

## **Chapter 2**

# **Estimation of Electricity Demand Distribution and Liquefied Natural Gas Demand**

To conduct a simulation of the delivery of LNG by ship to natural gas-fired power plants (GPPs), possible locations of the GPPs and LNG import terminals must be assumed. In this chapter, we envision electricity demand, the location of GPPs, and LNG demand in 2040. We use various sources of information, including the Transmission Development Plan and Port Statistics, to estimate the distribution of electricity demand for each province. Then we define the locations of GPPs and calculate the LNG demand for each GPP.

### **2.1 Electricity Demand Distribution by Grid**

First, we envisioned electricity demand of the regional grids – Luzon, Visayas, and Mindanao – in 2040. Table 2.1 presents gross electricity demand calculated based on peak demand, station use or own consumption, and transmission loss data obtained from the Power Development Plan 2016–2024.

### **2.2 Electricity Demand Distribution by Region**

Next, we envisioned electricity demand by region in 2040. We assume that the percentage share of total electricity demand of a certain region will be the same in 2040 as it was in 2015. Table 2.2 shows the estimated regional electricity demand in 2040.

**Table 2.1. Electricity Demand Distribution by Grid in 2040**

Grid	a Peak Demand (MW)	b SU/TL (%)	c=a*(1+b) Gross Peak Demand (MW)	d Load Factor (%)	e=c*d Gross Average Demand (MW)	f=e*24*365 Gross Electricity Demand (MWh)
Luzon	29,852	7.15	31,986	74.6	23,862	<b>209,029,962</b>
Visayas	9,210	5.88	9,752	71.6	6,982	<b>61,163,269</b>
Mindanao	10,225	3.84	10,618	72.6	7,708	<b>67,525,642</b>

MW = megawatt, MWh = megawatt-hour, SU/TL = station use/transmission losses.

Source: Government of the Philippines, Department of Energy (2016), *Power Development Plan 2016–2024*. Manila. Table 20: Grind Peak Demand Forecast, 2016–2040.

**Table 2.2. Electricity Demand Distribution by Region in 2040**

Grid	Region	g 2015 Electricity Sales (MWh)	h Share within Grid (%)	i 2040 Gross Electricity Demand by Grid (MWh)	j=i*h 2040 Gross Electricity Demand by Region (MWh)
Luzon	Metro Manila	23,967,048	46.2	209,029,962	<b>96,517,417</b>
	Cordillera	524,593	1.0		<b>2,112,582</b>
	Ilocos	1,943,746	3.7		<b>7,827,637</b>
	Cagayan Valley	1,088,391	2.1		<b>4,383,047</b>
	Central Luzon	5,514,639	10.6		<b>22,207,938</b>
	Calabarzon	16,888,957	32.5		<b>68,013,320</b>
	Mimaropa	647,674	1.2		<b>2,608,240</b>
	Bicol	1,330,932	2.6		<b>5,359,781</b>

Visayas	Western Visayas	1,579,353	18.4	61,163,269	<b>11,246,619</b>
	Central Visayas	4,601,673	53.6		<b>32,768,649</b>
	Negros Island	1,502,521	17.5		<b>10,699,496</b>
	Eastern Visayas	905,558	10.5		<b>6,448,505</b>
Mindanao	Zamboanga Peninsula	1,063,568	11.8	67,525,642	<b>7,961,924</b>
	Northern Mindanao	2,340,389	25.9		<b>17,520,270</b>
	Davao	3,067,712	34.0		<b>22,965,047</b>
	Soccsksargen	1,433,742	15.9		<b>10,733,065</b>
	Caraga	834,842	9.3		<b>6,249,669</b>
	Muslim Mindanao	279,943	3.1		<b>2,095,667</b>
	Philippines		100.0	337,718,874	<b>337,718,874</b>

MWh = megawatt-hour.

Source: Government of the Philippines, Department of Energy. Electricity sales.

### 2.3 Electricity Demand Distribution by Province

The electricity demand of each province is allocated according to the size of its population as of 1 July 2016. In other words, the provincial electricity demand is calculated by multiplying the regional electricity demand by the province's share of the population of the region. Table 2.3 provides the estimated result of provincial electricity demand in 2040.

