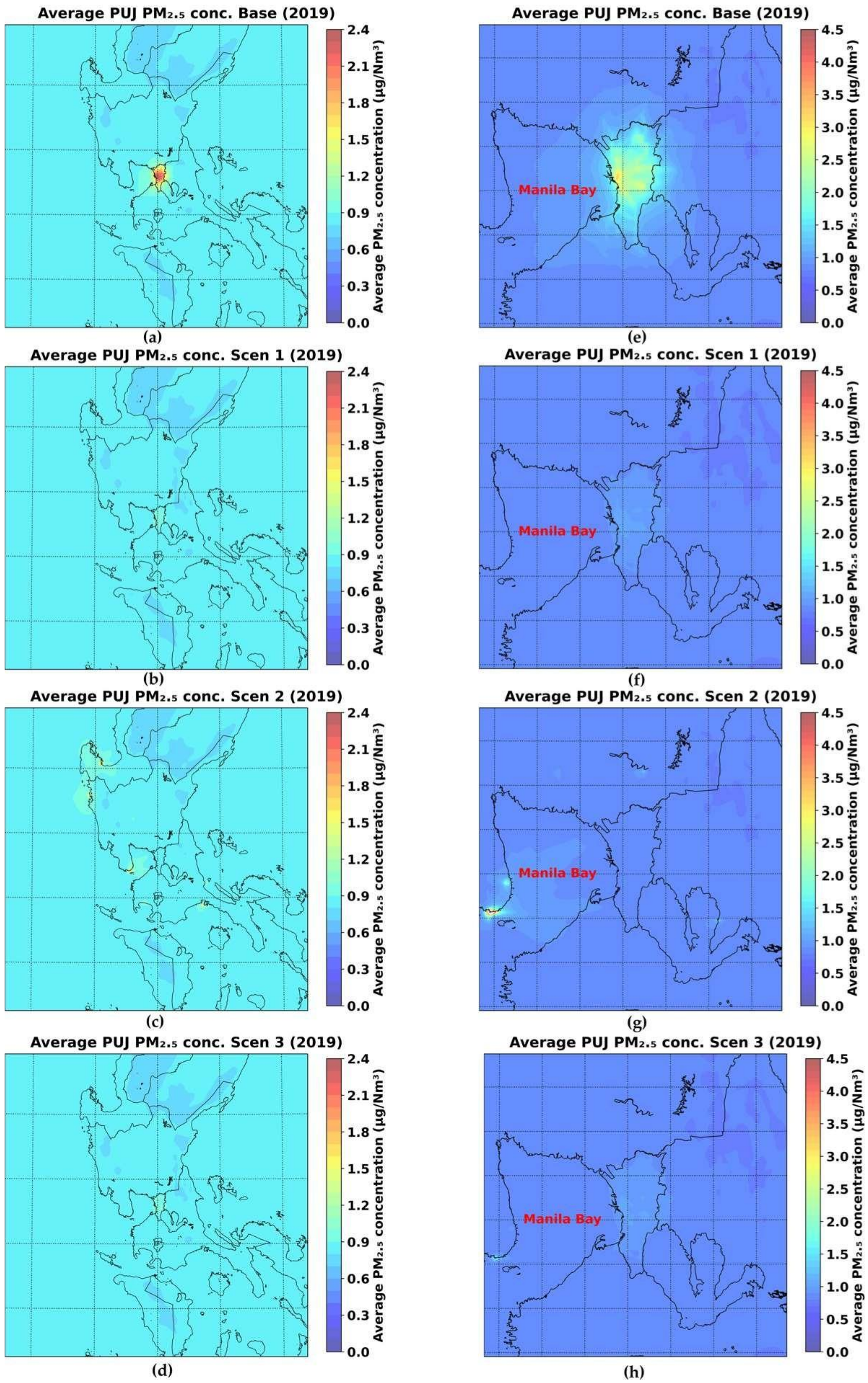


Figure 6 $PM_{2.5}$ for the Various Control Scenarios

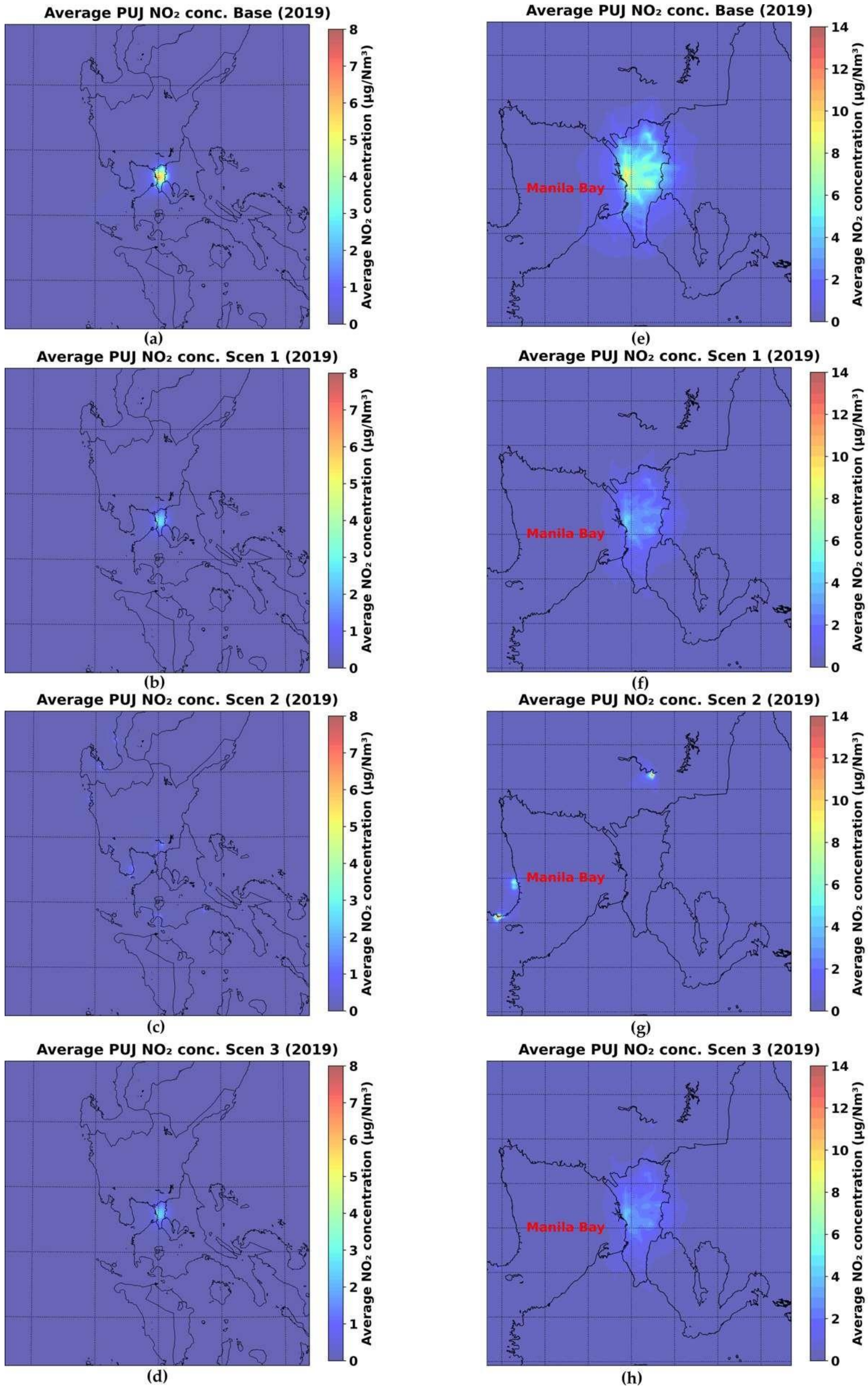


Figure 7 NO_2 for the Various Control Scenarios

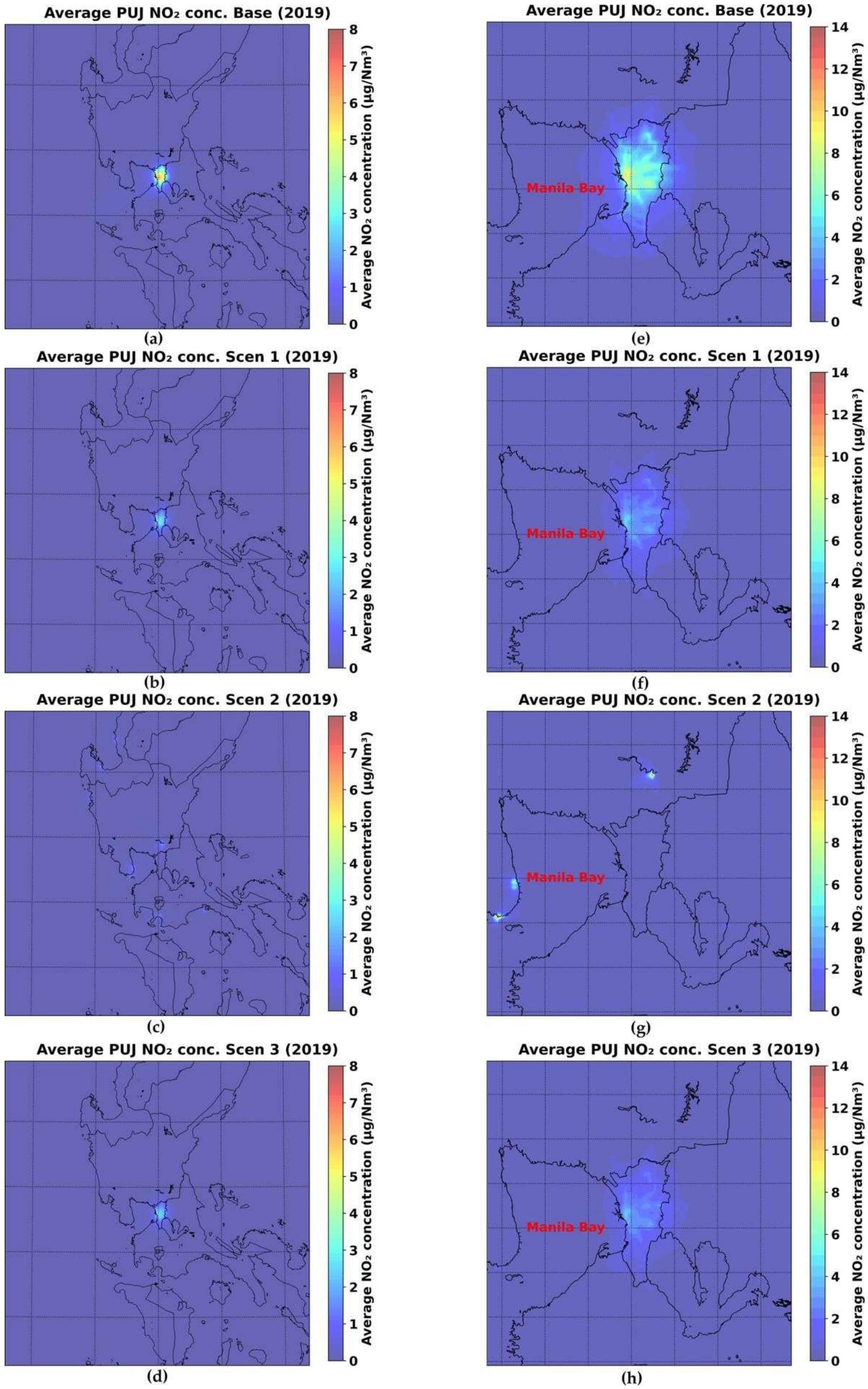


Figure 8 SO_2 for the Various Control Scenarios

Local wind patterns in Metro Manila also greatly affect pollutant concentrations throughout the day. Diurnal variations in temperature allow the heating of Metro Manila along with Manila Bay. Due to this, during noon time, the development of a strong temperature gradient between Metro Manila and Manila Bay creates a local circulation of wind flow pointing from Manila Bay towards Metro Manila. This effect is also known as a sea breeze, and it directly cancels out the outflow of air within the Metro, thus the increase in pollutant concentrations. This effect is more pronounced during the north-east monsoon, when the development of this type of circulation goes against the prevailing winds.

Figures 9 to **25** show the inner domain (1km by 1km) presenting the different LGUs of Metro Manila. As a reference for these figures, the reader is provided with a reference map of the LGUs in Metro Manila below (**Fig. 9**). The plots show the variation of each pollutant throughout the different scenarios. Moreover, the seasonal dependence on concentration is also clearly seen, with the most amounts of pollutants simulated during the cold winter months, and the lesser amount of pollutants are seen to be characteristic of the spring and summer boreal seasons. Complex topography and wind flow variations throughout the months cause these variations in pollutant concentrations and are quite more expressed during the surge of the winter- and summer- monsoons in the Philippines.

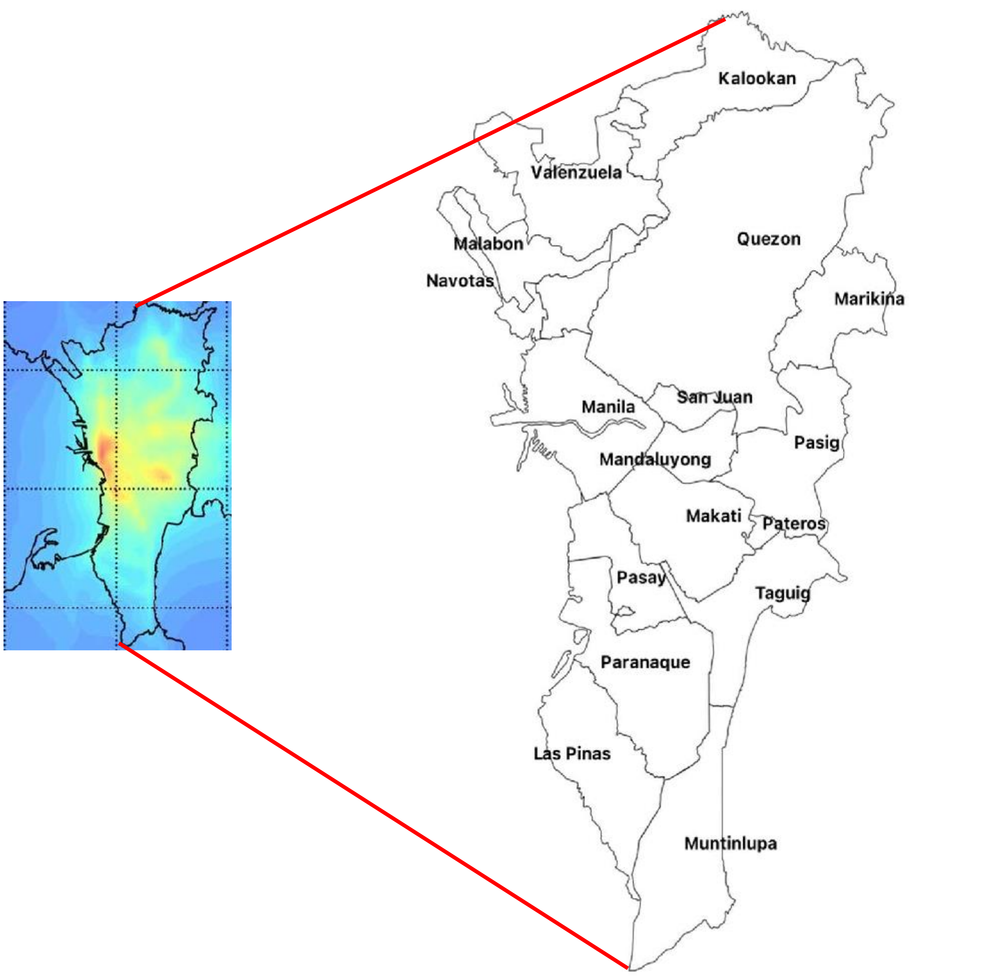


Figure 9 Reference map for succeeding plots.

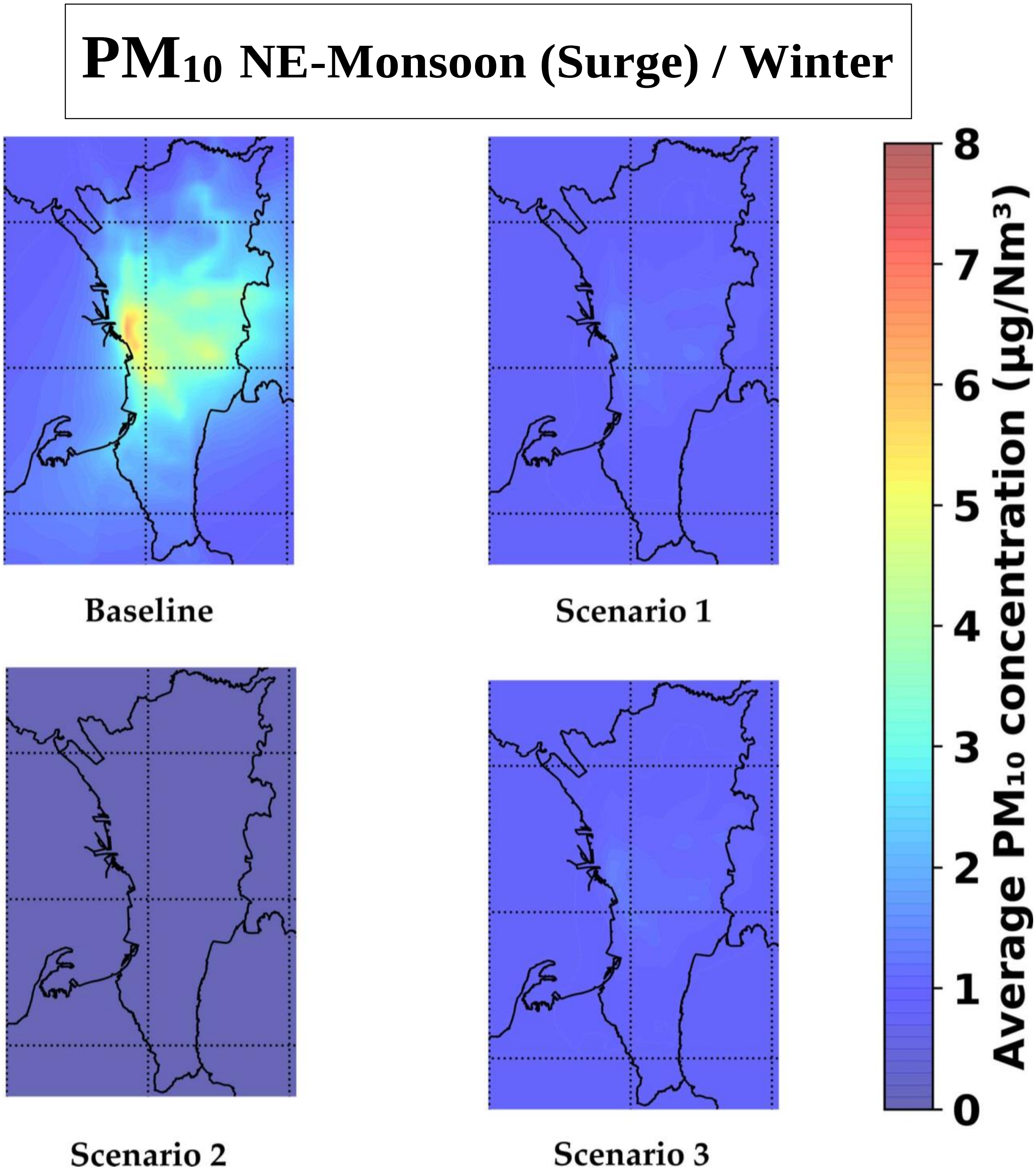


Figure 10 Average PM_{10} concentration for the Winter Boreal Season for all scenarios.

