



Parsons Brinckerhoff Associates

**OPTIMISATION OF
ASSETS OF MERALCO**

CONFIDENTIAL

**FOR
ERC & MERALCO**

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EXECUTIVE SUMMARY

1. Background & Objectives

The objective of this report is to propose adjustments to the Meralco ODRC asset register, in accordance with the principles espoused in the ERC Asset Valuation Guidelines. Optimisation adjustments that are validated will be made as a single entry, transparent adjustment to the ODRC register.

2. Approach

Optimization must be undertaken in accordance with Section 4.1.8 of the ERC Position Paper - Regulatory Reset for the Privately Owned Distribution Utilities Subject to Performance Based Regulation (PBR) for July 2007 to June 2011, whereby the load at the end of a planning horizon period is tested against the planned firm (N-1) capacity of assets.

In practice optimization is carried out in accordance with the following principles:

- a) Exclude stranded assets;
- b) Optimize the configuration of the network;
- c) Optimize the capacity of elements in the network;
- d) Optimize network engineering; and
- e) Optimize stores and spares.

3. Conclusions

After due consideration of the available data, PB Associates recommends that the ERC adopts the following amounts of optimisation for Meralco for purposes of an asset valuation:

Table 1 Proposed MERALCO Optimisation

DWRG Category		Optimization (Pesos)
A3	Station Equipment	
A3A	Power Transformers	0
A3B	Switchgear	659,677,151
A3C	Protective Equipment	0
A3D	Metering & Control	0
A3E	Communications Equipment	0
A3F	Other Substation Equipment	0
A4 & A5	Poles, Towers & Fixtures	0
A6 & A7	Overhead Conductors & Devices	0
A8 & A9	Underground Conduits	0

DWRG Category		Optimization (Pesos)
A10 & A11	Underground Conductors & Devices	0
A12 & A13	Line Transformers	0
A14	Power Conditioning Equipment	0
A15	Services	0
A16 & A17	Meters, Instruments & Metering Transformers	10,561,217,945
A20	Streetlights & Signalling	0

PB Associates finds that there is no case for optimization of network spares.

Surplus land and buildings are identified under a separate report prepared by Asian Appraisals CI.

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1. INTRODUCTION

1.1 MERALCO NETWORK

Meralco receives power at 230 kV and 115 kV at 11 major delivery points, and at distribution voltage level at various minor delivery points.

The majority of power is sourced from the National Power Corporation (NPC) and four independent power producers – Quezon Power Philippines, Duracom, Sta Rita and San Lorenzo.

From the delivery points, electricity is distributed through a sub-transmission network to major distribution substations throughout the supply area. This network operates at 115 kV and 69 kV and consists of approximately 727 km of lines.

The company operates 6 sub-transmission substations and 67 major distribution (with 128 power transformers) and 44 distribution substations. The total substation capacity of the major substations is 9,421 MVA.

At the distribution substations, voltage is converted to various distribution levels including 34.5, 13.8, 6.24 and 4.8 kV.

Electricity is conveyed through a primary distribution network of approximately 13,689 km predominantly overhead lines, and some underground cables.

A total of 146,252 distribution line transformers are used in the network to convert the distribution voltage levels to low voltage (230 V single phase or 460 V three-phase). Total line transformer capacity is 11,152 MVA.

1.2 ERC OPTIMISATION PRINCIPLES

Optimization of the network proceeds in two parts:

System Optimization – the system is reconfigured resulting in a lower value network with no loss of adequacy, security or reliability; and

Network Optimization – components of the network are replaced with components of a lower value with no loss of adequacy, security or reliability.

In practice, care must be taken to ensure that the optimization process does not result in a breach of the service levels stipulated under the Grid and Distribution Codes.

Furthermore, optimization must be undertaken in accordance with Section 4.1.8 of the ERC Position Paper - Regulatory Reset for the Privately Owned Distribution Utilities Subject to Performance Based Regulation (PBR) for July 2007 to June 2011, whereby the load at the end of a planning horizon period is tested against the planned firm (N-1) capacity of assets.