**Table 2.3. Electricity Demand Distribution by Province in 2040: Luzon**

Region	Province	k	l	m	n=l*m
		Population As of 1 July 2016	Share within Region (%)	2040 Gross Electricity Demand by Region (MWh)	2040 Gross Electricity Demand by Province (MWh)

Metro		1,750,930	100	96,517,417	<b>96,517,417</b>
Manila					
Cordillera	Abra	243,731	13.9	2,112,582	<b>294,073</b>
	Apayao	121,377	6.9		<b>146,447</b>
	Benguet	804,975	46.0		<b>971,242</b>
	Ifugao	206,714	11.8		<b>249,411</b>
	Kalinga	216,511	12.4		<b>261,231</b>
	Mountain	157,622	9.0		<b>190,179</b>
Ilocos	Ilocos Norte	595,075	11.7	7,827,637	<b>916,895</b>
	Ilocos Sur	694,252	13.7		<b>1,069,708</b>
	La Union	793,088	15.6		<b>1,221,995</b>
	Pangasinan	2,997,806	59.0		<b>4,619,038</b>
Cagayan Valley	Batanes	17,535	0.5	4,383,047	<b>21,998</b>
	Cagayan	1,212,759	34.7		<b>1,521,415</b>
	Isabela	1,612,532	46.2		<b>2,022,933</b>
	Nueva Vizcaya	458,465	13.1		<b>575,148</b>
	Quirino	192,549	5.5		<b>241,554</b>
Central Luzon	Aurora	219,064	1.9	22,207,938	<b>428,360</b>
	Bataan	769,699	6.8		<b>1,505,077</b>
	Bulacan	3,343,157	29.4		<b>6,537,242</b>
	Nueva Ecija	2,174,419	19.1		<b>4,251,880</b>
	Pampanga	2,637,063	23.2		<b>5,156,539</b>
	Tarlac	1,379,600	12.1		<b>2,697,683</b>
	Zambales	834,176	7.3		<b>1,631,156</b>
Calabarzon	Batangas	2,757,358	18.7	68,013,320	<b>12,717,226</b>
	Cavite	3,754,702	25.5		<b>17,317,081</b>
	Laguna	3,099,964	21.0		<b>14,267,361</b>
	Quezon	2,185,282	14.8		<b>10,078,751</b>
	Rizal	2,949,391	20.0		<b>13,602,902</b>

Mimaropa	Occidental Mindoro	496,635	16.5	2,608,240	<b>429,093</b>
	Oriental Mindoro	859,665	28.5		<b>742,750</b>
	Marinduque	238,468	7.9		<b>206,036</b>
	Romblon	298,015	9.9		<b>257,485</b>
	Palawan	1,126,014	37.3		<b>872,876</b>
Bicol	Albay	1,335,680	22.6	5,359,781	<b>1,212,864</b>
	Camarines Norte	594,506	10.1		<b>539,841</b>
	Camarines Sur	1,989,172	33.7		<b>1,806,268</b>
	Catanduanes	266,321	4.5		<b>241,833</b>
	Masbate	908,231	15.4		<b>824,719</b>
	Sorsogon	808,606	13.7		<b>734,255</b>

MWh = megawatt-hour.

Source: Government of the Philippines, Department of Energy, Population.

**Table 2.4. Electricity Demand Distribution by Province in 2040: Visayas**

Region	Province	k	l	m	n=l*m
		Population As of 1 July 2016	Share within Region (%)	2040 Gross Electricity Demand by Region (MWh)	2040 Gross Electricity Demand by Province (MWh)
Western	Aklan	582,793	12.9	11,246,619	<b>1,446,076</b>
Visayas	Antique	593,149	13.1		<b>1,471,772</b>
	Capiz	768,965	17.0		<b>1,908,022</b>
	Guimaras	176,860	3.9		<b>438,840</b>
	Iloilo	2,410,811	53.2		<b>5,981,910</b>

Central Visayas	Bohol	1,336,079	21.8	32,768,649	<b>7,143,064</b>
	Cebu	4,695,311	76.6		<b>25,102,488</b>
	Siquijor	97,843	1.6		<b>523,097</b>
Negros Island	Negros Occidental	4,474,495	69.3	10,699,496	<b>7,413,005</b>
	Negros Oriental	3,100,095	30.7		<b>3,286,491</b>
Eastern Visayas	Biliran	175,761	4.1	6,448,505	<b>265,250</b>
	Eastern Samar	475,599	11.1		<b>717,752</b>
	Leyte	1,754,201	41.1		<b>2,647,360</b>
	Northern Samar	645,300	15.1		<b>973,857</b>
	Samar	792,633	18.6		<b>1,196,205</b>
	Southern Leyte	429,433	10.1		<b>648,081</b>

MWh = megawatt-hour.