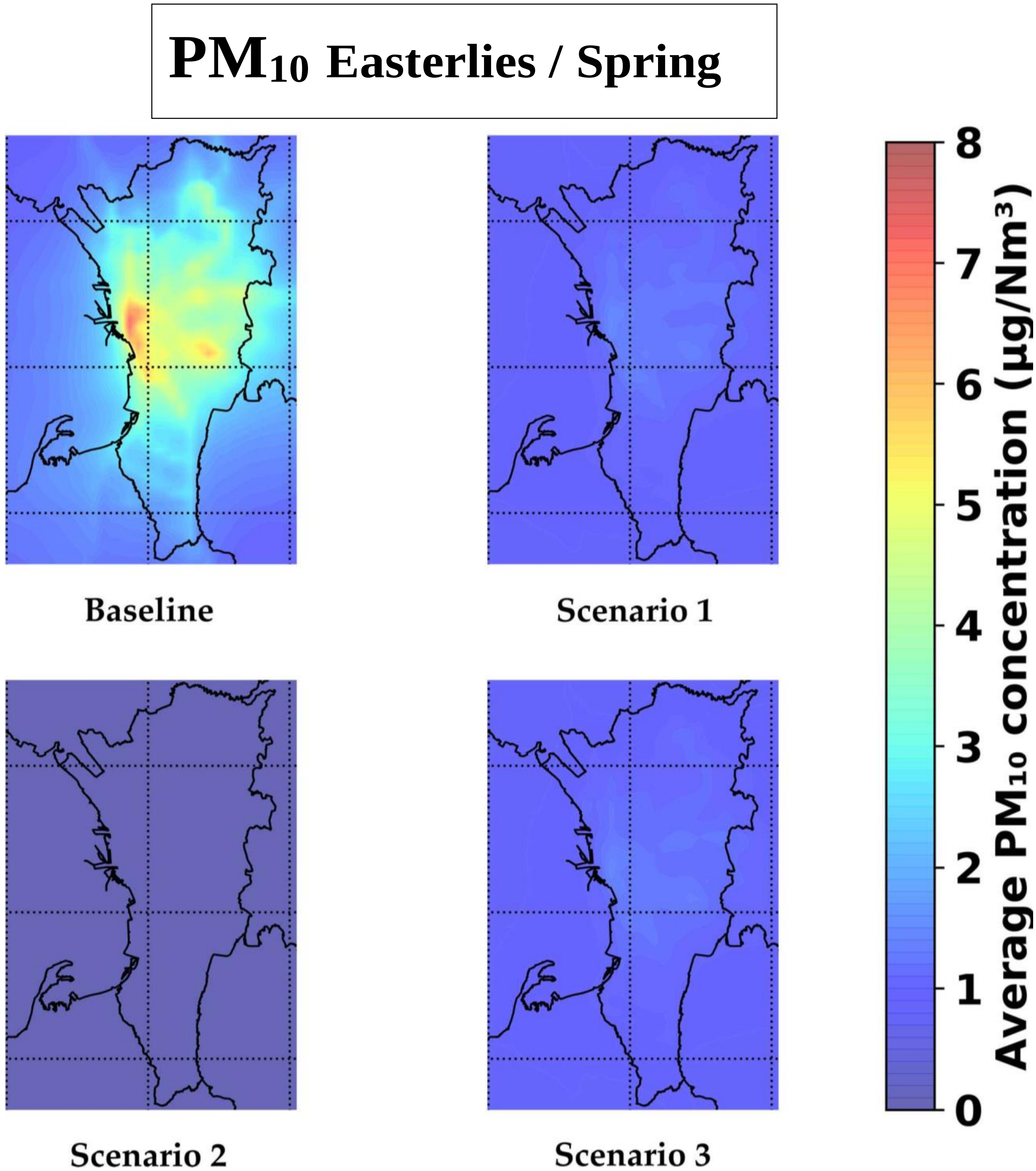


Figure 11 Average PM_{10} concentration for the Spring Boreal Season for all scenarios.

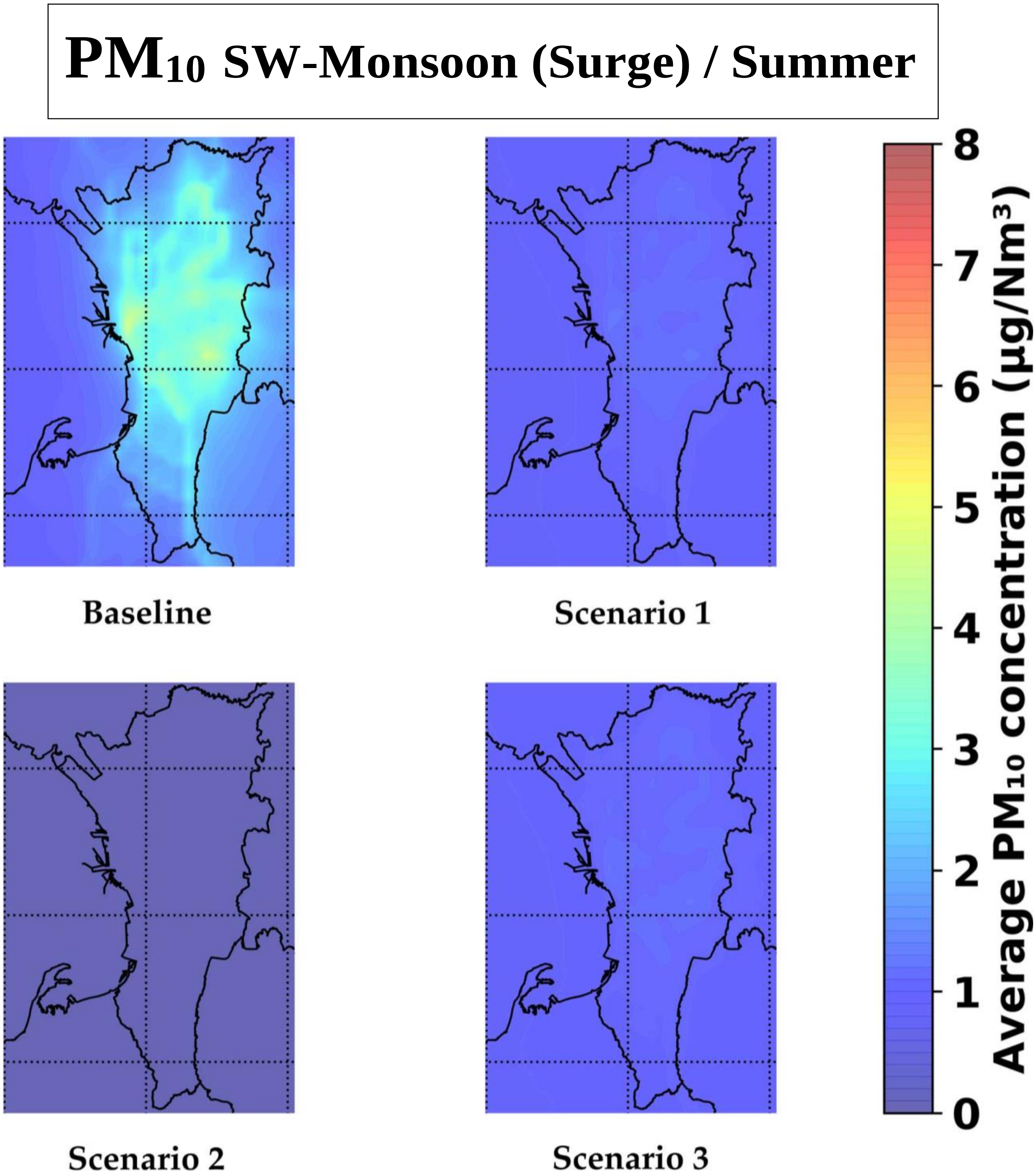


Figure 12 Average PM_{10} concentration for the Summer Boreal Season for all scenarios.

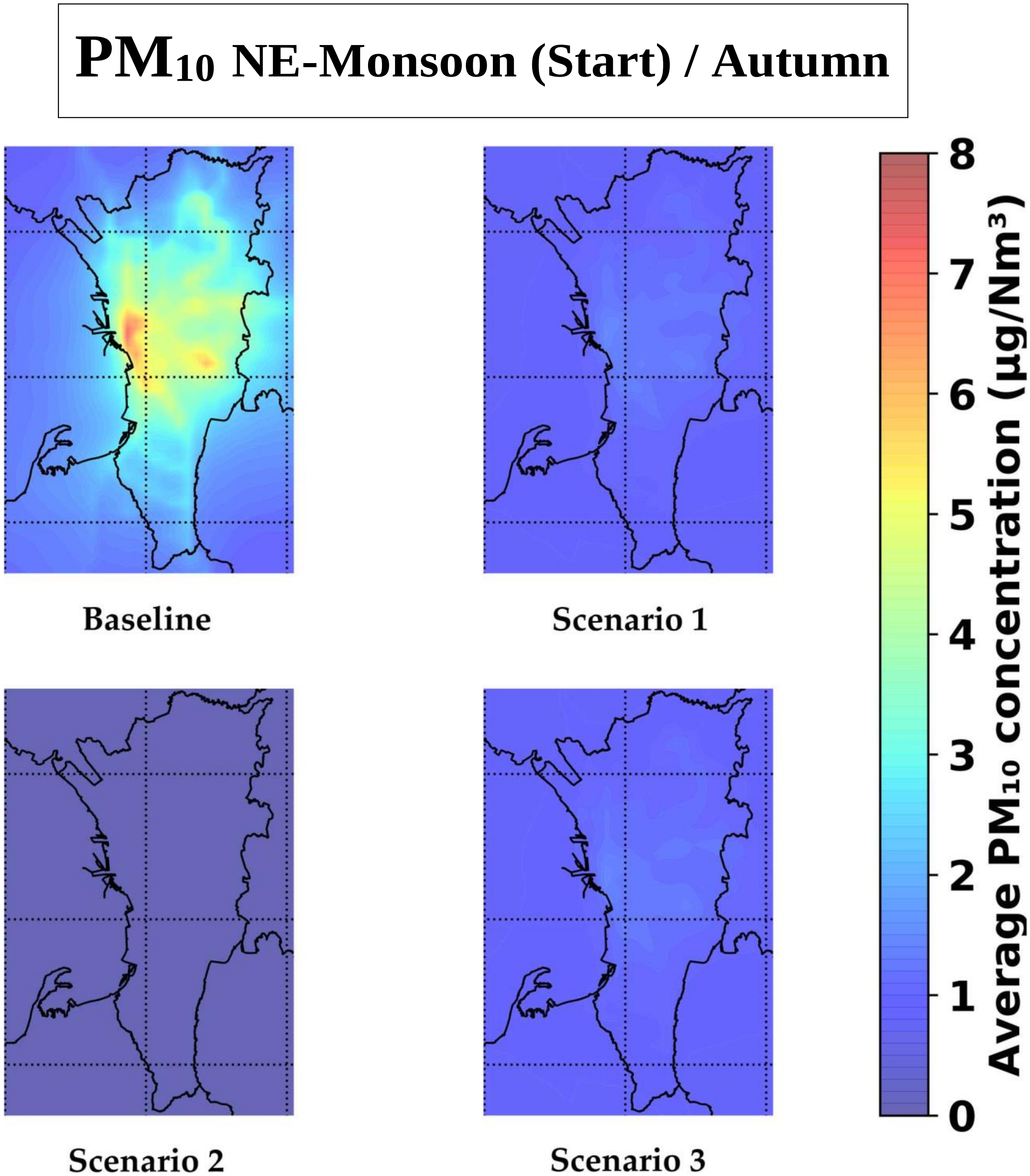


Figure 13 Average PM_{10} concentration for the Autumn Boreal Season for all scenarios.

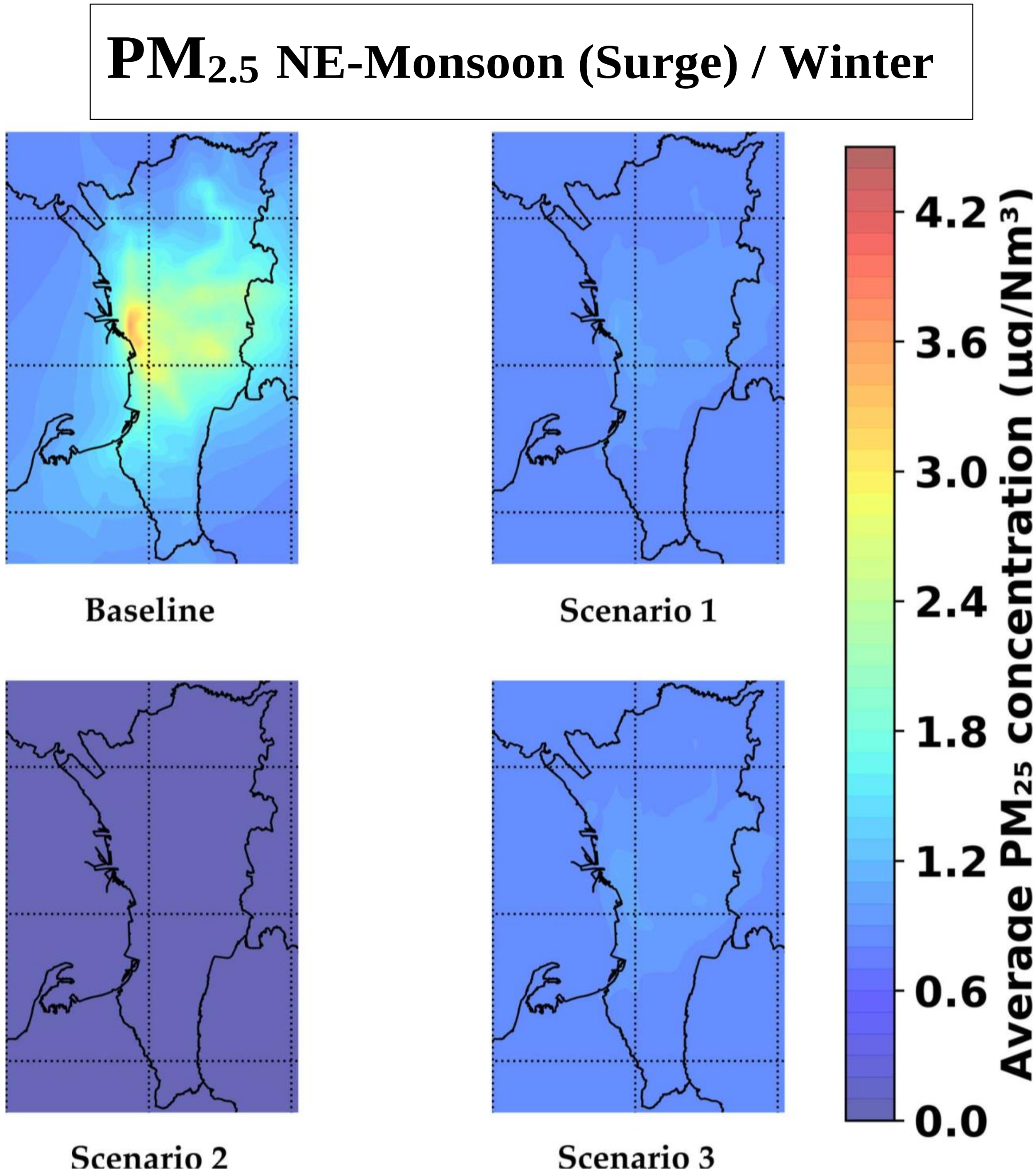


Figure 14 Average $PM_{2.5}$ concentration for the Winter Boreal Season for all scenarios.

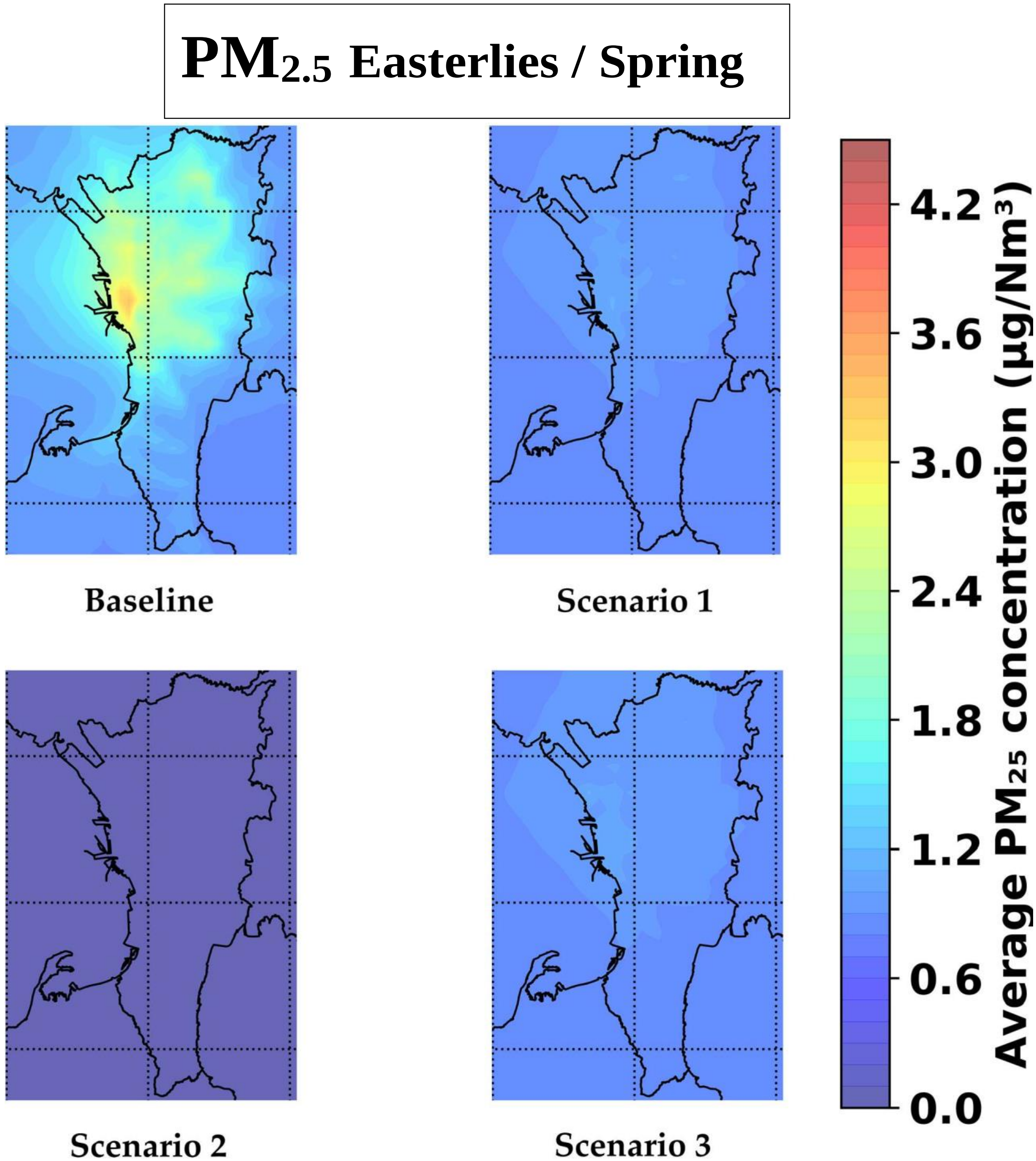


Figure 15 Average $PM_{2.5}$ concentration for the Spring Boreal Season for all scenarios.