As the load peak in the Philippines occurs in summer prior to 30 June, and the effective date of commencement of the regulatory reset period is 30 June 2007,

the planning horizon commences from year 2008. Accordingly, for forecasting purposes the end of the planning horizon is as follows:

Table 2: ERC Specified Planning Horizons

Network Components	Planning Horizon	Forecasting Year for End of Planning Horizon
<ul style="list-style-type: none"> • Sub-transmission lines • Substations (excluding transformers) • Primary distribution circuits¹ • Points of connection to transmission network 	15 years	2022
<ul style="list-style-type: none"> • Substation Transformers 	10 years	2017
<ul style="list-style-type: none"> • Distribution Line Transformers² • Secondary distribution circuits • Low voltage network • Other distribution assets 	5 years	2012

1.3 REPORT STRUCTURE

This report comprises four sections:

Section 1 comprises this Introduction;

Section 2 contains proposals for optimising the assets of Meralco by DWRG asset category;

Section 3 examines and proposes spares optimisation; and

Section 4 provides a verification of the robustness of Meralco's load forecasting.

¹ PB Associates considers primary distribution circuits to be primarily used for load transfer / backup purposes, or for supply to dedicated customer substations, even though in some cases there are connected line transformers supplying customers.

² PB Associates has included a 5 year planning horizon for line transformers in accordance with international regulatory practice in other jurisdictions for distribution transformers.

2. OPTIMISATION BY DWRG CATEGORY

2.1 SUBTRANSMISSION OPTIMISATION

Network Optimisation - Grid Exit Points (GXP)

Optimisation of GXPs is performed by removing GXPs one at a time, and determining whether load can be supplied by alternative supply sources e.g. by an adjacent GXP or by substations in the area.

The load that is considered is the load at the end of the 15 year planning horizon.

The eleven (11) GXPs supplying Meralco's network are shown in the following table:

Table 3: GXP Network Configurations

Name	Capacity (A)	2012 (A)	Utilization	2017 (A)	Utilization	2022 (A)	Utilization
Zapote Bk 1	753	671	89%	558	74%	708	94%
Zapote Bk 2	753	673	89%	559	74%	710	94%
Zapote Bk 3	753	564	75%	469	62%	595	79%
Dolores Bk 1	753	595	79%	736	98%	876	116%
Dolores Bk 2	753	602	80%	745	99%	887	118%
Dolores Bk 3	753	601	80%	743	99%	886	118%
Dolores Bk 4	753	449	60%	625	83%	746	99%
Sucacat Bk 1	753	625	83%	344	46%	512	68%
Sucacat Bk 2	753	625	83%	333	44%	498	66%
Sucacat Bk 3	753	622	83%	333	44%	498	66%
Araneta Bk 1	753	695	92%	853	113%	964	128%
Araneta Bk 2	753	705	94%	859	114%	970	129%
Araneta Bk 3	753	700	93%	846	112%	957	127%
Balintawak Bk 1	753	665	88%	837	111%	944	125%
Balintawak Bk 2	753	656	87%	825	110%	931	124%
Balintawak Bk 3	753	654	87%	823	109%	929	123%
Duhat Bk 1	753	571	76%	729	97%	849	113%
Duhat Bk 2	753	578	77%	737	98%	859	114%
Dasmarinas Bk 1	753	580	77%	663	88%	817	108%
Dasmarinas Bk 2	753	567	75%	648	86%	799	106%
Binan Bk 1	251	141	56%	151	60%	207	82%
Binan Bk 2	251	141	56%	152	61%	207	82%
Binan Bk 3	753	341	45%	442	59%	603	80%
Sta. Rosa Bk 1	753	532	71%	575	76%	754	100%
Calauan Bk 1	377	183	49%	264	70%	278	74%
Calauan Bk 2	377	172	46%	248	66%	262	70%
Malolos Bk 1	377	151.0	40%	176	47%	240	64%
Malolos Bk 2	377	151.0	40%	176	47%	240	64%

The table shows that at the end of the 15 year planning horizon, there is no spare capacity at any of the GXPs.

As discussed further in Section 0, there is also no spare capacity at adjacent substations that could accommodate the removal of any existing GXP supply point.

PB Associates has determined that GXP supply points cannot be optimised.

Network Optimisation - Subtransmission Lines

Optimisation of the subtransmission network begins with the 115 kV and 69 kV subtransmission overhead lines.

In this case the ratings of the line are determined by the conductor sizes employed by Meralco.