Source: Government of the Philippines, Department of Energy, Population.

**Table 2.5. Electricity Demand Distribution by Province in 2040: Mindanao**

Region	Province	k	l	m	n=l*m
		Population As of 1 July 2016	Share within Region (%)	2040 Gross Electricity Demand by Region (MWh)	2040 Gross Electricity Demand by Province (MWh)
Zamboanga	Zamboanga del Norte	1,026,204	27.8	7,961,924	<b>2,215,374</b>
Peninsula	Zamboanga del Sur	1,026,855	27.8		<b>2,216,780</b>
	Zamboanga	1,520,457	41.2		<b>3,282,370</b>
	Sibugay City of Isabela	114,600	3.1		<b>247,399</b>

Northern	Bukidnon	4,755,277	30.1	17,520,270	<b>5,282,144</b>
Mindanao	Camiguin	1,433,657	1.9		<b>330,990</b>
	Lanao del Norte	89,836	21.8		<b>3,814,024</b>
	Misamis Occidental	1,035,186	12.8		<b>2,247,832</b>
	Misamis Oriental	1,586,501	33.4		<b>5,845,280</b>
Davao	Compostela Valley	749,009	16.3	22,965,047	<b>3,737,975</b>
	Davao del Norte	963,505	20.9		<b>4,808,431</b>
	Davao del Sur	2,362,043	51.3		<b>11,787,921</b>
	Davao Oriental	527,139	11.5		<b>2,630,720</b>
Soccskasargen	North Cotabato	1,404,340	30.4	10,733,065	<b>3,259,431</b>
	Sarangani	553,417	12.0		<b>1,284,464</b>
	South Cotabato	1,535,559	33.2		<b>3,563,986</b>
	Sultan Kudarat	826,349	17.9		<b>1,917,931</b>
	Cotabato City	304,723	6.6		<b>707,253</b>
Caraga	Agusan del Norte	704,419	26.6	6,249,669	<b>1,663,568</b>
	Agusan del Sur	717,617	27.1		<b>1,694,737</b>
	Surigao del Norte	492,228	18.6		<b>1,162,454</b>
	Surigao del Sur	602,445	22.8		<b>1,422,745</b>
	Dinagat Islands	129,642	4.9		<b>306,165</b>
Muslim	Basilan	355,230	9.2	2,095,667	<b>192,513</b>
Mindanao	Lanao del Sur	1,071,349	27.7		<b>580,606</b>
	Maguindanao	1,197,836	31.0		<b>649,154</b>
	Sulu	842,656	21.8		<b>456,668</b>
	Tawi-Tawi	399,911	10.3		<b>216,727</b>

MWh = megawatt-hour.

Source: Government of the Philippines, Department of Energy, Population.

## 2.4 Liquefied Natural Gas Demand by Grid

We envisioned LNG demand for power generation in each grid based on the assumptions listed in Tale 2.6.

**Table 2.6. Assumptions of Liquefied Natural Gas Demand Forecast**

- All the natural gas supply for power generation will come from liquefied natural gas. (There will be no domestic natural gas source in 2040.)
- No electricity will be imported in 2040.
- The share of natural gas in power generation will be 33.4% (business-as-usual scenario, ERIA Energy Outlook).
- The share of natural gas in power generation is same for all grids.
- The gross thermal efficiency of gas-fired power plants (GPPs) is 54% (business-as-usual scenario, ERIA Energy Outlook).
- The electricity own use of GPPs is 4% (net thermal efficiency of GPPs is 50%).

Source: Author.

## 2.5 Selection of Liquefied Natural Gas Terminals

We selected GPPs and LNG terminals according to (i) electricity demand by province, (ii) current and future transmission lines and location of substations, (iii) ideal power plant locations (with reference to the Transmission Development Plan), and (iv) the operational situation of ports (i.e. whether bulk fuels are unloaded).

### 2.5.1 Luzon grid

Electricity demand in the Luzon grid is concentrated in the National Capital Region, Metro Manila, and its vicinity. The Transmission Development Plan 2014–2015 states that San Manuel (300 megawatts [MW]), Muntinlupa (300 MW), and Malaya (300 MW) are ideal locations of power plants. However, these three locations are far from the coastline. Given the distribution of the Luzon grid's electricity demand, the fact that the island of Mindoro is currently off-grid but will be connected to the Luzon grid, and that connection with the Visayas grid through Mindoro is planned, it is preferable that new GPPs are constructed on the southern coastline of the Luzon grid.