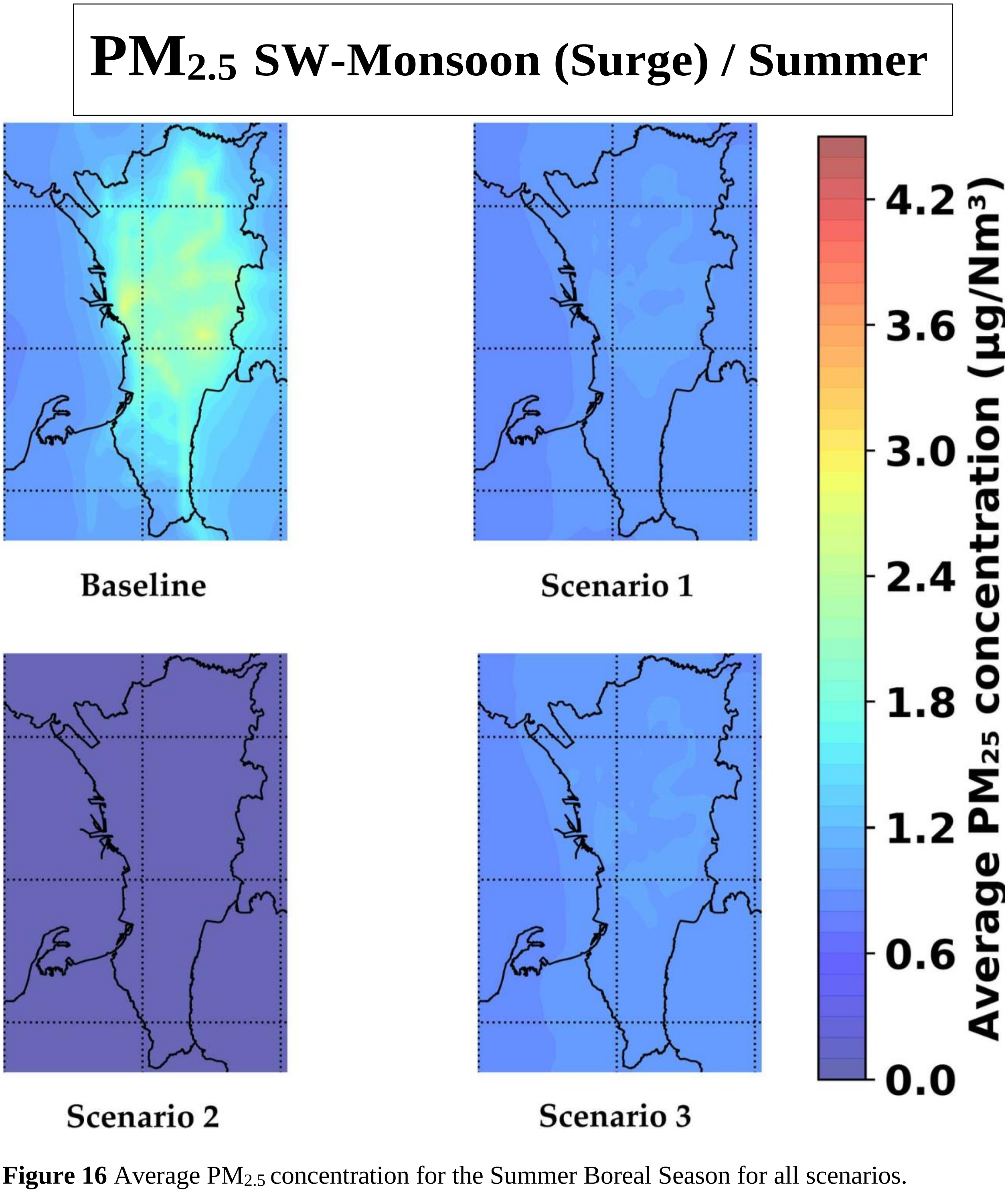


Figure 16 Average $PM_{2.5}$ concentration for the Summer Boreal Season for all scenarios.

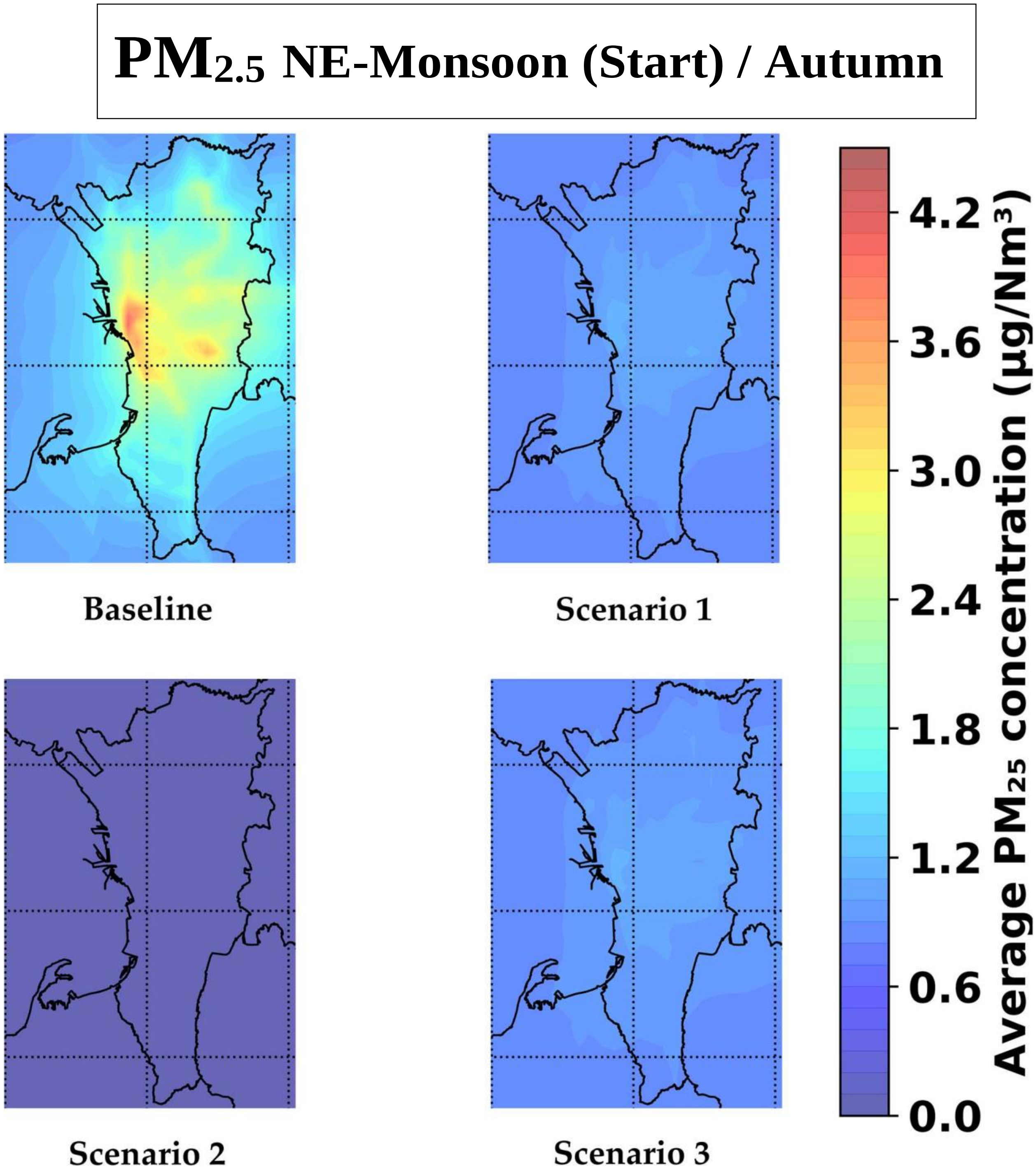


Figure 17 Average $PM_{2.5}$ concentration for the Autumn Boreal Season for all scenarios.

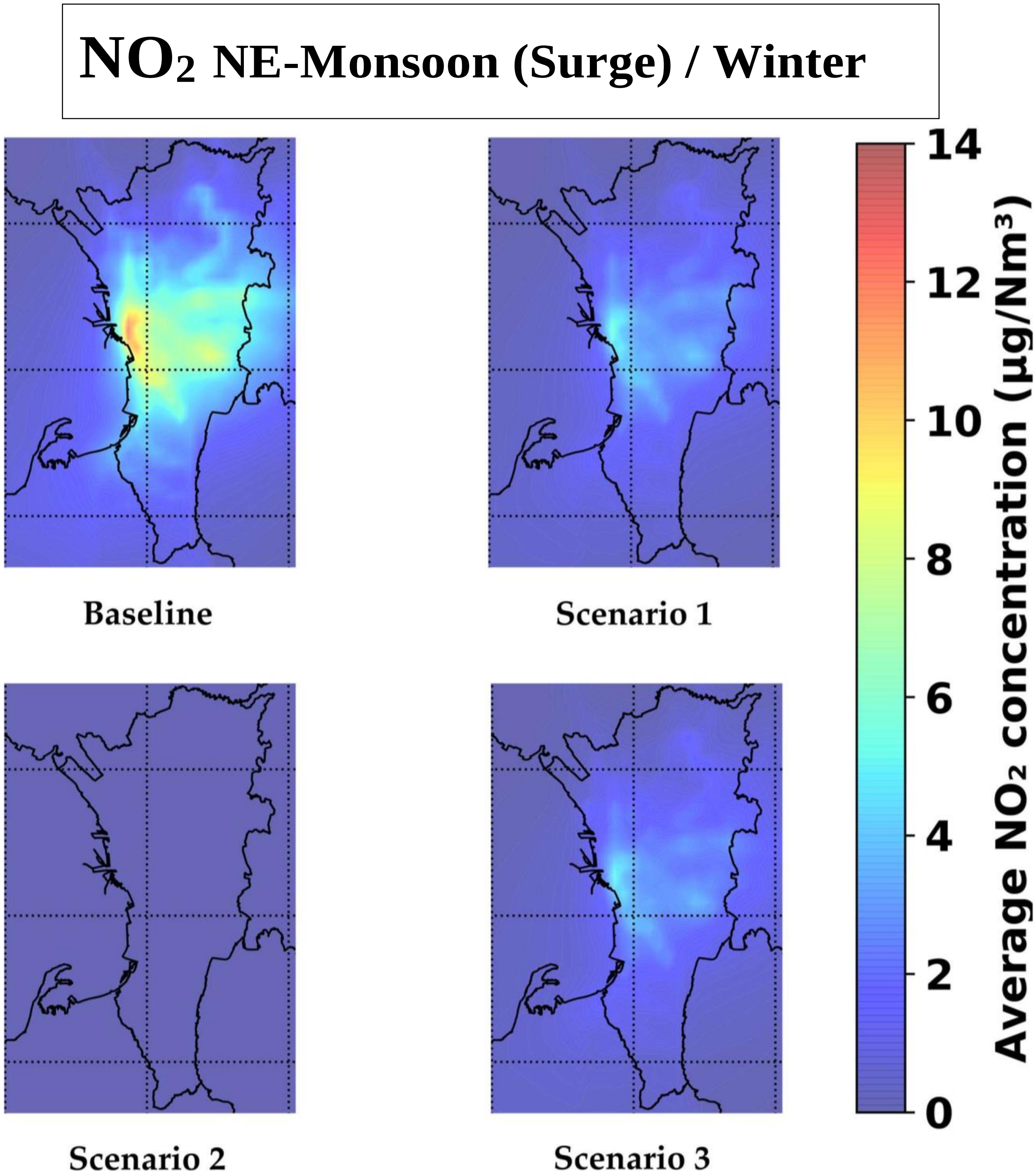


Figure 18 Average NO_2 concentration for the Winter Boreal Season for all scenarios.

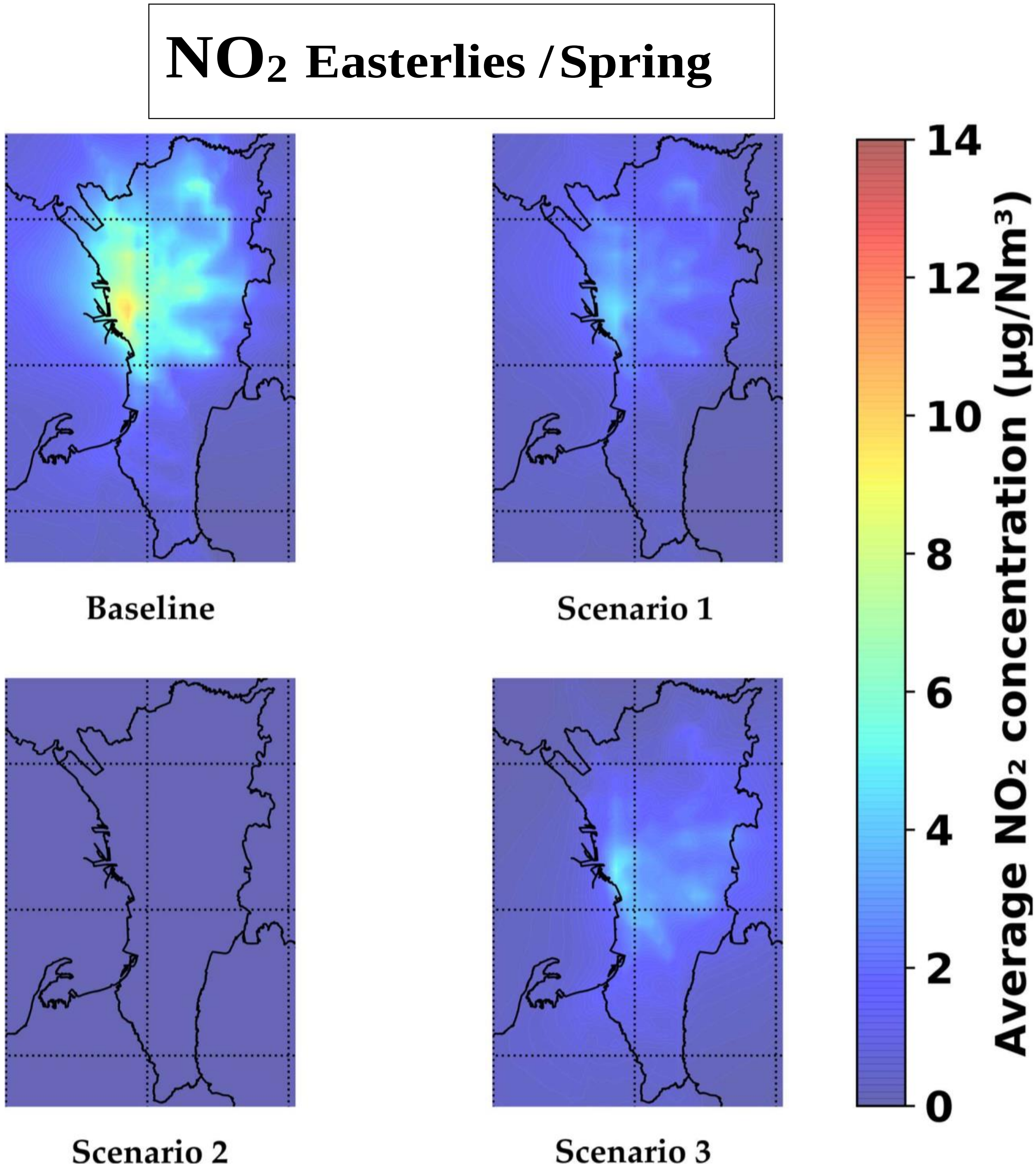


Figure 19 Average NO_2 concentration for the Spring Boreal Season for all scenarios.

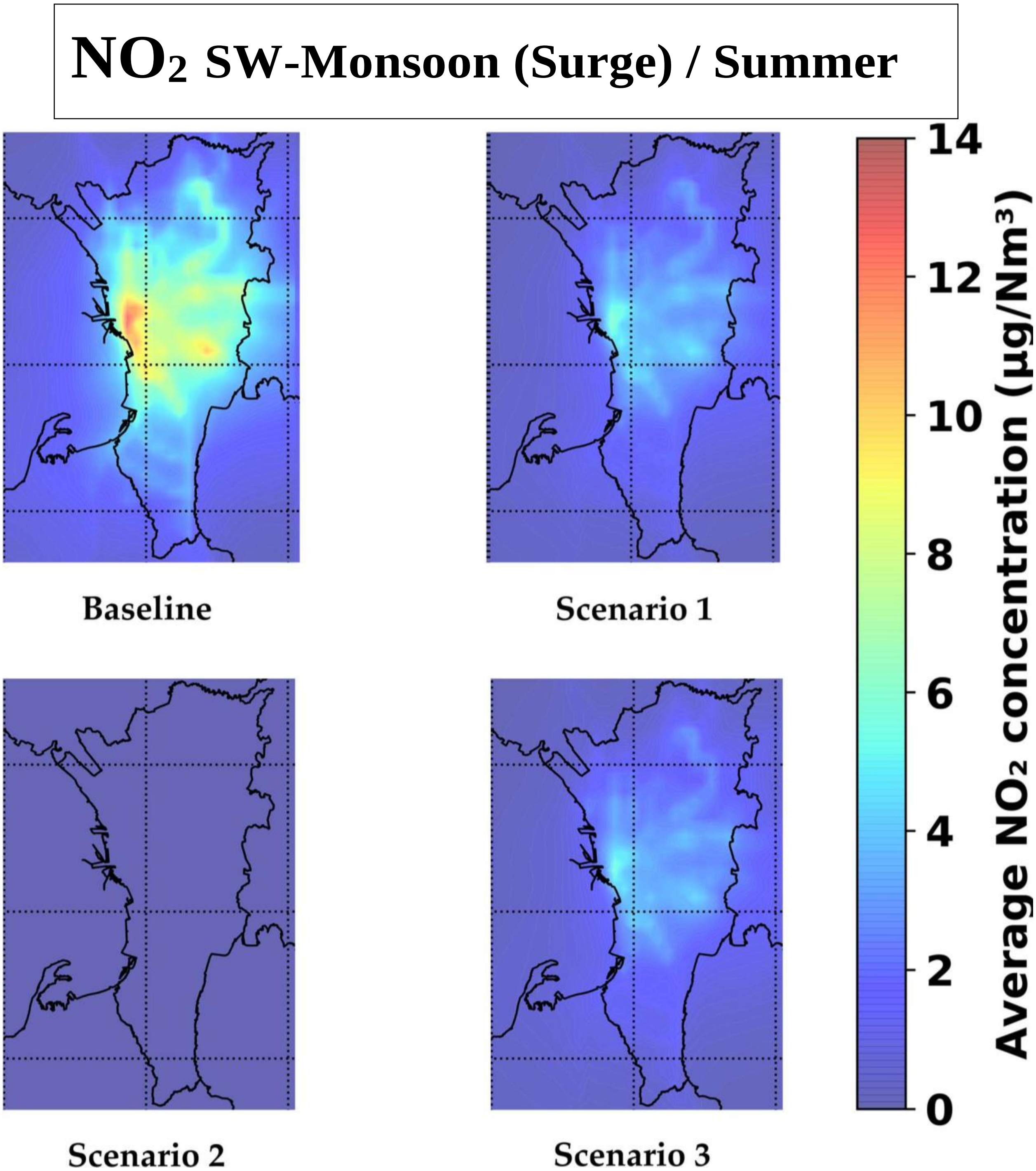


Figure 20 Average NO_2 concentration for the Summer Boreal Season for all scenarios.