The conductor configuration and sizes of 115kV and 69kV overhead conductors are as follows:

Table 4: Existing Zone Substations of the Meralco System

Voltage	Conductor	Conductor Configuration	Theoretical Rating
115 kV	2 x 795 MCM ASCR	3-phase, Single Circuit, Twin Conductor	343 MVA
115 kV	1 x 795 MCM ASCR	3-phase, Single Circuit, Single Conductor	171 MVA
69 kV	1 x 795 MCM ASCR	3-phase, Single Circuit, Single Conductor	108 MVA
69kV	1 x 336.4 MCM ACSR	3-phase, Single Circuit, Single Conductor	63MVA

Meralco reported that subtransmission lines are planned and designed to operate under N-1 reliability criteria with 40 – 60% loading criteria under normal operating conditions. With consideration of the N-1 planning criterion, PB Associates has made a test comparison of 50% of the theoretical line (conductor) rating against the peak load at the end of the 15 year planning horizon.

Table 4 below lists the subtransmission lines included in the test and the results in terms of spare capacity at the end of the planning horizon. There are no projects included in the planning horizon.

Subtransmission lines that do not achieve a peak load greater than the 50% threshold on theoretical rating will qualify to be considered for a reduction of the line capacity.

However, the standard line amperages are 530A, 900A and 1800A. This means that optimisation targets for these lines will be 1800A – 50%, 900A – 50% and for the 530A rating there is no smaller size (mechanical considerations require a minimum size conductor).

Table 5: Utilisation Forecast for Subtransmission Lines

Subtransmission Line	Capacity (A)	2012 (A)	Util'n	2017 (A)	Util'n	2022 (A)	Util'n
Malaya-Kalayaan-Caliraya	530	-	0%	-	0%	-	0%
Malaya-Teresa	1,800	-	0%	-	0%	-	0%
San Pedro-Pamplona	900	-	0%	-	0%	-	0%
Sta. Maria-Bocau	1,800	20	1%	75	4%	53	3%
Navotas-Grace Park	1,800	124	7%	90	5%	88	5%
Carmelray-Canlubang	1,800	40	2%	143	8%	103	6%
Gardner-BF Paranaque	1,800	462	26%	323	18%	112	6%
Sta. Rosa-LIIP	1,800	15	1%	37	2%	121	7%
Rockwell-Hillcrest	1,800	153	9%	392	22%	148	8%
Tutuban-Tegen	1,800	43	2%	22	1%	148	8%
Kamuning-Diliman	1,800	160	9%	194	11%	174	10%
Masinag-Marikina	1,800	163	9%	163	9%	210	12%
Shangrila-Mandaluyong	1,800	88	5%	167	9%	210	12%
Pamplona-Alabang	1,800	506	28%	135	8%	219	12%
Meycauayan-Novaliches	1,800	148	8%	254	14%	277	15%
Botocan-Caliraya	480	46	10%	26	5%	75	16%
Meycauayan-Bagbaguin	530	29	5%	75	14%	85	16%
Malabon-Navotas	1,800	124	7%	92	5%	300	17%
Zapote-BF Paranaque	1,800	722	40%	281	16%	316	18%
LISP-Carmelray	1,800	211	12%	177	10%	320	18%
Diliman-Novaliches	1,800	237	13%	278	15%	348	19%
Bacoor-Imus	1,800	247	14%	316	18%	405	23%
Masinag-Parang	1,800	239	13%	329	18%	420	23%
Hillcrest-Mandaluyong	1,800	223	12%	443	25%	456	25%
Dolores-Teresa	1,800	308	17%	383	21%	490	27%
Malolos-Tabang	900	150	17%	183	20%	249	28%
Kamuning-Cubao	1,800	299	17%	402	22%	513	29%
North Port-Tegen	960	152	16%	184	19%	296	31%
Legaspi-Kamagong-Paco	1,800	359	20%	462	26%	596	33%
Calauan-San Pablo II	900	189	21%	241	27%	301	33%
Bagbaguin-Kaybiga	1,800	422	23%	560	31%	645	36%
North Port-Grace Park	1,800	442	25%	562	31%	685	38%
Cubao-Hillcrest	1,800	585	33%	565	31%	712	40%
Sta. Rosa-LISP	1,800	459	26%	488	27%	739	41%
Sucat-Alabang	1,800	176	10%	701	39%	781	43%
TransCo Tayabas-Tayabas	900	223	25%	357	40%	394	44%
Cainta-Capasco	530	156.0	29%	183	35%	234	44%
Urdaneta-Rockwell	1,800	405	23%	753	42%	797	44%
Balibago-Canlubang	900	283	31%	258	29%	417	46%
Cainta-Marikina	1,800	545	30%	691	38%	853	47%