LNG demand by grid in 2040 is shown in Table 2.7.

**Table 2.7. Liquefied Natural Gas Demand by Grid in 2040**

	$o$	$p=o*33.4\%$	$q=p/11630$	$r=q/50\%$	$s=r*1.047$	$t=s*0.735$
	<b>Net Electricity Generation</b>	<b>Allocated Natural Gas Power Generation</b>		<b>Required Natural Gas Input</b>		
<b>Region</b>	(MWh)	(MWh)	(ktoe)	(ktoe)	(Mcm)	('000 tonnes)
Luzon	209,029,962	69,816,007	6,003	12,006	12,570	9,239
Visayas	61,163,269	20,428,532	1,757	3,513	3,678	2,703
Mindanao	67,525,642	22,553,564	1,939	3,879	4,061	2,985
<b>Philippines</b>	<b>337,718,874</b>	<b>112,798,104</b>	<b>9,699</b>	<b>19,398</b>	<b>20,309</b>	<b>14,927</b>
Mindanao	10,225	3.84	10,618	72.6	7,708	<b>67,525,642</b>

ktoe = thousand tonnes of oil equivalent, Mcm = million cubic metres, MWh = megawatt-hour.

Notes: Net electricity generation = gross electricity demand. Conversion factors are as follows.

1 toe = 11,630 kWh (1kWh = 859.845kcal), 1 ktoe = 1.047 Mcm (40 megajoules/cubic metre)

1,000 tonne of liquefied natural gas = 0.735 Mcm.

Source: Author.

The Luzon grid's LNG demand in 2040 is estimated to exceed 9 million tonnes annually. This volume is too large for one LNG terminal to handle. Therefore, considering the locations and sizes of ports and locations of substations, we envisioned a scenario in which, in the case of the Luzon grid, the amount LNG received would be distributed amongst the ports of Batangas, Limay, and Pagbilao (Figure 2.1, Table 2.8).

We allocated LNG demand equally amongst the three GPPs. Each GPP will consume more than 3 million tonnes annually, which is a volume that can be handled by a primary LNG terminal (LNG import terminal). Accordingly, it is thought that developing the Luzon grid's three LNG import terminals to provide a dedicated supply of regasified natural gas to their respective nearby GPP would be effective. (There would be no LNG supply to other secondary LNG terminals.)

LNG delivery would take place entirely within the Luzon grid, without any secondary LNG transaction between other grids. Thus, we exclude small-scale LNG delivery in the Luzon grid in this study.

### **2.5.2 Visayas grid**

The Transmission Development Plan 2014–2015 states that Calbayog (100 MW), Babatngon (100 MW), Daanbantayan (100 MW), Compostela (200 MW), Maasin (100 MW), and Bohol (100 MW) (a total of 700 MW) are ideal locations for power plants. However, these six locations are far from ports. Within the Visayas grid, Cebu has the largest electricity demand. This makes it preferable to locate GPPs in or near Cebu to reduce electricity transmission loss. Considering the locations and sizes of ports and the locations of substations, we envisioned a scenario in which GPPs would be constructed at Cebu, Tagbilaran, and Tacloban in the Visayas grid (Figure 2.2, Table 2.8).

We allocated three-sevenths of LNG demand to Cebu and two-sevenths each to Tagbilaran and Tacloban.

### **2.5.3 Mindanao grid**

The Transmission Development Plan 2014–2015 states that Placer (100 MW), Auropa (100 MW), Pitogo (100 MW), Tacurong (100 MW), and Bislig (100 MW) (a total of 500 MW) are ideal locations for power plants. The Mindanao grid's electricity demand is more dispersed than that of the Luzon and Visayas grids. Therefore, considering the ideal locations of power plants, locations and sizes of ports, and locations of substations, we envisioned a scenario in which GPPs would be constructed at Zamboanga, Iligan, Bislig, Surigao, and General Santos in the Mindanao grid (Figure 2.2). We allocated 20% of LNG demand to each GPP (Table 2.8).