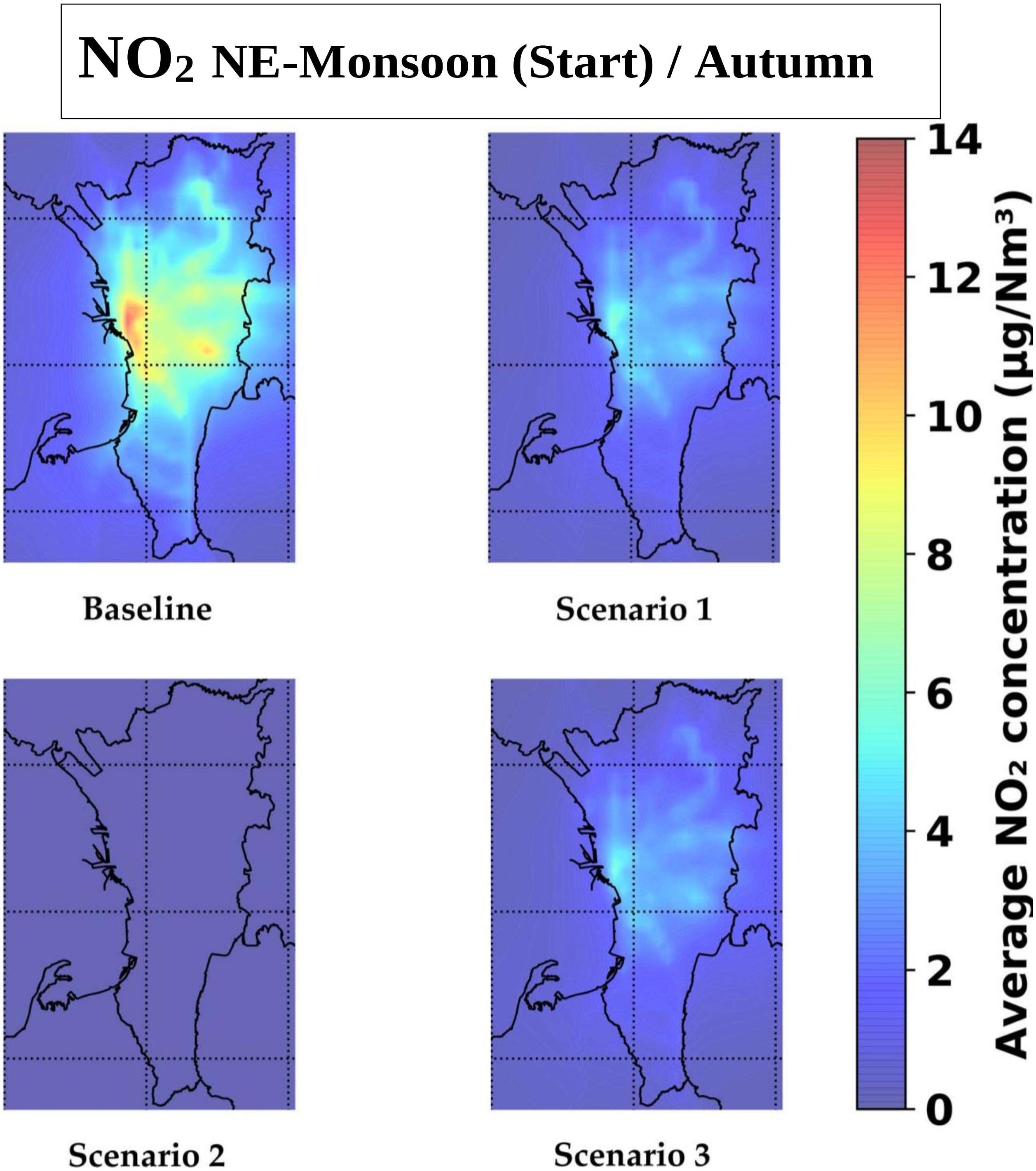


Figure 21 Average NO_2 concentration for the Autumn Boreal Season for all scenarios.

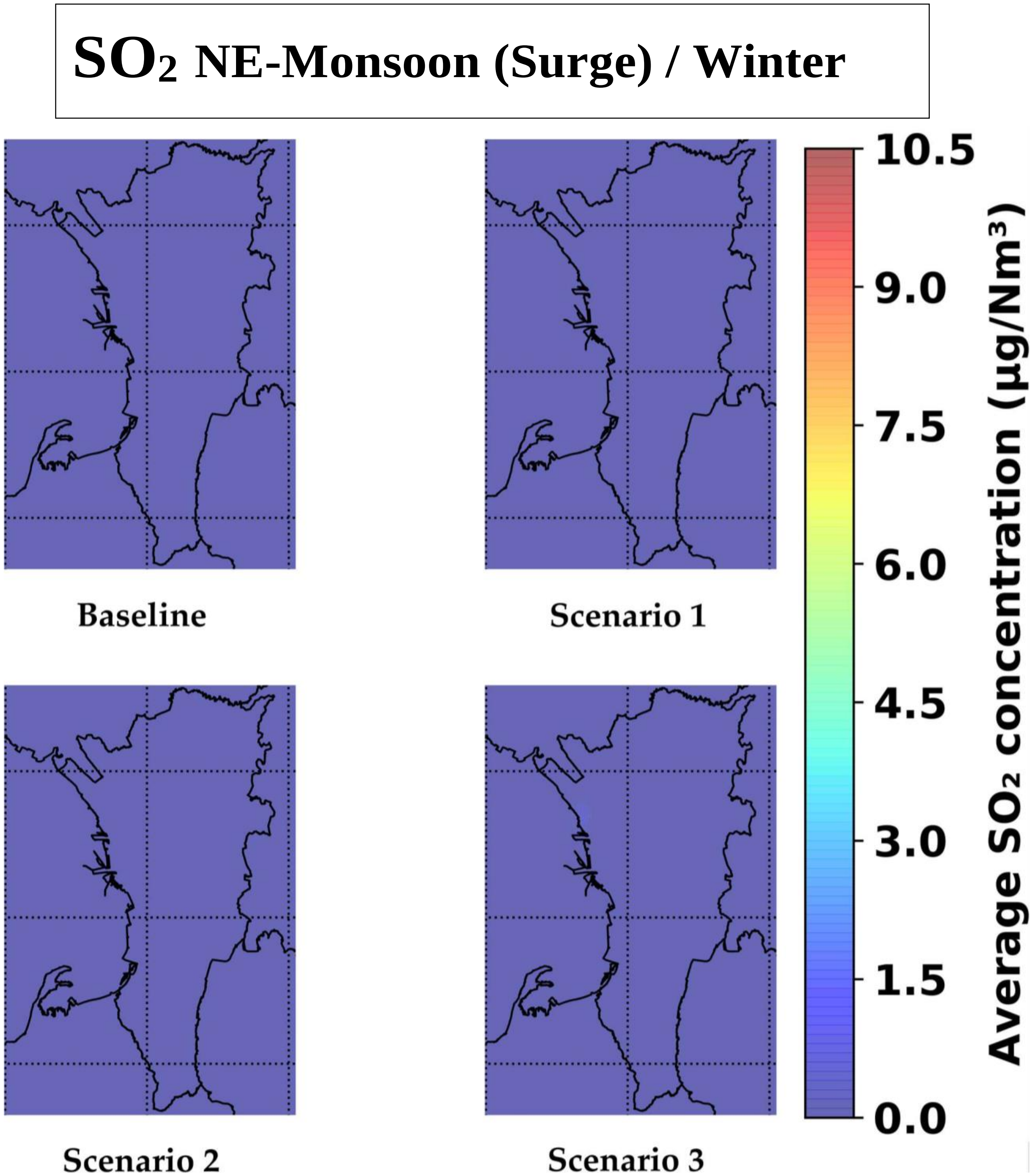


Figure 22 Average SO_2 concentration for the Winter Boreal Season for all scenarios.

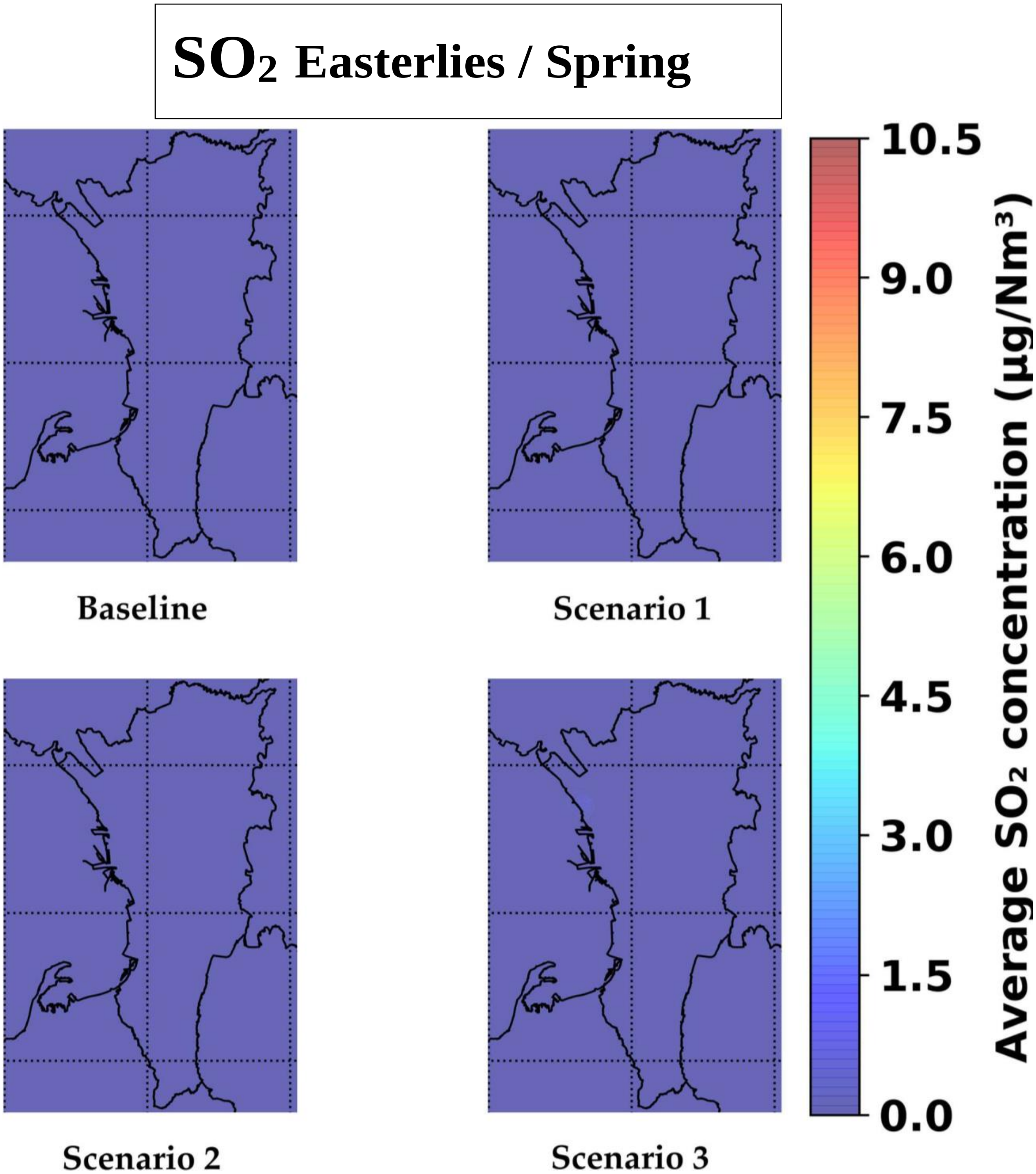


Figure 23 Average SO_2 concentration for the Spring Boreal Season for all scenarios.

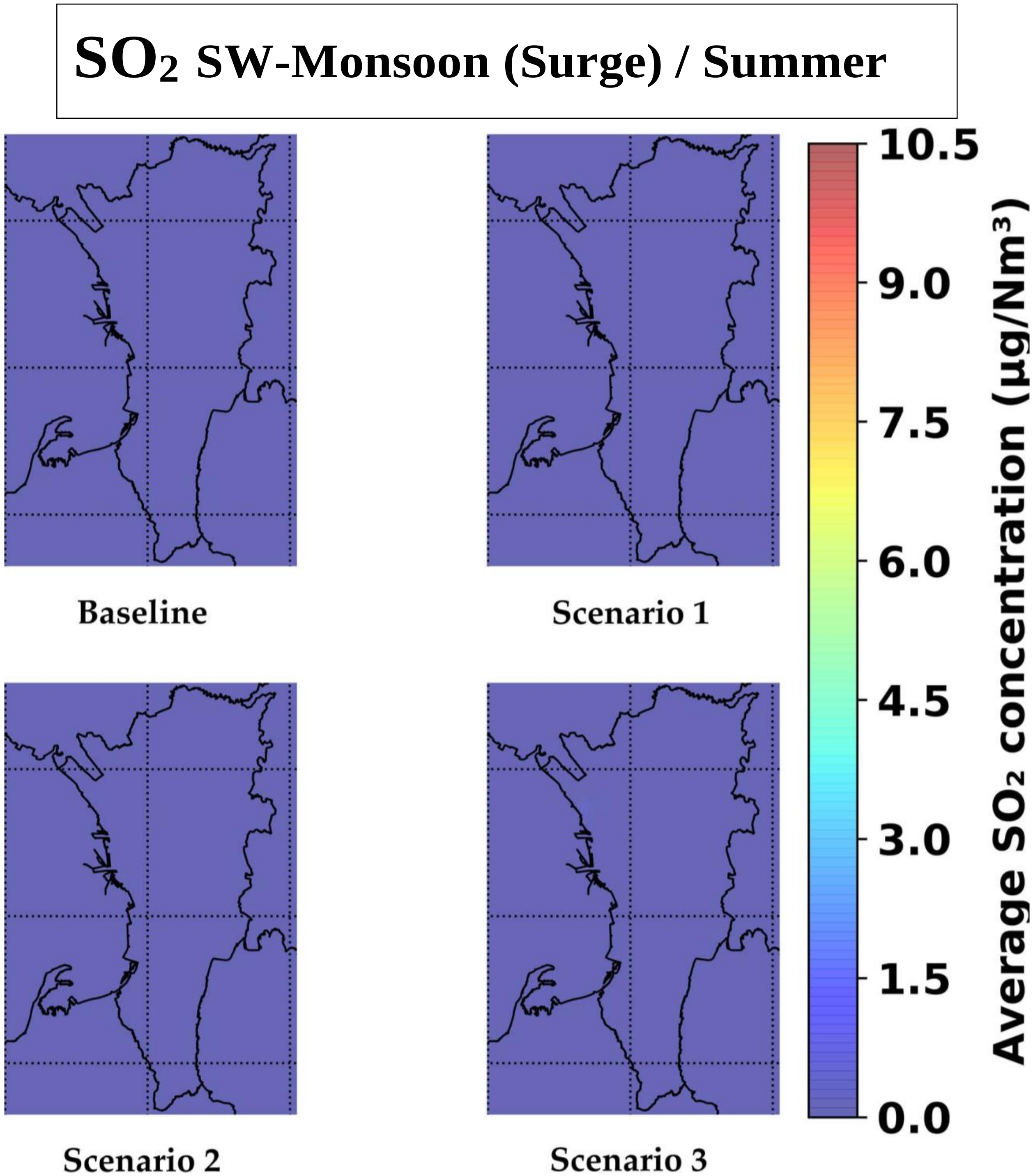


Figure 24 Average SO_2 concentration for the Summer Boreal Season for all scenarios.

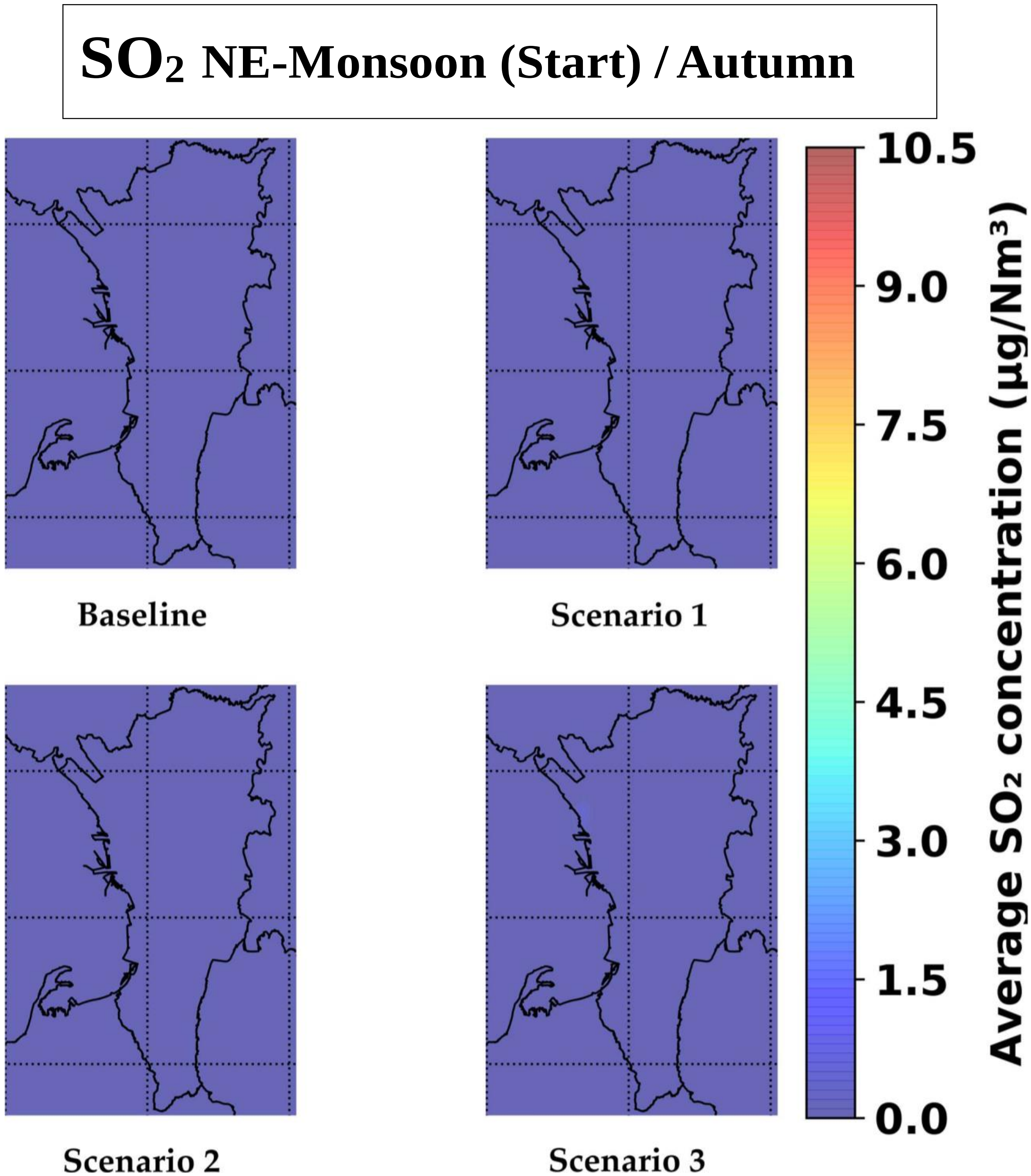


Figure 25 Average SO_2 concentration for the Autumn Boreal Season for all scenarios.

Comparison of Results to Available Station Data for PM_{10} and $PM_{2.5}$

Tables 17 and **18** summarize the estimated annual average PM_{10} and $PM_{2.5}$ concentrations in air quality monitoring sites in Metro Manila. The tables also indicate whether the values are within the current national standards (in Green) or not (in Orange). The current PM_{10} and $PM_{2.5}$ ambient standards are 60 ug/nm^3 and 25 ug/nm^3 respectively.