Subtransmission Line	Capacity (A)	2012 (A)	Util'n	2017 (A)	Util'n	2022 (A)	Util'n
NAIA-Malibay	1,800	472	26%	765	43%	875	49%
Duhat-Sta. Maria	1,800	661	37%	761	42%	884	49%
North Port-Tutuban	1,800	539	30%	692	38%	921	51%
Rockwell-Kamagong	1,800	485	27%	692	38%	922	51%
Malolos-Calumpit	900	322	36%	348	39%	473	53%
Bocause-Malinta	900	249	28%	442	49%	484	54%
Balintawak-Diliman	1,800	650	36%	809	45%	980	54%
Dolores-Masinag	1,800	632	35%	824	46%	982	55%
Binan-San Pedro	900	299	33%	377	42%	494	55%
FCIE-SMC-Gateway	900	372	41%	381	42%	502	56%
Balibago-LIIP	900	323	36%	383	43%	508	56%
Malibay-Legaspi	1,800	698	39%	830	46%	1,041	58%
Balintawak-Malinta	1,800	750	42%	913	51%	1,048	58%
Balintawak-Bagbaguin	1,800	748	42%	915	51%	1,072	60%
Malinta-Malabon	1,800	684	38%	945	53%	1,084	60%
Sta. Mesa-North Port	1,800	973	54%	1,240	69%	1,094	61%
Sunvalley-NAIA	1,800	652	36%	991	55%	1,122	62%
Marikina-Cubao	1,800	880	49%	942	52%	1,155	64%
Malolos-Baliwag	900	328	36%	417	46%	583	65%
Kaybiga-Novaliches	530	45	8%	38	7%	348	66%
Taguig-Rockwell	1,800	647	36%	1,115	62%	1,204	67%
Araneta-Sta. Mesa-Rockwell	1,600	836	52%	875	55%	1,123	70%
Duhat-Meycauyan	1,800	732	41%	1,074	60%	1,268	70%
Duhat-Bocause	1,800	914	51%	1,114	62%	1,284	71%
Dolores-Shangrila	1,800	918	51%	1,063	59%	1,287	72%
Los Banos-FPIP-Canlubang	900	405	45%	643	71%	677	75%
Sta. Mesa-Tegen	1,800	1,060	59%	1,340	74%	1,382	77%
Dolores-St. Anthony-Manggahan-Marikina	1,800	979	54%	1,226	68%	1,462	81%
Binan-CIGI-Balibago	1,800	925	51%	1,085	60%	1,503	84%
Balintawak-North Port-Duracom	1,800	949	53%	1,192	66%	1,629	91%
Calauan-Los Banos	900	508	56%	764	85%	831	92%
Zapote-Pamplona-Bacoor	1,800	1,437	80%	1,262	70%	1,691	94%
Araneta-Kamuming	1,600	958	60%	1,215	76%	1,511	94%
Araneta-Sta. Mesa L1	1,600	1,170	73%	1,468	92%	1,573	98%
Araneta-Sta. Mesa L2	1,600	1,170	73%	1,468	92%	1,573	98%
Dasmarinas-FCIE	900	653	73%	718	80%	931	103%
CBP-Malibay	1,800	1,388	77%	1,546	86%	1,875	104%
Gardner-Urdaneta	1,800	1,151	64%	1,745	97%	1,952	108%
Gardner-Taguig	1,800	1,186	66%	1,750	97%	1,973	110%
Dolores-Cainta	1,800	1,370	76%	1,726	96%	2,040	113%
Sucut-Sunvalley	1,800	1,218	68%	1,781	99%	2,111	117%
Zapote-CBP	1,800	1,677	93%	1,770	98%	2,137	119%

The orange shaded represent subtransmission lines that are candidates for optimization. The second step in the optimization process is to examine the N-1 redundancy for outage of adjacent subtransmission lines or power transformers.