**Table 2.8. Liquefied Natural Gas Demand by Secondary Liquefied Natural Gas Terminal in 2040**

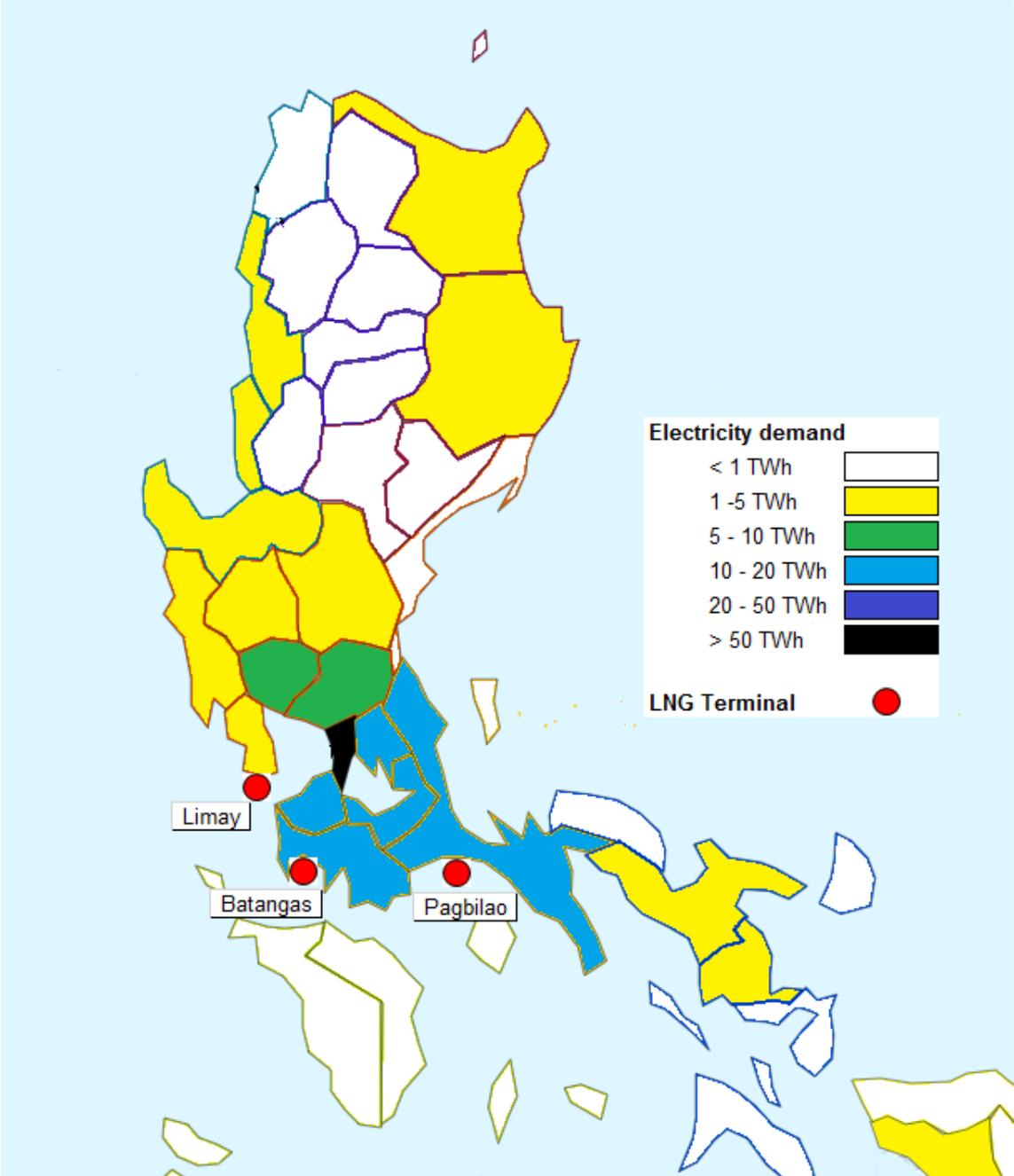
<b>Grid</b>	<b>Terminal</b>	<b>Liquefied Natural Gas Demand (‘000 tonnes)</b>	<b>Required Generation Capacity* (megawatts)</b>
Luzon	Batangas	3,080	13,257
	Limay	3,080	13,257
	Pagbilao	3,080	13,257
	<b>Subtotal</b>	<b>9,240</b>	<b>39,770</b>
Visayas	Cebu	1,159	4,990
	Tagbilaran	772	3,324
	Tacloban	772	3,324
	<b>Subtotal</b>	<b>2,703</b>	<b>11,637</b>
Mindanao	Zamboanga	597	2,569
	Iligan	597	2,569
	Bislig	597	2,569
	Surigao	597	2,569
	General Santos	597	2,569
	<b>Subtotal</b>	<b>2,985</b>	<b>12,847</b>
<b>Philippines</b>		<b>14,927</b>	<b>64,257</b>

\* Calculated using a capacity factor of 60%.