To compare simulation results to the NAAQGV, the researchers analyzed station data as provided by the DENR-EMB Central of Metro Manila and combined the reductions of each scenario simulated for the grid cell closest to the station. The ambient concentration (station values) was added to the reduction per scenario. A comparison may then be made as to whether that area would still be non- compliant; however, the stations used in this comparison are not representative of the whole area under study and many are distant to PUJ-routes used in the study. Thus, this may affect the results as well.

Table 17 Estimated Annual Average PM_{10} Ambient Air Concentration in AQ Monitoring Sites

Station ID	LGU	Baseline	Scen 1	Scen 2	Scen 3
1	Las Pinas	50.22	49.91	49.91	49.91
2	Makati	44.96	42.11	41.82	42.08
3	Malabon	45.18	44.11	44.00	44.10
4	Mandaluyong	60.11	57.27	56.97	57.24
5	Marikina	40.72	38.96	38.77	38.94
6	Muntinlupa	22.82	22.82	22.83	22.82
7	Navotas	53.86	52.50	52.37	52.49
8	Caloocan	38.40	37.87	37.82	37.86
9	Paranaque	39.81	39.27	39.26	39.27
10	Pasay	54.61	53.39	53.32	53.38
11	Pasig	21.69	19.31	19.07	19.29
12	Pateros	61.54	59.20	58.99	59.18
13	San Juan	33.37	30.96	30.72	30.94
14	Taguig	34.52	33.65	33.63	33.65
15	Caloocan	24.69	22.94	22.76	22.93
16	Quezon	44.00	41.54	41.28	41.52
17	Marikina	51.00	49.24	49.05	49.22
18	Manila	57.00	54.62	54.36	54.59
19	Makati	36.00	32.80	32.46	32.77

Table 18 Estimated Annual $PM_{2.5}$ Average Ambient Air Concentrations in AQ Monitoring Sites

Station ID	LGU	Baseline	Scen 1	Scen 2	Scen 3
1	Las Pinas	31.60	31.44	31.46	31.44
2	Makati	119.58	118.15	118.02	118.14
3	Malabon	22.26	21.72	21.68	21.72
4	Mandaluyong	No Data	No Data	No Data	No Data
5	Marikina	No Data	No Data	No Data	No Data
6	Muntinlupa	17.46	17.37	17.39	17.37
7	Navotas	43.21	42.53	42.47	42.52
8	Caloocan	No Data	No Data	No Data	No Data
9	Paranaque	16.61	16.34	16.35	16.34
10	Pasay	No Data	No Data	No Data	No Data
11	Pasig	19.11	17.92	17.81	17.91
12	Pateros	26.55	25.38	25.30	25.37
13	San Juan	26.81	25.60	25.49	25.59
14	Taguig	No Data	No Data	No Data	No Data
15	Caloocan	14.25	13.37	13.29	13.37
16	Quezon	No Data	No Data	No Data	No Data
17	Marikina	No Data	No Data	No Data	No Data
18	Manila	No Data	No Data	No Data	No Data
19	Makati	No Data	No Data	No Data	No Data

Results indicate that adoption of any of the control options would bring down ambient PM_{10} concentration to acceptable levels in all monitoring sites. It is however a different case in $PM_{2.5}$ where concentration will remain to be beyond the limits regardless of the control option adopted. This could be attributed to the very high concentration exceedance in the concerned sites.

Given the reductions above, a similar approach was done to compare the simulation results to the AQI. **Tables 19** through **21** summarize the estimated annual average PM_{10} and $PM_{2.5}$ concentrations in air quality monitoring sites in Metro Manila and compared with the AQI value as seen in **Table 19**, below.

Table 19 AQI Color code.

Category	AQI lo	AQI hi
Good	0	50
Moderate	51	100
Unhealthy for Sensitive Groups	101	150
Unhealthy	151	200
Very Unhealthy	201	300
Hazardous	301	500

Table 20 AQI for PM_{10} for different stations per scenario.

Station ID	LGU	Ambient PM_{10}	AQI Ambient	PM_{10} Scen 1	AQI Scen 1	PM_{10} Scen 2	AQI Scen 2	PM_{10} Scen 3	AQI Scen 3
1	Las Pinas	50.22	46.50	49.91	46.21	49.91	46.21	49.91	46.21
2	Makati	44.96	41.63	42.11	38.99	41.82	38.72	42.08	38.96
3	Malabon	45.18	41.83	44.11	40.84	44.00	40.74	44.10	40.83
4	Mandaluyong	60.11	53.53	57.27	52.12	56.97	51.98	57.24	52.11
5	Marikina	40.72	37.70	38.96	36.07	38.77	35.90	38.94	36.06
6	Muntinlupa	22.82	21.13	22.82	21.13	22.83	21.14	22.82	21.13
7	Navotas	53.86	49.87	52.50	48.61	52.37	48.49	52.49	48.60
8	Caloocan	38.40	35.56	37.87	35.06	37.82	35.02	37.86	35.06
9	Paranaque	39.81	36.86	39.27	36.36	39.26	36.35	39.27	36.36
10	Pasay	54.61	50.56	53.39	49.44	53.32	49.37	53.38	49.43
11	Pasig	21.69	20.08	19.31	17.88	19.07	17.66	19.29	17.86
12	Pateros	61.54	54.24	59.20	53.08	58.99	52.97	59.18	53.07
13	San Juan	33.37	30.90	30.96	28.67	30.72	28.44	30.94	28.65
14	Taguig	34.52	31.96	33.65	31.16	33.63	31.14	33.65	31.16
15	Caloocan	24.69	22.86	22.94	21.24	22.76	21.07	22.93	21.23
16	Quezon	44.00	40.74	41.54	38.46	41.28	38.22	41.52	38.44

17	Marikina	51.00	47.22	49.24	45.59	49.05	45.42	49.22	45.57
18	Manila	57.00	51.99	54.62	50.57	54.36	50.33	54.59	50.55
19	Makati	36.00	33.33	32.80	30.37	32.46	30.06	32.77	30.34

Table 21 AQI for $PM_{2.5}$ for different stations per scenario.

Station ID	LGU	Ambient $PM_{2.5}$	AQI Ambient	$PM_{2.5}$ Scen 1	AQI Scen. 1	$PM_{2.5}$ Scen 2	AQI Scen. 2	$PM_{2.5}$ Scen 3	AQI Scen. 3
1	Las Pinas	31.60	92.01	31.44	91.67	31.46	91.71	31.44	91.67
2	Makati	119.58	184.09	118.15	183.35	118.02	183.28	118.14	183.34
3	Malabon	22.26	72.37	21.72	71.23	21.68	71.15	21.72	71.23
4	Mandaluyong	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
5	Marikina	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6	Muntinlupa	17.46	62.27	17.37	62.08	17.39	62.12	17.37	62.08
7	Navotas	43.21	119.98	42.53	118.31	42.47	118.16	42.52	118.29
8	Caloocan	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
9	Paranaque	16.61	60.48	16.34	59.92	16.35	59.94	16.34	59.92
10	Pasay	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
11	Pasig	19.11	65.74	17.92	63.24	17.81	63.01	17.91	63.22
12	Pateros	26.55	81.39	25.38	78.93	25.30	78.76	25.37	78.91
13	San Juan	26.81	81.94	25.60	79.39	25.49	79.16	25.59	79.37
14	Taguig	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
15	Caloocan	14.25	55.52	13.37	53.67	13.29	53.50	13.37	53.67
16	Quezon	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
17	Marikina	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
18	Manila	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
19	Makati	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data

4.3 Mortality and Morbidity

Scenario 1 : 100% Euro 4 Jeepney

Tables 22 and **23**, as provide below, show the avoided mortalities and morbidities under this scenario, from which 750 air pollution related deaths and 12,199 air pollution morbidities were found to be prevented. It is expected that due to the proximity of the NCR to the PUJ routes, the bulk of avoided deaths were found greatest in this area. In terms of health endpoints, the bulk of avoided deaths were found to be those under ischemic heart disease, pneumonia, cerebrovascular diseases, and tuberculosis.

Table 22 Scenario 1 Euro 4 Jeepneys Avoided Mortality by Disease and Region.

Disease	Region							Total
	CAR	NCR	1	2	3	4A	5	
Acute rheumatic fever and chronic rheumatic heart diseases	0	3	0	0	0	0	0	3
Cerebrovascular diseases	0	84	0	3	8	0	0	95
Chronic lower respiratory diseases	0	46	0	1	4	0	0	51
Hypertensive Diseases	0	68	0	1	5	0	0	74
Ischemic heart diseases	0	262	0	7	20	0	0	289
Other acute lower respiratory infections	0	0	0	0	0	0	0	0
Other Heart Diseases	0	44	0	1	4	0	0	49
Other respiratory conditions of newborn	0	4	0	0	0	0	0	4
Pneumonia	0	95	0	2	7	0	0	104
Remainder of diseases of the circulatory system	0	4	0	0	0	0	0	4

Disease	Region							Total
	CAR	NCR	1	2	3	4A	5	
Remainder of diseases of the respiratory system	0	8	0	0	0	0	0	8
Respiratory distress of newborn	0	6	0	0	0	0	0	6
Respiratory tuberculosis	0	58	0	1	4	0	0	63
Whooping cough	0	0	0	0	0	0	0	0

Morbidity effects follows a similar trend wherein the benefits are mostly concentrated in the NCR and regions 3 and 4A.

Table 23 Scenario 1 Euro 4 Jeepneys Annual Avoided Morbidity Incidence by Disease and Region.

Disease	Region							Total
	CAR	NCR	1	2	3	4A	5	
Acute Lower Respiratory Infection and Pneumonia	0	1,207	0	17	76	0	0	1,300
Acute Respiratory Infection	0	5,365	0	70	358	2	3	5,798
Bronchitis	0	2,498	0	33	106	1	2	2,640
Hypertension	0	903	0	12	69	0	0	984
Pneumonia	0	1,207	0	17	76	0	0	1,300
Tuberculosis	0	170	0	2	5	0	0	177

Scenario 2: 100% Electric Jeepneys

Under this scenario, the total avoided mortalities are much higher as compared to the previous scenario, amounting to 873, while the avoided morbidities amounted to 14,293. Expectedly, the benefits will be focused on Metro Manila and its adjacent provinces. It could be noted that the effect of additional emissions released from powerplants attributed to power consumed by the e-jeepneys will be responsible only for one additional mortality. While additional power consumption leads to significant SO_x releases in coal power plant location, there has been no mortality concentration-response relationship observed for SO_x thus the negligible effects. The projected death may thus be attributed to the slight increases in particulate matter in the vicinity of powerplants.

Table 24 Scenario 2 E-Jeepneys Avoided Mortality by Disease and Region.

Disease	Region							Total
	CAR	NCR	1	2	3	4A	5	
Acute rheumatic fever and chronic rheumatic heart diseases	0	4	0	0	0	0	0	4
Cerebrovascular diseases	0	100	0	1	7	0	0	108
Chronic lower respiratory diseases	0	59	0	0	4	0	0	63
Hypertensive Diseases	0	80	0	1	4	0	0	85
Ischemic heart diseases	0	300	0	3	17	0	0	320
Other acute lower respiratory infections	0	0	0	0	0	0	0	0
Other Heart Diseases	0	52	0	0	3	0	0	55
Other respiratory conditions of newborn	0	5	0	0	0	0	0	5
Pneumonia	0	122	0	1	7	0	0	130
Remainder of diseases of the circulatory system	0	5	0	0	0	0	0	5
Remainder of diseases of the respiratory system	0	11	0	0	0	0	0	11
Respiratory distress of newborn	0	8	0	0	0	0	0	8
Respiratory tuberculosis	0	74	0	0	5	0	0	79
Whooping cough	0	0	0	0	0	0	0	0

The shift from Euro 4 engines to pure electric PUJs equated to an increase in powerplant emissions outside of the NCR. Nonetheless, the effects on mortality due to the release of powerplant-attributed emissions was not found to be responsible for any deaths. However, based on projected additional morbidities, the CAR, Region II, Region 5, and Region 1were found to have additional morbidities as seen in the table below.

Table 25 Scenario 2 E-Jeepneys Annual Avoided Morbidity Incidence by Disease and Region.

Disease	Region							Total
	CAR	NCR	1	2	3	4A	5	
Acute Lower Respiratory Infection and Pneumonia	0	1,507	-1	16	80	-1	-3	1,598
Acute Respiratory Infection	-5	6,700	-2	71	377	-10	-157	6,974
Bronchitis	-7	2,748	-1	29	99	-8	-96	2,764
Hypertension	-1	1,107	0	11	68	-3	-40	1,142
Pneumonia	0	1,507	-1	16	80	-1	-3	1,598
Tuberculosis	0	212	0	2	6	0	-3	217

Scenario 3: Combined Euro 4 and Electric Jeepneys

The benefits and negative impacts of scenario 3 veers mostly to the effects of scenario 1 considering that 91% of the annual veh-km will be served by Euro 4 units. Unlike in scenario 1, however, scenario 3 is projected to have some negative effects in CAR and regions 1,2 and 5 despite their low proximity from Metro Manila. This could be traced from the emissions produced in the power generation requirements of the electric jeepneys. This impact however is on a lesser degree compared to scenario 2.

Table 26 Scenario 3 Combined Euro 4 and E-Jeepneys Avoided Mortality by Disease and Region.

Disease	Region							Total
	CAR	NCR	1	2	3	4A	5	
Acute rheumatic fever and chronic rheumatic heart diseases	0	3	0	0	0	0	0	3
Cerebrovascular diseases	0	86	0	3	8	0	0	97
Chronic lower respiratory diseases	0	47	0	1	4	0	0	52
Hypertensive Diseases	0	69	0	1	5	0	0	75
Ischemic heart diseases	0	266	0	7	20	0	0	293
Other acute lower respiratory infections	0	0	0	0	0	0	0	0
Other Heart Diseases	0	44	0	1	4	0	0	49

Disease	Region							Total
	CAR	NCR	1	2	3	4A	5	
Other respiratory conditions of newborn	0	4	0	0	0	0	0	4
Pneumonia	0	98	0	2	7	0	0	107
Remainder of diseases of the circulatory system	0	4	0	0	0	0	0	4
Remainder of diseases of the respiratory system	0	8	0	0	0	0	0	8
Respiratory distress of newborn	0	6	0	0	0	0	0	6
Respiratory tuberculosis	0	59	0	1	4	0	0	64
Whooping cough	0	0	0	0	0	0	0	0

Table 27 Scenario 3 Combined Euro 4 and E-Jeepneys Annual Avoided Morbidity Incidence by Disease and Region.

Disease	Region							Total
	CAR	NCR	1	2	3	4A	5	
Acute Lower Respiratory Infection and Pneumonia	0	1,235	0	17	76	0	0	1,328
Acute Respiratory Infection	0	5,487	0	70	360	1	-10	5,908
Bronchitis	-1	2,521	0	32	105	0	-6	2,651
Hypertension	0	922	0	12	69	0	-2	1,001
Pneumonia	0	1,235	0	17	76	0	0	1,328
Tuberculosis	0	173	0	2	5	0	0	180

4.4 Health Monetary Benefits

Table 28 summarizes the monetized health benefits of the various control scenarios. The adoption of E-Jeepneys provides higher benefits compared to Euro 4 units and could reach to about 8.59 billion of Php annually despite having some atmospheric pollution concentration effects in vicinities of coal and other fossil fueled power plants in the Island. The benefits of better air quality in Metro Manila and nearby provinces far outweighs these effects owing to their higher population density. Note that the size of population exposed to pollutant dictate, among others, the morbidity and mortality incidence. The adoption of Euro 4 units also provides significant annual health benefits of around 7.45 billion of Php yearly. Considering the current limitations and cost of electric jeepneys, a combining them with Euro 4 units is expected to the most probable scenario which alternatively translates to more than 7.55 billion annual health benefits.

Table 28 Annual Health Monetary Benefits for All Cases by Region in Millions of Php.

Scenario	Region							Total
	CAR	NCR	1	2	3	4A	5	
Scenario 1 Euro 4 Jeepneys	-0.42	6,695.39	0.67	1.03	205.47	539.74	4.78	7,446.66
Scenario 2 E- Jeepneys	-3.33	6,110.06	-31.69	-4.21	230.78	386.43	1,898.39	8,586.44
Scenario 3 Combined Euro 4 and E- Jeepneys	-0.70	6,691.68	-2.26	0.51	203.42	530.08	128.72	7,551.45

Figure 26 indicates that bulk of the benefits are derived from the avoided mortality.

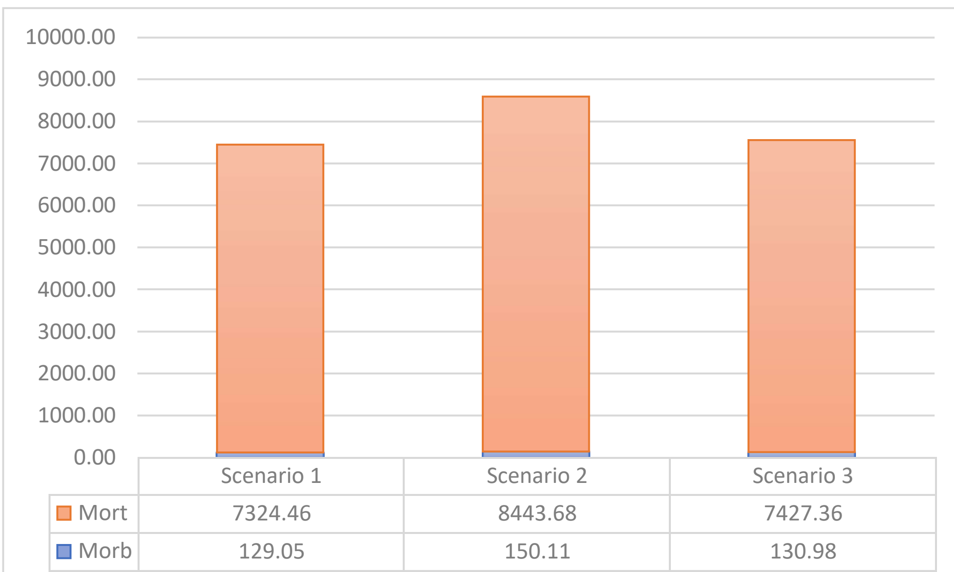


Figure 26 Mortality and Morbidity Monetary Benefits Share by Control Scenarios in Millions of Php

Table 29 shows that annually, each modern unit adopted could provide at between 180 to 210 thousand pesos health benefits which translates to between 1.39 million to 1.59 million in net present value benefits throughout their 15 operational life.

Table 29 Annual and Life Cycle Benefits (Present Value) per vehicle in Million Php and Health Benefits to Government Subsidy Ratio.