Loss of such facilities will potentially increase the subtransmission line loading substantially.

Table 6: Utilisation Forecast for Subtransmission Lines

Subtransmission Line	Capacity (A)	2022 (A)	Util'n	Outage Scenario	New Util'n
Malaya - Teresa	1,800	-	0%	Outage of Dolores-Malaya 230 kV lines	277%
San Pedro - Pamplona	900	-	0%	Outage of Binan-San Pedro	59%
Sta. Maria- Bocaue	1,800	53	3%	Outage of Duhat-Bocaue	63%
Navotas - Grace Park	1,800	88	5%	Outage of Malabon-Malinta	65%
Carmelray - Canlubang	1,800	103	6%	Outage of Sta. Rosa-LISP	53%
Gardner - BF Paranaque	1,800	112	6%	Outage of Sucat-Alabang	54%
Sta. Rosa - LIIP	1,800	121	7%	Outage of Binan-Balibago	56%
Rockwell - Hillcrest	1,800	148	8%	Outage of Araneta-Rockwell line	75%
Tutuban -Tegen	1,800	148	8%	Outage of Sta. Mesa-Tegen	54%
Kamuning - Diliman	1,800	174	10%	Outage of Marikina-Cubao	54%
Masinag - Marikina	1,800	210	12%	Outage of Dolores-Cainta	63%
Shangrila - Mandaluyong	1,800	210	12%	Outage of Dolores-Shangrila	76%
Pamplona - Alabang	1,800	219	12%	Outage of Sucat-Alabang	59%
Meycauayan - Novaliches	1,800	277	15%	Outage of San Jose-Novaliches	77%
Malabon - Navotas	1,800	300	17%	Outage of Malabon-Malinta	63%
Zapote - BF Paranaque	1,800	316	18%	Outage of Zapote-CBP	60%
LISP - Carmelray	1,800	320	18%	Outage of Calauan-Los Banos	59%
Diliman - Novaliches	1,800	348	19%	Outage of Balintawak-Bagbaguin	53%
Bacoor - Imus	1,800	405	23%	Outage of Dasmarias-Rosario line	99%
Masinag - Parang	1,800	420	23%	Outlet of proposed San Mateo Delivery Point Substation	23%
Hillcrest - Mandaluyong	1,800	456	25%	Outage of Dolores-Shangrila	102%
Dolores - Teresa	1,800	490	27%	Outage of	67%

Subtransmission Line	Capacity (A)	2022 (A)	Util'n	Outage Scenario	New Util'n
				Dolores-Malaya lines	
Malolos - Tabang	900	249	28%	Outage of Malolos-Calumpit	80%
Kamuning - Cubao	1,800	513	29%	Outage of Marikina-Cubao	62%
North Port - Tegen	960	296	31%	Outage of Sta. Mesa-Tegen	94%
Legaspi-Kamagong - Paco	1,800	596	33%	Base load with project	65%
Calauan - San Pablo II	900	301	33%	Outage of TransCoTayabas-Tayabas	87%
Bagbaguin - Kaybiga	1,800	645	36%	Outage of Novaliches-Kaybiga	50%
North Port - Grace Park	1,800	685	38%	Outage of Malabon-Malinta	98%
Cubao - Hillcrest	1,800	712	40%	Outage of Dolores-Shangrila	86%
Sta. Rosa - LISP	1,800	739	41%	Outage of Calauan-Los Banos	69%
Sucat - Alabang	1,800	781	43%	Outage of Zapote-Bacoor-Pamplona	99%
TransCo Tayabas -Tayabas	900	394	44%	Outage of Calauan-Los Banos	87%
Urdaneta - Rockwell	1,800	797	44%	Outage of Garder-Taguig	92%
Balibago - Canlubang	900	417	46%	Outage of Sta. Rosa-LISP	125%
Cainta - Marikina	1,800	853	47%	Outage of Dolores-Masinag	83%
NAIA - Malibay	1,800	875	49%	Outage of Zapote-CBP	100%
Duhat - Sta. Maria	1,800	884	49%	Outage of Duhat-Bocaue	110%

The table shows that at the end of the 15 year planning horizon there is only one subtransmission line that is not expected to achieve the required utilization.

PB Associates has determined that the Masinag-Parang subtransmission line should be optimised to a 900A rating.