Source: Author.

Figure 2.1. Electricity Demand by Province and Location of Liquefied Natural Gas Terminal:

Luzon

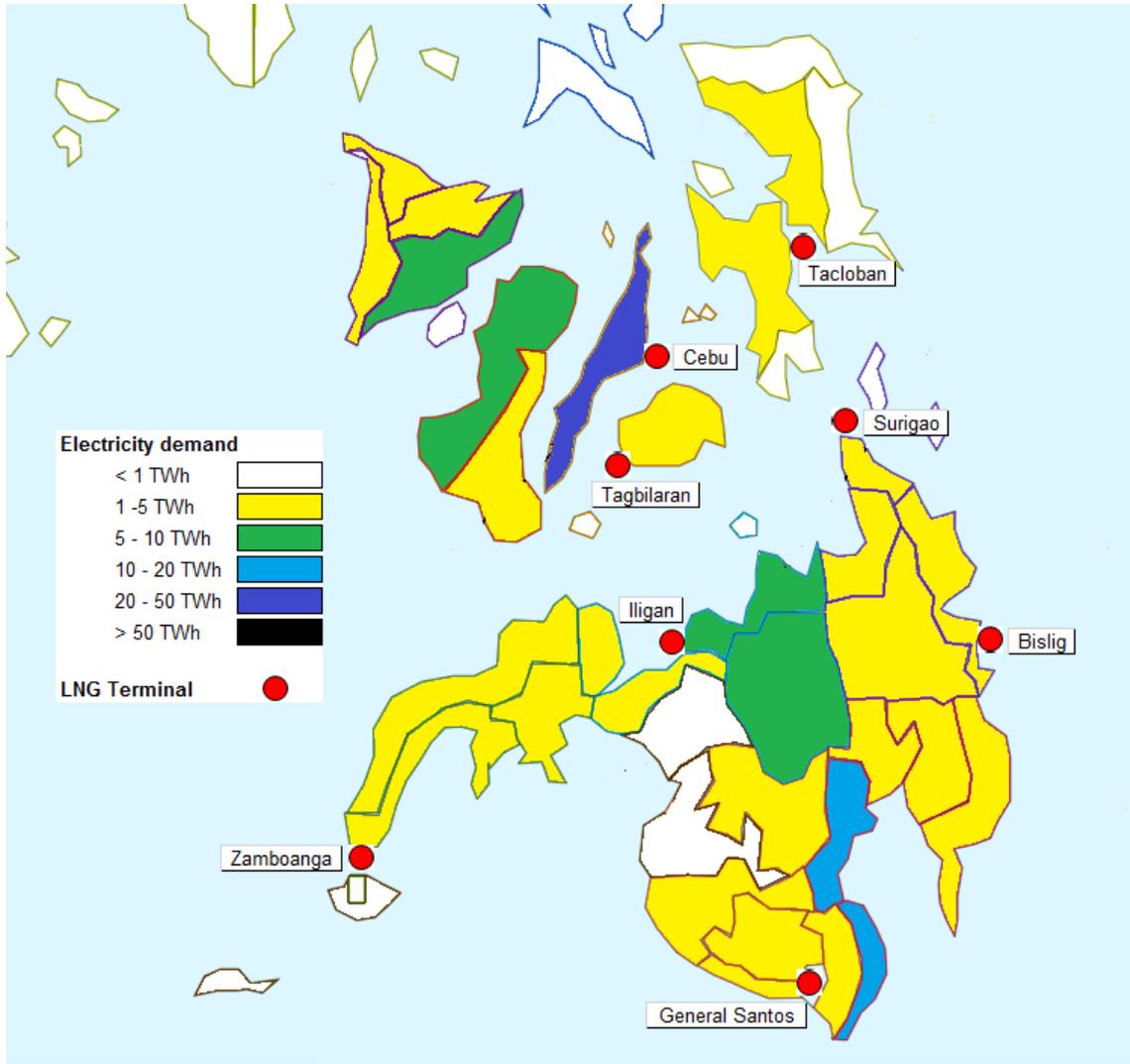


LNG = liquefied natural gas, TWh = terawatt-hour.

Source: Author.

Figure 2.2. Electricity Demand by Province and Location of Liquefied Natural Gas Terminal:

Visayas and Mindanao



LNG = liquefied natural gas, TWh = terawatt-hour.

Source: Author.