Control Scenario	Annual Health Benefits per unit (million Php)	Life Cycle Benefits NPV (million Php)	Health Benefits to Government Subsidy Ratio
Scenario 1 Euro 4 Jeepneys	0.18	1.39	8.66
Scenario 2 E-Jeepneys	0.21	1.59	9.96

The government has just recently increased the upfront subsidy for the modern units to Php 160,000.00. The present value of the health benefits provided by each unit over their life ranged from 8.66 to 9.96 times the government subsidy provided

5 Conclusions

Key findings of the study are as follows:

- The adoption of modern jeepneys in Metro Manila will translate to significant reductions in air pollutant emissions. The LTFRB 2015 database indicates 50,073 jeepney units (distributed into 497 routes) are operating in Metro Manila and all were considered in this study. The specific benefits of the technologies are as follows:
- The replacement of all jeepneys with Modern Euro 4 units may be expected to reduce CO, NMVOC, SO_x, NO_x, and PM emission production by 90.2%, 93.6%, 28.6%, 51.2% and 89.6% respectively.
- The replacement of all jeepneys with Modern E-jeep units may be expected to reduce NMVOC and PM emission production to very negligible levels but will increase SO_x emissions by almost 5 times. It shall reduce NOx and CO production by 62.1% and 87.5% respectively.
- The replacement of the jeepneys with Euro 4 jeepneys, E-Jeepneys and a combination of the two will ensure compliance to the PM_{10} Annual Ambient Concentration Standards in all air quality monitoring sites. They will however not be able to provide enough reductions to adequately reduce $PM_{2.5}$ concentrations in hotspot areas to level set by the standards. It should be noted that $PM_{2.5}$ emissions in the hotspot areas are severely elevated.
- The adoption of modern units regardless of the technology will provide health benefits far exceeding their cost. These benefits could mostly be traced to the air pollution related mortality avoidance in Metro Manila, CALABARZON, and Central Luzon. The details of the health benefits for the various control scenarios are as follows:
- The replacement of all jeepneys with Modern Euro 4 units may be expected to provide a Php 7.45 billion annual health benefits. Each of the unit adopted provides Php 180 thousand annual health benefits.
- The replacement of all jeepneys with E-Jeepney units may be expected to provide an Php 8.59 billion annual health benefits. Each of the unit adopted provides Php 180 thousand annual health benefits.
- The replacement of all jeepneys with a combination of Euro 4 jeepney and E-Jeepney units following the share adopted in the study may be expected to provide a Php 7.55 billion

annual health benefits.

- The replacement of all jeepneys with Modern E-jeep units may be expected to reduce CO, NMVOC, NO_x and PM emission production to very negligible levels but will increase SO_x emissions by almost 4 times.
- The health benefits of refleeting of the old jeepneys with modern units regardless of the technology far outweighs the Php 160,000.00 upfront subsidy that the government is providing. The health benefits were found to range between 8.66 to 9.96 times the assistance provided with the higher limit linked to E-Jeepneys.
- It should be emphasized however that projected benefits are highly sensitive to the fleet size of the modern units that will be adopted. It should be ensured therefore that the number of replacement units are properly rationalized considering their bigger capacities compared to the existing units. In addition, their ability to take in more passengers during peak hours as they allow standing allows a more optimized operation. Their operation is expected to be further streamlined after the rationalization of the routes are completed which consequentially translates to additional health benefits.

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Appendix

Appendix A Jeepney Routes and Vehicle Fleet Size Considered in the Study

Route	Number of Franchises	Number of Units	Distance (km)	Daily Distance
A Bonifacio-A Mabini (via 10th Ave)	212	229	3.2	63.8
A Bonifacio-E Rodriguez	22	27	3.1	61.2
AFP/PNP Housing-Guadalupe	108	112	7.8	110.9
Alabang-Baclaran (via Aquino Ave)	191	205	19.2	237.6
Alabang-Baclaran (via Coastal)	19	33	20.0	248.5
Alabang-Baclaran (via Zapote)	763	888	19.8	246.0
Alabang-FTI	8	8	11.3	140.0
Alabang-Las Pinas	1	1	12.1	150.5
Alabang-Pasay Rotonda	690	834	20.2	250.6
Alabang-Pasay Rotonda (via FTI)	367	395	20.2	250.6
Alabang-Pasay Rotonda (via Nichols)	308	333	18.9	234.4
Alabang-San Joaquin	13	16	16.7	206.8
Alabang-Signal Village	117	138	11.5	142.2
Alabang-Sucat (via Cupang)	160	175	4.5	90.0
Alabang-Sucat (via SLEX)	85	114	5.2	73.2
Alabang-Zapote	138	149	11.0	136.9
Almar-Ever Gotesco	5	12	13.0	160.8
Amorsolo-Legaspi Village	7	7	1.5	30.2
Amparo-Novaliches	30	57	8.2	116.5
Angono-Cubao (via Imelda Avenue)	50	57	21.5	266.2
Angono-EDSA/Shaw	19	20	18.2	226.1
Angono-NCC Market	2	2	9.3	131.4
Angono-Pasig	72	75	18.2	225.7
Angono-Rosario (via Taytay)	3	3	14.8	183.7
Antipolo-Cubao (via Imelda Avenue)	86	112	19.0	235.7
Antipolo-Cubao (via Sumulong Hi-way)	124	146	19.7	244.5
Antipolo-EDSA/Shaw	79	85	15.3	190.3
Antipolo-JRC/JRU	59	69	19.7	244.3
Antipolo-Marikina (via Sumulong)	173	223	14.8	183.1
Antipolo-Pasig	1	1	16.2	200.9
Antipolo-Rosario	1	1	10.2	126.5
Ayala Alabang-Alabang	69	72	3.8	76.2
Ayala-Washington	121	140	2.6	51.7
Baclaran-Dapitan (via L Guinto)	121	182	12.4	153.2
Baclaran-Dapitan (via Mabini)	110	146	12.8	158.2
Baclaran-Divisoria (via L Guinto)	153	247	10.1	124.8
Baclaran-Divisoria (via Mabini)	188	315	10.4	128.4
Baclaran-P Campa (via L Guinto)	14	67	10.4	128.7

Baclaran-P Campa (via Mabini)	9	10	10.0	124.6
Baclaran-Quezon Institute (via L Guinto)	13	18	14.3	177.4
Baclaran-Quezon Institute (via Mabini)	21	26	12.6	156.0
Baclaran-Retiro (via L Guinto & Quiapo)	4	4	12.0	148.9
Baclaran-Retiro (via Mabini & Sta Cruz)	7	7	12.0	148.4
Bacood-Quiapo	75	77	6.7	94.8
Bacood-Stop N Shop	30	30	3.0	59.9
Bacoor-Baclaran	66	97	13.3	165.0
Bagbaguin-Malinta	56	60	5.2	74.1
Bagong Barrio-G De Jesus (via EDSA)	36	92	1.6	31.2
Bagong Nayon II-Marikina	143	149	13.1	162.7
Bagong Silangan-Ever Gotesco	46	48	5.7	81.6
Bagong Silangan-Sampaguita	16	16	5.7	81.6
Bagong Silang-Ever Gotesco	25	26	14.5	180.1
Bagong Silang-Novaliches	272	415	8.1	114.8
Bagong Silang-Philcoa	45	233	20.1	249.1
Bagong Silang-SM Fairview (via Maligaya)	47	57	7.6	108.2
Bagumbayan-Pasig	326	446	11.5	142.8
Bahayang-Baclaran	4	28	19.7	244.2
Balara-TM Kalaw	26	30	16.3	202.5
Balibago-Alabang	114	118	22.9	284.4
Balic-Bustillos	22	25	2.2	44.4
Balic-Espana	80	84	2.3	45.8
Balic-Quiapo (via Lepanto)	164	174	3.8	75.4
Balintawak-Blumentritt	53	58	5.2	73.2
Balintawak-Frisco	112	134	3.4	66.8
Balintawak-Marcos Ave	82	90	8.3	117.2
Balintawak-Monumento	353	390	3.7	73.4
Baliwag-Malinta	35	53	37.8	226.8
Balut-Blumentritt	125	136	2.9	57.6
Balut-Divisoria	19	19	4.1	80.8
Bangkusay-Divisoria	25	31	1.1	20.8
BBB-Recto	11	12	9.3	132.5
BF Homes (Paranaque)-Sucat	1	40	1.9	37.0
BF Homes-Novaliches	18	19	4.4	86.8
Bicutan-Pasay Rotonda	16	16	11.4	141.2
Bicutan-Pasig	33	34	10.4	129.1
Bignay-Novaliches	15	15	5.2	74.4
Bigte-Novaliches	189	272	20.5	254.3
Bilibid Prison-Alabang	10	12	6.0	85.5
Binan-Alabang (via National Rd)	223	250	10.5	130.4

Binan-Bicutan (via National Rd)	1	1	14.0	174.0
Binangonan-EDSA/Shaw (via Angono)	66	69	26.3	325.7
Binangonan-EDSA/Shaw (via Floodway)	9	10	26.2	324.4
Binangonan-JRC/JRU (via Floodway)	249	257	29.1	360.7
Binangonan-JRC/JRU (via Taytay)	7	8	28.3	350.7
Binangonan-Pasig	33	36	26.6	330.1
Binangonan-Rosario	3	4	20.4	253.3
Binangonan-Sta Lucia (via Taytay)	7	7	20.9	258.8
Blumentritt-Arroceros	45	49	4.6	90.1
Blumentritt-Baclaran (via L Guinto & Quiapo)	136	185	11.8	146.5
Blumentritt-Baclaran (via L Guinto & Sta Cruz)	159	261	12.7	156.9
Blumentritt-Baclaran (via Mabini & Quiapo)	71	77	14.3	177.9
Blumentritt-Baclaran (via Mabini & Sta Cruz)	106	579	14.8	183.0
Blumentritt-Divisoria	34	36	2.8	54.5
Blumentritt-Libertad (via L Guinto & Quiapo)	24	27	9.6	135.6
Blumentritt-Libertad (via L Guinto & Sta Cruz)	95	112	9.4	133.0
Blumentritt-Libertad (via Mabini & Sta Cruz)	16	17	10.3	127.2
Blumentritt-North Harbour	41	43	4.5	88.1
Blumentritt-P Campa	44	48	2.5	49.7
Blumentritt-Pasay Rotonda (via L Guinto & Quiapo)	52	58	10.7	133.2
Blumentritt-Pasay Rotonda (via L Guinto & Sta Cruz)	44	56	10.1	125.7
Blumentritt-Pasay Rotonda (via Mabini & Sta Cruz)	17	24	11.3	140.6
Blumentritt-Pier South 15	14	15	5.3	75.2
Blumentritt-PUC	18	18	7.3	103.1
Blumentritt-Recto	16	18	3.4	67.0
Blumentritt-Remedios	7	10	7.0	100.0
Blumentritt-Retiro	35	36	2.0	40.0
Blumentritt-Vito Cruz LRT (via L Guinto & Sta Cruz)	23	23	7.3	103.8
Blumentritt-Vito Cruz LRT (via Mabini & Quiapo)	6	6	10.3	127.4
Bocaue-Malinta	18	18	13.6	168.6
Boni/Pinatubo-Kalentong (via JRC/JRU)	43	46	5.6	79.5
Boni/Robinsons-Kalentong	47	51	4.6	91.1
Buendia/PICC-Fort Bonifacio	9	13	7.2	101.6
Bulacan-Malanday	18	18	13.3	164.6
Bulacan-Malinta	5	5	14.5	180.4
Buting-Guadalupe	81	91	4.0	79.0
Cabrera-Libertad	20	38	1.5	30.5
Cainta-Cubao (via Imelda Ave)	59	64	14.8	183.0
Cainta-Cubao (via Ortigas Ave)	25	25	13.0	160.6

Calamba-Alabang (via National Rd)	226	235	30.0	180.0
Calumpang-Cubao	107	120	8.6	122.3
Calumpang-Katipunan	10	11	4.4	87.1
Calumpang-Stop N Shop	110	141	12.4	154.3
Camarin-Balintawak	23	37	17.3	215.1
Camarin-Ever Gotesco	4	4	14.1	174.3
Camarin-Novaliches	150	179	5.9	84.2
Camarin-QMC	4	40	17.3	214.8
Camarin-SM Fairview	42	42	3.3	65.8
Camella Homes-Talon	9	9	7.9	111.9
Capitol Homes-SM Fairview	30	30	5.4	76.9
Carmona-Alabang	88	101	17.5	217.1
CCP Complex-Vito Cruz LRT	9	43	3.0	59.6
Celito Homes-Novaliches	48	88	3.8	75.2
Cogeo-Cubao	265	320	14.7	182.8
Crame-Q Mart	18	69	4.3	84.8
Crame-San Juan	65	82	3.4	66.6
Cubao-Arroceros	29	29	9.5	135.3
Cubao-Crame (via Murphy)	113	201	2.8	55.5
Cubao-Pier South 15	7	7	12.1	150.0
Cubao-Quiapo	14	14	8.9	126.3
Cubao-Recto	16	18	8.4	119.7
Cubao-Remedios	291	323	12.1	149.6
Cubao-Roces	93	155	4.3	84.4
Cubao-San Juan	97	112	4.2	83.3
Cubao-Stop N Shop	5	6	5.6	79.6
Cubao-TM Kalaw	24	24	11.3	139.8
Cubao-Vito Cruz LRT	222	352	14.9	185.3
Cubao-Welcome Rotonda	7	7	5.8	82.4
Dagat Dagatan-Divisoria	36	40	5.1	72.4
Dapitan-Arroceros	28	28	5.7	80.8
Dapitan-Libertad (via L Guinto)	22	31	10.8	133.9
Dapitan-Libertad (via Mabini)	17	22	10.4	129.5
Dapitan-P Campa	28	36	2.4	48.1
Dapitan-Pasay Rotonda (via L Guinto)	49	123	11.5	142.4
Dapitan-Pier South 15	39	47	6.2	87.9
Dasmarinas-Baclaran	452	529	28.5	353.9
Del Monte-Kanlaon	97	105	1.5	29.6
Del Monte-Quezon Ave (via Banaue)	21	24	1.8	34.8
Del Pan-Guadalupe	49	55	4.3	84.8
Dela Costa-Balintawak	4	4	15.1	187.2
Dela Costa-SM Fairview	27	28	3.9	77.8

Deparo-Novaliches	14	14	4.9	97.7
Divisoria-Cubao	464	576	10.0	141.3
Divisoria-TM Kalaw	26	48	3.3	64.8
Dominga-Libertad	10	53	3.2	62.5
Don Bosco-Divisoria	20	21	2.6	51.7
Don Mariano Marcos Ave-Quirino Highway	235	259	5.8	82.5
E Rodriguez (C5)-EDSA/Shaw (via Ortigas)	17	18	5.2	73.2
EDSA/Shaw-Guadalupe	34	35	2.2	43.7
EDSA/Shaw-Kalentong	149	171	3.3	65.3
EDSA/Shaw-Quiapo	5	5	9.6	136.8
Escolta-Libertad (via L Guinto)	2	3	7.1	100.5
Escolta-Libertad (via Mabini)	6	6	6.8	96.9
Espana-Rizal Ave	35	46	2.2	44.5
Fairview (Dahlia)-Cubao (via Arayat)	20	76	16.0	198.7
Fairview (Dahlia)-Cubao (via Kalayaan)	125	138	16.5	204.1
Fairview (Dahlia)-Philcoa	2	2	9.8	138.7
Fairview (Dahlia)-Pier South 15	10	10	22.8	283.3
Fairview-Arroceros	10	14	26.5	328.0
Fairview-Philcoa	31	44	9.7	138.0
Fairview-Pier South 15	14	14	23.1	286.9
Fairview-Quiapo	1	1	20.7	257.0
Fairview-TM Kalaw	50	57	22.5	278.4
Forbes Park-Pasay Rd	26	33	3.0	58.8
Francisco Homes-Cubao	3	243	31.5	189.1
Francisco Homes-Novaliches	24	24	15.2	188.2
Francisco Homes-Philcoa	31	50	26.4	326.9
Frisco-Arroceros	1	1	7.9	112.7
Frisco-Blumentritt	10	12	4.1	80.9
Frisco-Pier South 15	6	8	9.6	136.7
Frisco-Remedios	12	17	10.5	130.7
Frisco-Vito Cruz LRT (via Mabini & Sta Cruz)	39	43	13.1	162.9
FTI-Guadalupe	531	549	12.0	148.3
FTI-Kayamanan C	14	47	6.7	95.1
Gasak-Divisoria	217	231	10.0	124.5
Gasak-Sta Cruz	17	19	13.8	170.6
Gastambide-Divisoria	98	105	1.7	34.5
Gate 5-Greenhills Shopping Center	14	19	0.9	18.1
Gate III-Guadalupe	110	123	8.7	123.0
GMA-Alabang (via National Rd)	688	711	24.9	309.4
GMA-Alabang (via SLEX)	120	244	21.2	262.9
Golden City Subd-Talon	8	10	16.8	207.9
Grotto-Novaliches	67	85	13.5	167.6

Guadalupe-Ayala	114	132	6.2	87.6
Guadalupe-Buendia/Cartimar	187	192	6.2	88.7
Gumaok-Novaliches	46	47	13.5	167.6
Hagonoy-Malinta	1	2	37.5	225.0
Heritage Homes-Monumento (via NLEX)	50	50	19.2	237.6
Hulo-Kalentong	139	149	6.1	87.2
Imus-Baclaran	89	113	15.3	189.1
Jordan Plains-Philcoa	7	8	12.2	151.8
Kalentong-Boni/Pinatubo	201	209	3.7	73.4
Kamuning-Remedios	7	7	11.7	144.8
Kamuning-TM Kalaw	1	4	11.2	138.6
Kamuning-Vito Cruz LRT	14	22	12.3	152.4
Karuhatan-Divisoria	9	12	10.1	124.8
Karuhatan-Monumento	13	13	4.9	97.7
Karuhatan-Sta Cruz	13	23	11.7	145.7
Karuhatan-Ugong (Valenzuela)	164	714	3.2	62.7
Katarungan Village-Alabang	136	144	6.2	87.5
Kayamanan C-Washington	45	47	2.5	49.0
Kaybiga-Malinta	10	12	5.5	78.6
L Guinto-Guadalupe	582	630	10.2	126.9
L Guinto-Makati (via San Andres)	86	87	8.3	117.8
L Guinto-Pandacan	196	262	3.1	62.4
Lagro-Anonas LRT	71	191	18.6	231.0
Lagro-Balintawak (via Novaliches)	61	65	16.2	201.1
Lagro-Cubao	421	475	20.2	250.6
Lagro-Novaliches	84	90	4.9	97.5
Lagro-Panay Ave	19	52	19.0	235.1
Lagro-Philcoa	24	25	12.5	155.1
Lagro-Queens/EDSA	18	22	19.1	237.3
Lagro-Rizal Ave (via A Bonifacio)	103	109	20.7	256.6
Lagro-SM Fairview	90	100	3.1	60.4
Lagro-SM North	118	138	16.2	201.4
Lagro-Welcome Rotonda	70	92	20.7	256.6
Langgam-Alabang	7	47	12.9	159.6
Lardizabal-Rizal Ave	252	281	3.3	64.7
Libertad-A Luna	1	1	2.7	53.7
Libertad-Dian	36	40	3.3	64.9
Libertad-Divisoria (via L Guinto)	16	21	7.7	108.8
Libertad-Divisoria (via Mabini)	11	20	8.4	119.8
Libertad-Evangelista	168	223	2.0	39.0
Libertad-Pier South 15	85	98	7.5	106.1
Libertad-Pinagbarilan	12	21	3.9	77.4