However, the cost difference between a 795 and 336.4MCM conductored line at the same voltage is equal to the conductor cost and this is a relatively small amount. In this case the cost difference between these two conductors is approximately 150 Peso per metre. An average circuit length of 10 km results in a total optimization amount of around Php1,500,000.

PB Associates considers that this optimization amount is not material to the valuation, and does not propose to optimise this circuit to a lower rating.

System Optimisation – Subtransmission

Following consideration of equipment optimisation of the GXP's and subtransmission lines, the subtransmission system is now considered holistically.

In this regard PB Associates tests for security levels greater than N-1.

The standard configuration is described in terms of planning principles as follows:

- (a) 220 / 115kV substations are designed with minimum 2 x 300MVA or 2 x 150MVA transformers as the standard design. Therefore in this substation group, based on the N-1 reliability criteria, the substation has the firm capacity of 300MVA or 150MVA respectively.
- (b) 115 / 34.5kV substations are designed with 2 x 83MVA transformers as the standard design. The substation will have 83MVA firm capacity under the N-1 reliability criteria. Also, on the 34.5kV side of the substation, 8 x 800A rated outgoing circuits are normally supplied.
- (c) 115 / 13.8kV standard substation design contains 2 x 33MVA power transformers. In this design, these substations will have a firm capacity of 33MVA under normal parallel operation with N-1 supply reliability level. The substation will provide 8 x 800A 13.8kV outgoing feeders to the distribution network.

Meralco also has a relatively small number of 69kV subtransmission networks – the total number of 69 kV substations is eight.

- (a) 220 / 69kV substations are designed with 2 x 150MVA transformers as the standard design, allowing 150MVA firm capacity when operating parallel under the N-1 reliability level.
- (b) 69 / 13.8kV standard substation design contains 2 x 33MVA power transformers. These substations will have a firm capacity of 33MVA under normal parallel operation with N-1 supply reliability level. The substation will provide 8 x 300A 13.8kV outgoing feeders to the distribution network.

Overall PB Associates finds that the system configuration is designed in an optimal manner with regard to both system adequacy and security.

2.2 SUBSTATIONS

Network Optimisation – Power Transformers

In general terms, optimisation of substations is performed by comparing the firm capacity of the substation against the load at the end of a 10 year planning horizon.

The standard transformer sizes in use are as follows:

220 / 115 kV Substations	150 MVA and 300 MVA
220 / 69 kV Substations	150 MVA
115 / 34.5 kV Substations	83 MVA
115 / 13.8 kV Substations	33 MVA
69 / 13.8 kV Substations	33 MVA

PB Associates has assessed the power transformers using a loading criterion specified in the ERC Asset Valuation Guidelines viz a viz an N-1 loading criterion of 70% of installed capacity under normal operating conditions. With consideration of the N-1 planning criterion, PB Associates has made a test comparison of this criterion against the peak load at the end of the 10 year planning horizon.

Table 5 below lists the substations included in the test and the results in terms of spare capacity at the end of the planning horizon. Substations that do not achieve a peak load greater than the 70% threshold of installed capacity qualify to be considered for a reduction of the substation capacity to smaller standard transformer size.

Table 7: Power Transformers

Substation Name	Bank No	Maximum Continuous MVA 2006	UTILIZATION 2017	
			MW	%
BALIBAGO	1	100.00	89.43	90.89%
B. F. PARANAQUE	1	83.00	68.92	84.40%
BOTOCAN	5	33.30	27.18	101.62%
CANLUBANG	1	83.00	109.12	133.63%
CANLUBANG	2	83.00	74.47	91.19%
DASMARINAS (NPC owned)	1	83.00	52.42	70.09%
DASMARINAS (NPC owned)	2	50.00	34.95	77.56%
FCIE	1	83.00	55.33	71.98%
FCIE	2	83.00	54.24	70.55%
FPIP	1	83.00	60.19	73.70%
GARDNER	1	83.00	58.80	71.83%
GARDNER	2	83.00	61.20	74.76%
GATEWAY	1	83.00	59.22	72.51%
GEN. M. ALVAREZ	1	83.00	82.27	99.77%
LIIP	1	83.00	79.36	97.18%