Libertad-PRC	121	146	4.8	95.0
Libertad-Quezon Institute (via L Guinto)	18	19	10.3	127.5
Libertad-Quezon Institute (via Mabini)	2	2	11.0	136.5
Libertad-Vito Cruz LRT	1	1	1.8	35.9
Libertad-Washington	38	39	2.1	41.4
Libis-Cubao	26	26	4.6	92.0
LRT 5th Ave-Quezon Ave	3	4	4.4	88.0
Lupang-Litex	76	82	4.0	78.5
M Dela Cruz-Libertad	43	48	1.2	24.4
M Reyes-Libertad	61	78	2.9	57.7
Malabon-Monumento (via Acacia)	256	687	6.6	93.5
Malabon-Monumento (via Letre)	209	238	3.6	72.1
Malanday-Pier South 15	128	267	17.5	217.0
Malanday-Recto	220	366	15.7	194.5
Malanday-Sta Cruz	72	142	15.2	188.3
Malibay-Libertad (via SM MOA)	124	257	3.7	72.5
Malinao-JRC/JRU	111	158	4.4	87.4
Malinta-Monumento	1	1	5.4	77.2
Malinta-Recto	53	58	11.2	138.9
Malinta-Sta Cruz	38	40	11.7	145.7
Malolos-BBB	2	45	33.1	198.4
Malolos-Malinta	114	169	29.4	364.9
Malugay-Kamagong	9	11	1.5	29.0
Mambugan-Marikina	16	16	6.4	91.3
Mantrade-Ayala	34	48	1.9	37.5
Marikina-Pasig	411	454	10.7	132.8
Marikina-Pateros	108	117	11.7	144.8
Marilao-Monumento	3	4	12.4	153.8
Market Market-Guadalupe	8	9	3.8	76.0
Maypajo-Divisoria	28	30	4.6	91.3
MCU-Divisoria	211	230	7.3	103.6
MCU-Escolta	19	23	7.5	106.5
MCU-Libertad (via Mabini)	19	21	15.0	185.5
MCU-Libertad (via Taft Ave)	42	52	15.0	185.5
MCU-Pasay Rotonda (via Mabini)	19	20	14.6	181.2
MCU-Pasay Rotonda (via Taft Ave)	64	71	14.9	185.3
MCU-Pier South 15	1	1	9.6	136.6
MCU-Recto	74	77	8.3	117.6
MCU-Vito Cruz LRT	11	12	11.7	145.7
Meycauayan-Malinta	6	6	7.5	106.1
Meycauayan-Monumento (via McArthur)	101	130	10.9	135.6
Meycauayan-Monumento (via NLEX)	191	210	19.6	242.5

Montalban-Cubao	255	259	19.7	244.4
Montalban-Litex	126	163	10.2	126.1
Montalban-Marikina	164	180	12.8	158.1
Montalban-Philcoa	115	129	16.1	199.4
Monumento-Escolta	13	18	6.8	96.7
Monumento-Libertad (via Mabini)	4	5	14.1	174.9
Monumento-Pasay Rotonda (via Mabini)	2	3	13.9	172.6
Monumento-Pasay Rotonda (via Taft)	24	28	14.1	174.7
Monumento-Pier South 15	13	18	9.1	129.6
Monumento-Vito Cruz (via Taft)	10	11	11.1	137.1
Moonwalk-Baclaran	57	74	15.5	192.0
Morong-EDSA/Shaw (via Antipolo)	116	124	29.7	368.3
Morong-EDSA/Shaw (via Binangonan)	2	3	34.2	205.1
Munoz-Pantranco	59	65	2.8	55.4
Munoz-QMC (via Visayas)	11	13	5.4	76.6
Munoz-Remedios	153	186	13.0	161.5
Munoz-Vito Cruz LRT	208	284	15.3	189.9
Muntinlupa-Alabang (via National Rd)	3	3	9.0	127.4
Navotas-Divisoria	131	199	9.9	141.2
Navotas-Monumento	155	186	6.8	97.0
Navotas-Recto	86	138	13.2	163.7
New Panaderos-JP Rizal	1	1	6.6	93.6
Nichols-Baclaran	85	116	2.1	42.4
Nichols-Nichols PNR	85	85	2.5	48.9
Nichols-SM MOA	3	3	6.1	86.7
Nichols-Vito Cruz LRT	23	25	7.0	99.5
North Harbour-Quiapo	90	99	3.6	70.9
North Harbour-Sta Mesa	1	1	6.1	85.9
Norzagaray-Malinta	19	20	30.4	182.4
Norzagaray-SM Fairview	72	155	25.1	310.7
Novaliches-Balintawak	105	112	9.4	133.9
Novaliches-Blumentritt	14	15	12.8	159.2
Novaliches-Malinta	374	403	9.0	128.1
Novaliches-Rizal Ave	714	785	13.1	162.2
Obando-Malabon	27	27	7.5	106.8
Obando-Monumento	158	165	12.5	155.1
Ortigas Complex-EDSA/Shaw	21	25	4.5	88.8
Ortigas Complex-Robinsons Galleria	24	24	0.4	8.0
Pabahay 2000-SM Fairview	2	3	8.7	122.9
Pabahay Ni Erap-Commonwealth Market	67	146	12.2	151.0
Pacita-Sucat	38	39	13.0	160.8
Paco-Pier South 15	13	13	4.3	85.5

Padilla-Cubao	154	165	15.3	189.3
Paenaan-Cogeo	10	10	15.9	197.5
Paenaan-Marikina	260	282	25.7	318.2
Pag asa-Arroceros	2	4	12.7	158.0
Pag asa-SM North	10	10	1.8	35.9
Paliparan-Talon	6	59	19.6	243.4
Palmera-Novaliches	196	267	17.9	221.9
Pandacan-Nagtahan Rotonda	16	20	1.0	19.1
Pandacan-Pier South 15	21	23	5.7	81.2
Parang-Cubao	22	23	7.3	103.8
Parang-Marikina	97	111	6.6	93.2
Parang-Recto	23	58	18.9	234.8
Parang-Stop N Shop	345	399	15.9	196.7
Pasay Rd-Libertad	94	119	3.6	71.1
Pasay Rotonda-Divisoria	20	23	8.9	126.4
Pasay Rotonda-Libertad	7	7	1.7	34.5
Pasay Rotonda-Quezon Institute	4	5	11.8	146.8
Pasig/San Joaquin-Quiapo	883	949	15.8	196.3
Pasig-EDSA/Shaw	210	225	6.3	89.6
Pasig-Napindan (via Nacsor)	22	24	4.9	96.2
Pasig-Stop N Shop	10	10	14.3	176.7
Pasig-Ugong	30	31	4.9	96.7
Pateros-Ayala	131	134	8.2	116.2
Pateros-EDSA/Pioneer	154	159	9.0	127.6
Pateros-EDSA/Shaw	21	22	8.4	119.2
Pateros-Guadalupe	285	307	5.8	82.1
Pateros-Robinsons Galleria	1	20	7.9	111.7
Philcoa-Arroceros	9	11	12.5	154.5
Philcoa-Pier South 15	89	101	13.2	164.1
Philcoa-Recto	11	11	10.5	130.8
Philcoa-TM Kalaw	210	247	12.8	159.3
Pier North-Divisoria	54	57	3.9	76.7
Pier South 15-Pag asa	92	105	12.7	157.3
Pinugay-Marikina	29	29	11.5	142.1
Plaridel/Bintog-Malinta	42	64	18.7	232.3
Plaridel-BBB	1	10	21.8	269.9
Polo-Monumento	170	186	7.9	112.9
Polo-Sangandaan	98	113	5.9	84.3
PRC-Buendia/Cartimar	4	6	4.4	87.2
PRC-Kayamanan C	223	241	3.9	76.9
Prenza-Monumento	11	11	17.0	211.2
Project 2/3-Arroceros (via E Rodriguez)	13	16	12.1	149.5

Project 2/3-Arroceros (via Timog)	1	1	13.5	167.8
Project 2/3-Cubao	49	57	4.4	86.7
Project 2/3-Pantranco	66	81	6.3	89.4
Project 2/3-Pier South 15 (via E Rodriguez)	24	26	12.9	159.7
Project 2/3-Pier South 15 (via Timog)	15	20	15.4	190.9
Project 2/3-Q Mart	15	30	2.1	41.7
Project 2/3-Recto (via E Rodriguez)	1	1	9.9	140.5
Project 2/3-Remedios	18	48	12.8	159.0
Project 2/3-TM Kalaw (via E Rodriguez)	87	114	12.4	153.6
Project 2/3-Vito Cruz LRT	4	6	15.7	194.1
Project 2/3-Welcome Rotonda	92	136	11.2	138.4
Project 4-Cubao	194	211	3.6	70.8
Project 4-Pier South 15	29	33	12.2	150.9
Project 4-Quiapo	8	10	11.5	142.6
Project 4-Recto	2	2	9.1	129.4
Project 4-Stop N Shop	2	2	4.9	97.6
Project 6-Arroceros	9	12	10.5	130.8
Project 6-Pier South 15	170	196	14.7	181.7
Project 6-Recto	10	10	10.4	128.6
Project 6-SM North	21	25	2.8	56.2
Project 6-TM Kalaw	145	238	14.3	176.8
Project 6-Vito Cruz LRT	1	10	16.9	209.2
Project 7-Arroceros	1	11	11.5	142.2
Project 7-Pier South 15	7	7	11.7	145.2
Project 7-Quiapo	5	5	8.9	125.7
Project 7-TM Kalaw	5	5	11.3	140.3
Project 8-Arroceros	34	220	13.1	162.3
Project 8-Munoz	5	9	3.5	68.6
Project 8-Pantranco	31	34	5.5	77.9
Project 8-Pier South 15	71	85	14.5	179.9
Project 8-TM Kalaw	181	202	14.1	175.1
Project 8-Welcome Rotonda	8	8	7.8	110.6
Punta-Divisoria	37	50	8.4	119.4
Punta-Quiapo	150	169	7.4	105.8
QMC-Aurora	70	81	5.4	77.1
QMC-Cubao	95	116	6.2	88.4
QMC-SM North	50	63	2.3	46.4
Queens Row-Talon	28	33	3.1	61.9
Quezon Institute-TM Kalaw	1	1	6.1	86.9
Quiapo-Divisoria	35	37	1.6	32.4
Quiapo-Project 8	2	94	11.8	146.2
Quirino Highway-Katipunan	120	145	8.0	113.1

Retiro-Arroceros	5	5	6.9	98.4
Retiro-Divisoria	48	57	5.3	75.7
Retiro-Libertad (via Mabini & Quiapo)	25	31	12.7	157.4
Rosario-Cubao	306	321	7.6	108.0
Rosario-San Juan	203	220	7.8	110.3
Roxas-Arroceros	1	1	7.9	112.5
Roxas-Recto	27	35	6.4	91.1
San Andres-P Faura	156	188	4.3	85.7
San Juan-Divisoria	260	323	7.5	106.8
San Juan-Quiapo (via Legarda)	5	6	6.5	92.2
San Mateo-Marikina	18	18	5.4	76.8
San Miguel-Lawton (IKOT)	38	39	1.5	30.5
San Miguel-Quiapo (via Palanca)	73	81	1.9	36.7
Sangandaan-Divisoria/Quiapo	513	578	8.3	117.4
Sangandaan-MCU	82	91	2.2	42.6
Santol-Pina Ave	37	41	1.7	34.3
Santol-Quiapo (via Sta Mesa)	49	54	4.2	83.2
Sapang Palay-Novaliches	26	106	25.0	310.1
Signal Village-Pasay Rotonda	79	101	9.4	133.4
Silangan-Cubao	186	189	13.8	170.6
Silang-Zapote	12	12	30.4	182.2
SM City Marikina-Pasig	15	15	12.6	155.7
SM Fairview-Marikina	17	21	18.5	228.9
SM MOA-Buendia LRT	22	36	3.3	65.1
SM MOA-Pasay Rotonda	1	41	1.8	35.9
SM North-Panay Ave	2	26	4.4	86.4
Soldier Hills II-Talon	38	39	7.4	105.3
Soldier Hills IV/Molino-Talon	104	109	9.8	139.2
Soldier Hills-Molino Loop	5	7	6.2	87.9
SSS Village-Cubao	40	41	10.9	135.2
SSS Village-Recto	1	24	19.2	238.7
SSS Village-Stop N Shop	283	322	16.6	205.6
Sta Ana-L Guinto	103	260	4.3	85.0
Sta Ana-P Faura	19	30	4.4	86.5
Sta Ana-Pier South 15	45	105	7.9	112.3
Sta Cruz-Divisoria	77	109	1.6	32.6
Sta Maria-Malinta	10	10	17.7	219.9
Sta Maria-Monumento (via McArthur)	235	255	22.7	281.1
Sta Maria-Monumento (via NLEX)	94	121	23.1	286.4
Sta Mesa-Divisoria	44	44	5.3	75.8
Sta Mesa-Paco	92	98	4.9	97.7
Sta Quiteria-Balintawak	34	35	3.8	75.7

Sta Quiteria-Blumentritt	104	121	7.8	110.9
Sto Nino-Monumento	187	190	17.1	212.0
Stop N Shop-Boni/Pinatubo	254	279	7.0	99.5
Sucat-Baclaran	1000	976	14.7	182.6
Sucat-Bagumbayan	86	91	2.6	52.3
Sucat-EDSA/SSH	15	15	10.7	133.1
Sucat-Kabihasnan	84	91	8.3	118.0
Sucat-Market Market	1	15	13.1	162.5
Sucat-Pasay Rotonda	39	43	14.9	184.8
Sucat-SM MOA	1	2	15.2	188.4
Taguig-Guadalupe	56	61	5.0	71.7
Taguig-Pasig (via Tipas)	39	40	5.3	75.5
Tala-Novaliches (via Camarin)	64	79	8.4	118.8
Tala-Novaliches (via Quirino)	74	116	11.8	146.2
Talayan Village-A Bonifacio	1	63	3.0	59.6
Tanay-EDSA/Shaw (via Antipolo)	219	298	36.1	216.5
Tanay-Robinsons Galleria	8	16	37.4	224.6
Tanza-Zapote	13	13	21.2	262.9
Taytay-Cubao	234	249	17.0	210.6
Taytay-EDSA/Shaw	72	75	12.8	158.5
Taytay-Pasig	85	95	13.0	161.7
Taytay-Rosario	3	3	16.6	206.1
Taytay-San Juan	18	19	16.9	209.6
Tayuman-Divisoria	6	7	1.3	25.5
Tipas-EDSA/Shaw	75	76	6.3	89.8
Trece Martirez-Zapote	3	4	29.1	360.9
Tumana-Balara	52	52	4.0	80.1
UP Campus-IKOT (Loop)	41	52	4.5	89.7
UP Campus-Pantranco	47	69	7.0	99.1
UP Campus-Philcoa	6	6	2.2	44.1
UP Campus-SM North	32	38	4.9	97.9
UP Campus-TM Kalaw	5	5	14.9	184.9
Urduja-Novaliches	19	19	3.3	65.6
V Luna-Cubao	52	60	4.7	93.6
Velasquez-Divisoria	181	183	3.8	74.8
Victoria Homes Subd-Alabang	21	21	11.3	140.1
Visayas Ave-Tandang Sora	85	94	5.8	82.8
Washington-Bel Air	108	125	3.3	64.5
West Ave-TM Kalaw	9	9	10.6	131.9
Zabarte-Panay Ave	426	453	19.6	243.6
Zabarte-Welcome Rotonda	182	200	24.5	303.8
Zapote-Baclaran	81	105	9.6	136.9
Zobel Roxas-L Guinto	119	128	1.3	25.1

Appendix B Power Plant Emission Factors Used in the Study

Powerplant Type	Sub-Class	CO	NOX	SOX	VOC	PM	PM_{10}	Units	Thermal Efficiency (%)
Circulating Fluidized Bed (CFB) Coal		0.335	0.093	0.389	0.001	0.177	0.231	g/MJ	40%
Pulvurized Sub Critical Coal		0.009	0.284	5.647	0.001	0.029	0.038	g/MJ	38%
Circularized Fluidized Bed (CFB) Coal Co-generation		0.335	0.093	0.389	0.001	0.177	0.231	g/MJ	40%
Bunker/Diesel Internal Combustion Engine		0.366	1.379	1.175	0.039	0.022	0.025	g/MJ	36%
Modular Gas Turbine		0.018	0.079	0.000	0.001	0.003	0.003	g/MJ	35%
Bunker-fired Thermal Plant	> 30 MW	0.016	0.105	0.866	0.002	0.014	0.022	g/MJ	38%
	< 30 MW	0.016	0.117	0.751	0.002	0.000	0.017	g/MJ	38%
Combined Cycle Gas Turbine (CCGT)		0.035	0.138	0.000	0.001	0.003	0.003	g/MJ	46%
Open Cycle Gas Turbine (OCGT)		0.035	0.138	0.000	0.001	0.003	0.003	g/MJ	35%
Biogas		0.215	0.302	0.005	0.018	0.007	0.007	g/MJ	36%
Rice Husk-fired Cogeneration Plant		0.112	0.141	0.085	0.000	0.003	0.003	g/MJ	22%
Bagasse-fired Cogeneration Plant		0.000	0.035	0.000	0.000	0.349	0.441	g/MJ	54%
Bunker/Diesel Internal Combustion Engine Power Barge		0.366	1.379	1.175	0.039	0.022	0.025	g/MJ	36%
Landfill Gas Recovery System		0.215	0.302	0.005	0.018	0.007	0.007	g/MJ	36%

Appendix C Power Plants Considered in the Study

POWER PLANT		CAPACITY, MW		NUMBER OF UNITS	LOCATION	REGION	OPERATOR
FACILITY NAME	SUBTYPE	INS	Dep		MUNICIPALITY /PROVINCE		
GRID-CONNECTED							
COAL							
ANDA	Circulating Fluidized Bed (CFB) Coal	83.7	72.0	1	Mabalacat, Pampanga	3	Anda Power Corporation
APEC	Pulvurized Sub Critical Coal	52.0	46.0	1	Mabalacat, Pampanga	3	Asia Pacific Energy Corporation
CALACA U1	Pulvurized Sub Critical Coal	300.0	230.0	1	Calaca, Batangas	4-A	SEM-Calaca Power Corporation (SCPC)
CALACA U2	Pulvurized Sub Critical Coal	300.0	300.0	1	Calaca, Batangas	4-A	SEM-Calaca Power Corporation (SCPC)
MARIVELES U1	Pulvurized Sub Critical Coal	345.0	316.0	1	Mariveles, Bataan	3	GN Power Mariveles Coal Plant Ltd.Co
MARIVELES U2	Pulvurized Sub Critical Coal	345.0	316.0	1	Mariveles, Bataan	3	GN Power Mariveles Coal Plant Ltd.Co
MASINLOC U1	Pulvurized Sub Critical Coal	315.0	315.0	1	Masinloc, Zambales	3	Masinloc Power Partners Co. Ltd. (MPPCL)
MASINLOC U2	Pulvurized Sub Critical Coal	344.0	344.0	1	Masinloc, Zambales	3	Masinloc Power Partners Co. Ltd. (MPPCL)
PAGBILAO U1	Pulvurized Sub Critical Coal	382.0	382.0	1	Pagbilao, Quezon	4-A	TeaM Pagbilao Corporation
PAGBILAO U2	Pulvurized Sub Critical Coal	382.0	382.0	1	Pagbilao, Quezon	4-A	TeaM Pagbilao Corporation
PAGBILAO U3	Pulvurized Sub Critical Coal	420.0	420.0	1	Pagbilao, Quezon	4-A	Pagbilao Energy Corporation (PEC)
QUEZON POWER	Pulvurized Sub Critical Coal	511.0	460.0	1	Mauban, Quezon	4-A	Quezon Power (Philippines) Ltd. Co.
SCPC U1 (SMC LIMAY U1)	Circulating Fluidized Bed (CFB) Coal	150.0	135.0	1	Limay, Bataan	3	SMC Consolidated Power Corporation (SCPC)
SCPC U2 (SMC LIMAY U2)	Circulating Fluidized Bed (CFB) Coal	150.0	135.0	1	Limay, Bataan	3	SMC Consolidated Power Corporation (SCPC)
SCPC U3 (SMC LIMAY U3)	Circulating Fluidized Bed (CFB) Coal	150.0	135.0	1	Limay, Bataan	3	SMC Consolidated Power Corporation (SCPC)
SLPGC U1	Circulating Fluidized Bed (CFB) Coal	150.0	140.0	1	Calaca, Batangas	4-A	Southwest Luzon Power Generation Corporation (SLPGC)
SLPGC U2	Circulating Fluidized Bed (CFB) Coal	150.0	140.0	1	Calaca, Batangas	4-A	Southwest Luzon Power Generation Corporation (SLPGC)
SLTEC PUTING BATO U1	Circulating Fluidized Bed (CFB) Coal	135.0	121.0	1	Calaca, Batangas	4-A	South Luzon Thermal Energy Corporation (SLTEC)
SLTEC PUTING BATO U2	Circulating Fluidized Bed (CFB) Coal	135.0	122.9	1	Calaca, Batangas	4-A	South Luzon Thermal Energy Corporation (SLTEC)
SUAL U1	Pulvurized Sub Critical Coal	647.0	647.0	1	Sual, Pangasinan	1	TeaM Sual Corporation
SUAL U2	Pulvurized Sub Critical Coal	647.0	647.0	1	Sual, Pangasinan	1	TeaM Sual Corporation
UPPC	Circularized Fluidized Bed (CFB) Coal Co-generation	30.0	24.0	1	Calumpit, Bulacan	3	United Pulp & Paper Co., Inc. (UPPC)
OIL-BASED							
Diesel							
BAUANG DPP	Bunker/Diesel Internal Combustion Engine	227.5	190.0	21	Bauang, La Union	1	1590 Energy Corporation
CIP II	Bunker/Diesel Internal Combustion Engine	21.0	20.4	1	Bacnotan, La Union	1	CIP II Power Corporation

RCBMI	Bunker/Diesel Internal Combustion Engine	12.4	12.0	2	Taysan, Batangas	4-A	Republic Cement and Building Materials Inc. (RCBMI)
SLPGC U3	Modular Gas Turbine	25.0	23.0	1	Calaca, Batangas	4-A	Southwest Luzon Power Generation Corporation (SLPGC)
SLPGC U4	Modular Gas Turbine	25.0	23.0	1	Calaca, Batangas	4-A	Southwest Luzon Power Generation Corporation (SLPGC)
SUBIC DPP	Bunker/Diesel Internal Combustion Engine	120.0	116.0	8	Olongapo, Zambales	3	One Subic Power Generation Corporation
TRANS ASIA POWER	Bunker/Diesel Internal Combustion Engine	54.5	50.0	1	Norzagaray, Bulacan	3	Trans Asia Power Generation Corporation
Oil Thermal							
MALAYA	Bunker-fired Thermal Plant	650.0	150.0	2	Pililla, Rizal	4-A	STX Marine Inc.
Gas Turbine							
LIMAY CCGT	Combined Cycle Gas Turbine (CCGT)	648.0	540.0	8	Limay, Bataan	3	Panasia Energy Holding Inc. (PEHI)
NATURAL GAS							
AVION	Open Cycle Gas Turbine (OCGT)	100.6	97.0	2	Bolbok, Batangas City	4-A	Prime Meridian Powergen Corporation (PMPC)
ILIJAN	Combined Cycle Gas Turbine (CCGT)	1,277.0	1,200.0	6	Ilijan, Batangas City	4-A	KEPCO Ilijan Corporation (KEILCO)
SAN GABRIEL	Combined Cycle Gas Turbine (CCGT)	430.0	420.0	1	Sta. Rita, Batangas City	4-A	First NatGas Power Corp (FNPC)
SAN LORENZO	Combined Cycle Gas Turbine (CCGT)	549.1	526.6	2	Sta. Rita, Batangas City	4-A	FGP Corporation
SANTA RITA	Combined Cycle Gas Turbine (CCGT)	1,094.8	1,042.5	4	Sta. Rita, Batangas City	4-A	First Gas Power Corporation (FGPC)
GEOTHERMAL							
BACMAN	Flash Type Steam recovery	156.1	140.0	3	Manito, Albay	5	Bac-Man Geothermal Inc. (BGI)
MAKBAN	Flash/Binary Type Steam recovery	442.8	420.0	10	Calauan, Laguna	4-A	AP Renewable Inc. (APRI)
MAKBAN-BINARY	Flash/Binary Type Steam recovery	6.0	5.4	1	Bitin bay, Laguna	4-A	AP Renewable Inc. (APRI)
TIWI	Flash Type Steam recovery	234.0	207.9	4	Tiwi, Albay	5	AP Renewable Inc. (APRI)
HYDROELECTRIC							
Large Hydroelectric Plants							
AMBUKLAO	Dam-type HEPP	105.0	105.0	3	Bokud, Benguet	CAR	SN Aboitiz Power (SNAP)- Benguet, Inc.
ANGAT MAIN	Dam-type HEPP	200.0	200.0	4	Norzagaray, Bulacan	3	Angat Hydro Power Corporation (AHPC)
ANGAT AUX	Dam-type HEPP	18.0	18.0	3	Norzagaray, Bulacan	3	
BAKUN	Run-of-River type HEPP	75.4	73.6	2	Alilem, Ilocos Sur	1	Luzon Hydro Corporation

BINGA	Dam-type HEPP	140.0	138.0	4	Itogon, Benguet	CAR	SN Aboitiz Power (SNAP) - Benguet, Inc.
CALIRAYA	Dam-type HEPP	39.1	35.0	2	Lumban, Laguna	4-A	Caliraya-Botocan-Kalayaan Power Company Ltd.
CASECNAN (NIA)	Dam-type HEPP	168.0	150.0	2	Pantabangan, Nueva Ecija	3	CE Casecnan Water & Energy Co., Inc.
KALAYAAN PSPP	Dam-type HEPP	736.0	720.0	4	Kalayaan, Laguna	4-A	Caliraya-Botocan-Kalayaan Power Company Ltd.
MAGAT	Dam-type HEPP	380.0	360.0	4	Ramon, Isabela	2	SN Aboitiz Power (SNAP) - Magat, Inc.
PANTABANGAN	Dam-type HEPP	120.8	120.0	2	Pantabangan, Nueva Ecija	3	First Gen Hydro Power Corporation (FG Hydro)
MASIWAY	Run-of-River type HEPP	12.0	12.0	1	Pantabangan, Nueva Ecija		First Gen Hydro Power Corporation (FG Hydro)
SAN ROQUE	Dam-type HEPP	435.0	435.0	3	San Manuel, Pangasinan	1	San Roque Power Corporation (SRPC)
Small Hydroelectric Plants							
AMPOHAW	Run-of-River type HEPP	8.0	7.5	3	Sablan, Benguet	CAR	Hydro Electric Development Corporation (HEDCOR), Inc.
FLS	Run-of-River type HEPP	6.4	6.0	4	Bakun, Benguet	CAR	Hydro Electric Development Corporation (HEDCOR), Inc.
MARIS 1 MAIN CANAL	Run-of-River type HEPP	8.5	8.0	2	Ramon, Isabela	2	SN Aboitiz Power (SNAP) - Magat, Inc.
NIA-BALIGATAN	Run-of-River type HEPP	6.2	6.0	1	Ramon, Isabela	2	National Irrigation Administration (NIA)
SABANGAN	Run-of-River type HEPP	15.0	15.0	1	Sabangan, Mt. Province	CAR	Hydro Electric Development Corporation (HEDCOR), Inc.
Mini Hydroelectric Plants							
BINENG 1	Run-of-River type HEPP	3.2	3.2	4	La Trinidad, Benguet	CAR	Hydro Electric Development Corporation (HEDCOR), Inc.
BINENG 2	Run-of-River type HEPP	2.0	1.7	3	La Trinidad, Benguet	CAR	Hydro Electric Development Corporation (HEDCOR), Inc.
BINENG 3	Run-of-River type HEPP	4.5	3.6	1	La Trinidad, Benguet	CAR	Hydro Electric Development Corporation (HEDCOR), Inc.
IRISAN 1	Run-of-River type HEPP	3.8	3.3	1	Tuba, Benguet	CAR	Hydro Electric Development Corporation (HEDCOR), Inc.
IRISAN 3	Run-of-River type HEPP	1.2	1.1	3	Tuba, Benguet	CAR	Hydro Electric Development Corporation (HEDCOR), Inc.
LON-OY	Run-of-River type HEPP	3.6	3.3	4	Bakun, Benguet	CAR	Hydro Electric Development Corporation (HEDCOR), Inc.
LOWER LABAY	Run-of-River type HEPP	2.4	2.3	4	Bakun, Benguet	CAR	Hydro Electric Development Corporation (HEDCOR), Inc.
SAL-ANGAN	Run-of-River type HEPP	2.4	1.8	4	Itogon, Benguet	CAR	Hydro Electric Development Corporation (HEDCOR), Inc.
Micro Hydroelectric Plants							
BINENG 2B	Run-of-River type HEPP	0.8	0.6	2	La Trinidad, Benguet	CAR	Hydro Electric Development Corporation (HEDCOR), Inc.
WIND							
BANGUI WIND POWER Ph1 and Ph2	On-shore Wind Turbine	33.0	33.0		Bangui Bay, Ilocos Norte	1	North Wind Power Development Corporation (NWPDC)
BANGUI WIND POWER Ph3	On-shore Wind Turbine	18.9	18.9		Bangui Bay, Ilocos Norte	1	North Wind Power Development Corporation (NWPDC)

BURGOS WIND	On-shore Wind Turbine	150.0	150.0		Burgos, Ilocos Norte	1	EDC Burgos Wind Power Corporation (EBWPC)
CAPARISPISAN WIND	On-shore Wind Turbine	81.0	81.0		Caparispisan, Ilocos Norte	1	North Luzon Renewable Energy Corporation (NLREC)
BIOMASS							
ACNC	Biogas	2.0	0.6		Tarlac City, Tarlac		Asian Carbon Neutral Power Corporation (ACNPC)
BATAAN 2020	Rice Husk-fired Cogeneration Plant	13.0	11.0	1	Samal, Bataan	3	Bataan 2020 Inc.
BBEC	Rice Husk-fired Cogeneration Plant	5.0	4.0	1	Pili, Camarines Sur	5	Bicol Biomass Energy Corporation (BBEC)
GIFT	Bagasse-fired Cogeneration Plant	12.0	10.8	1	Talavera, Nueva Ecija	3	Green Innovations for Tomorrow Corporation (GIFTC)
GREEN FUTURE	Bagasse-fired Cogeneration Plant	19.8	12.2	4	San Mariano, Isabela	2	Green Future Innovation Inc. (GFII)
IBEC	Rice Husk-fired Cogeneration Plant	20.0	18.3	1	Alicia, Isabela	2	Isabela Biomass Energy Corporation (IBEC)
SJC IPOWER Phase I	Rice Husk-fired Cogeneration Plant	12.0	11.0	1	San Jose City, Nueva Ecija	3	San Jose City I Power Corporation
SJC IPOWER Phase II	Rice Husk-fired Cogeneration Plant	12.0	10.8	1	San Jose City, Nueva Ecija	3	San Jose City I Power Corporation
SOLAR							
CALATAGAN SOLAR	Ground Mounted Solar PVs	63.0	44.1		Calatagan and Balayan, Batangas	4-A	Solar Philippines Calatagan Corporation
CLARK SOLAR	Ground Mounted Solar PVs	22.3	22.3		Prince Balagtas Extension, Clark Special Economic Zone, Mabalacat, Pampanga	3	Enfinity Philippines Renewable Resources Inc.
CURRIMAO SOLAR	Ground Mounted Solar PVs	20.0	16.3		Currimao, Ilocos Norte	1	Mirae Asia Energy Corporation
MARIVELES SOLAR	Ground Mounted Solar PVs	18.0	18.0		Freeport Area of Bataan (FAB), Mariveles, Bataan	3	Next Generation Power Technology Corporation
PETROSOLAR	Ground Mounted Solar PVs	50.1	45.5		Tarlac City, Tarlac	3	PetroSolar Corporation
STA. RITA SOLAR	Ground Mounted Solar PVs	32.3	29.3		Mt. Sta. Rita, Subic Bay Freeport Zone	3	Jobin-Sqm Inc. (JOBIN)
YH GREEN	Ground Mounted Solar PVs	14.5	12.6		Hermosa, Bataan	3	YH Green Energy Incorporated
EMBEDDED							
COAL							
PETRON RSFFB	Pulvurized Sub Critical Coal	140.0	100.0	4	Limay, Bataan	3	Petron Corporation
OIL-BASED							
Diesel							
CALIBU DPP	Bunker/Diesel Internal Combustion Engine	30.6	27.5	5	Angeles City	3	Angeles Power Inc. (API)
FCVC DPP	Bunker/Diesel Internal Combustion Engine	25.6	24.0	4	Cabanatuan City	3	First Cabanatuan Venture Corporation (FCVC)

PETERSVILLE DPP	Bunker/Diesel Internal Combustion Engine	7.5	6.0	3	Angeles City	3	Angeles Electric Corporation (AEC)
TARLAC POWER	Bunker/Diesel Internal Combustion Engine	18.6	17.0	3	Capas, Tarlac	3	Tarlac Power Corporation
TMO	Bunker/Diesel Internal Combustion Engine Power Barge	242.0	161.0	4	Navotas, Metro Manila	NCR	Therma Mobile Inc. (TMO)
Gas Turbine							
MILLENNIUM GTPP	Open Cycle Gas Turbine (OCGT)	100.0	73.0	1	Navotas, Metro Manila	NCR	Millenium Energy Inc. (MEI)
GEOTHERMAL							
MAIBARARA 1	Flash Type Steam recovery	20.0	20.0	1	Sto. Tomas, Batangas	4-A	Maibarara Geothermal Inc. (MGI)
MAIBARARA 2	Flash Type Steam recovery	12.0	12.0	1	Sto. Tomas, Batangas	4-A	Maibarara Geothermal Inc. (MGI)
HYDROELECTRIC							
Small Hydroelectric Plants							
BOTOCAN	Run-of-River type HEPP	22.8	22.0	3	Kalayaan, Laguna	4-A	Caliraya-Botocan-Kalayaan Power Company Ltd.
Mini Hydroelectric Plants							
AGUA-GRANDE	Run-of-River type HEPP	4.5	4.5	2	Pagudpod, Ilocos Norte	1	Ilocos Norte Electric Cooperative, Inc. (INEC)
BUHI-BARIT	Run-of-River type HEPP	1.8	1.8	1	Buhi, Camarines Sur	5	People's Energy Services, Inc. (PESI)
BULANAO HEPP	Run-of-River type HEPP	1.1	1.0	1	Tabuk, Kalinga	CAR	DPJ Engineers and Consultants
COMMUNAL-UDDIAWAN	Run-of-River type HEPP	1.8	1.8	2	Solano, Nueva Viscaya	2	Smith-Bell Mini-Hydro Corporation (SBMHC)
MAGAT A&B	Run-of-River type HEPP	2.5	0.6	7	Ramon, Isabela	2	Isabela I Electric Cooperative, Inc. (ISELCO 1)
Micro Hydroelectric Plants							
BALUGBOG	Run-of-River type HEPP	0.7	0.5	3	Nagcarlan, Laguna	4-A	Philippine Power and Development Company (PHILPODECO)
CALIBATO	Run-of-River type HEPP	0.06	0.06	1	San Pablo, Laguna	4-A	Philippine Power and Development Company (PHILPODECO)
CAWAYAN I	Run-of-River type HEPP	0.6	0.4	2	Guinlajon, Sorsogon City	5	Sunwest Water and Electric Company, Inc. - Sorsogon Electric Cooperative II (SUWECO-SORECO II)
INARIHAN	Run-of-River type HEPP	1.0	1.0	3	Panicuason, Naga City	5	Bicol Hydropower Corp.
PALAKPAKIN	Run-of-River type HEPP	0.4	0.3	1	San Pablo, Laguna	4-A	Philippine Power and Development Company (PHILPODECO)
SAN LUIS	Run-of-River type HEPP	0.8	0.6	2	San Luis, Aurora	3	EPower Technologies Corp.
BIOMASS							
MONTALBAN LFG	Landfill Gas Recovery System	8.2	4.1	9	Rodriguez, Rizal	4-A	Montalban Methane Power Corp.
PANGEA	Landfill Gas Recovery System	1.5	1.1	5	Payatas, Quezon City, M. Manila	NCR	Pangea Green Energy Phil., Inc.
SOLAR							
ARMENIA SOLAR	Ground Mounted Solar PVs	8.8	7.1		Barangay Armenia, Tarlac City, Tarlac	3	nv vogt Philippines Solar Energy Three, Inc. (nv vogt 3)
BULACAN III SOLAR	Ground Mounted Solar PVs	15.0	10.5		San Ildefonso, Bulacan	3	Bulacan Solar Energy Corporation

BURGOS SOLAR 1	Ground Mounted Solar PVs	4.2	4.2		Burgos, Ilocos Norte	1	EDC Burgos Wind Power Corporation (EBWPC)
BURGOS SOLAR 2	Ground Mounted Solar PVs	2.7	2.4		Burgos, Ilocos Norte	1	EDC Burgos Wind Power Corporation (EBWPC)
CABANATUAN SOLAR	Ground Mounted Solar PVs	10.3	9.1		Cabanatuan City, Nueva Ecija	3	First Cabanatuan Renewable Ventures, Inc.
CW HOME DEPOT SOLAR	Ground Mounted Solar PVs	1.7	1.2		CW Home Depot, Barangay Pulong, Sta. Rosa City, Laguna	4-A	CW Marketing & Development Corporation (CW)
DALAYAP SOLAR	Ground Mounted Solar PVs	7.5	5.9		Barangay Dalayap, Tarlac City, Tarlac	3	nv vogt Philippines Solar Energy Four, Inc. (nv vogt 4)
LIAN SOLAR	Ground Mounted Solar PVs	2.0	1.6		Lian, Batangas	4-A	Absolut Distillers Inc.
MAJESTIC	Rooftop Installed Solar PVs	41.3	33.0		CEZA, Rosario, Cavite	4-A	Majestic Power Corporation
MORONG SOLAR	Ground Mounted Solar PVs	5.0	3.5		Morong, Bataan	3	Just Solar Corporation (JSC)
PALAUIG SOLAR	Ground Mounted Solar PVs	5.0	3.5		Palauig, Zambales	3	Just Solar Corporation (JSC)
RASLAG SOLAR PH 1	Ground Mounted Solar PVs	10.0	8.0		Brgy. Suclaban, Mexico, Pampanga	3	RASLAG Corporation
RASLAG SOLAR PH 2	Ground Mounted Solar PVs	13.1	9.2		Brgy. Suclaban, Mexico, Pampanga	3	RASLAG Corporation
SAN RAFAEL SOLAR	Ground Mounted Solar PVs	3.8	2.7		San Rafael, Bulacan	3	Just Solar Corporation (JSC)
SARRAT SOLAR	Ground Mounted Solar PVs	0.9	0.7		Sarrat, Ilocos Norte	1	Bosung Solartec, Inc.
SPCRPI SM NORTH EDSA	Rooftop Installed Solar PVs	1.5	1.5		Quezon City, Metro Manila	NCR	Solar Philippines Commercial Rooftop Projects, Inc.
VALENZUELA SOLAR	Ground Mounted Solar PVs	8.5	8.5		Brgy. Isla, Valenzuela City	NCR	Valenzuela Solar Energy Inc.
WIND							
PILILIA WIND	Mountain Range-Installed Wind Turbine	54.0	54.0		Pililia, Rizal	4-A	Alternergy Philippine Holdings Corporation