Substation Name	Bank No	Maximum Continuous MVA 2006	UTILIZATION 2017	
			MW	%
PAMPLONA	1	100.00	70.02	71.17%
PAMPLONA	2	83.00	57.63	70.57%
SAN PABLO II	1	83.00	66.86	81.87%
SAN PEDRO	1	83.00	77.90	95.39%
STA. ROSA II	1	50.00	41.91	83.88%
STA. ROSA II	3	83.00	95.45	115.08%
SUNVALLEY	1	83.00	72.75	89.08%
SUNVALLEY	2	83.00	75.90	92.94%
TAYABAS	1	83.00	72.20	87.92%
TRECE MARTIREZ II	1	83.00	60.19	73.83%
BALINTAWAK	4	83.00	66.51	80.22%
BALINTAWAK	5	133.00	94.03	70.78%
BALINTAWAK	6	83.00	68.80	82.98%
CAINTA	1	83.00	72.99	89.38%
CAINTA	2	83.00	93.49	114.48%
CUBAO	1	83.00	70.66	86.53%
CUBAO	2	83.00	73.74	90.29%
DILIMAN	1	83.00	72.61	88.92%
DILIMAN	2	83.00	59.41	72.75%
DOLORES	1	100.00	92.10	94.66%
KAMAGONG	1	83.00	57.24	70.09%
KAMAGONG	2	83.00	58.40	71.51%
KAMUNING	1	83.00	82.83	101.43%
KAMUNING	2	83.00	70.18	85.94%
MALAYA	1	33.33	28.39	86.39%
MALIBAY	1	100.00	83.37	84.74%
MALIBAY	2	133.00	104.56	79.90%
MALIBAY	3	83.00	60.82	74.48%
MANDALUYONG	2	83.00	74.50	91.23%
MANGGAHAN	1	83.00	73.41	89.90%
MARIKINA	1	83.00	62.32	76.32%
MARIKINA	2	133.00	93.48	71.44%
MASINAG	1	83.00	79.72	97.62%
NEW TERESA	1	83.00	87.97	107.73%
NORTH PORT	1	83.00	68.12	83.42%
NORTH PORT	2	83.00	59.33	72.66%
NORTH PORT	6	133.00	92.30	70.53%
ROCKWELL CENTER	1	83.00	59.79	73.21%
ROCKWELL CENTER	2	83.00	63.45	77.69%
ROCKWELL CENTER	3	83.00	62.23	76.20%
ROCKWELL CENTER	4	83.00	58.57	71.71%
SM - SHANGRILA	1	83.00	70.68	86.55%
SM - SHANGRILA	2	83.00	98.04	120.06%
SM - SHANGRILA	3	83.00	59.28	72.59%
ST. ANTHONY	1	25.00	8.70	37.66%
STA. MESA	1	133.00	108.50	82.91%
STA. MESA	5	83.00	82.95	101.58%
STA. MESA	7	83.00	57.66	70.61%
TAGUIG	1	100.00	74.14	75.36%

Substation Name	Bank No	Maximum Continuous MVA 2006	UTILIZATION 2017	
			MW	%
TAGUIG	2	83.00	75.47	92.42%
TEGEN	3	133.00	135.54	103.15%
TEGEN	6	100.00	112.22	113.59%
TEGEN	7	83.00	90.07	109.84%
TUTUBAN	1	83.00	64.67	79.19%
TUTUBAN	2	83.00	73.91	90.50%
URDANETA	1	83.00	57.19	70.03%
URDANETA	2	83.00	57.19	70.03%
URDANETA	3	83.00	57.19	70.03%
BOCAUE	1	83.00	138.56	169.67%
BOCAUE	2	83.00	64.45	78.92%
KAYBIGA	1	83.00	57.32	70.19%
KAYBIGA	2	83.00	59.66	73.05%
MALABON	1	83.00	59.06	72.33%
MALABON	2	83.00	59.95	73.41%
MALABON	3	83.00	57.30	70.17%
MALINTA	1	83.00	78.51	96.14%
MEYCAUAYAN	1	83.00	84.59	103.58%
MEYCAUAYAN	2	83.00	85.90	105.19%
NOVALICHES	1	83.00	57.84	70.82%
NOVALICHES	2	83.00	62.66	76.73%
STA. MARIA	1	83.00	117.23	143.55%
STA. MARIA	2	83.00	107.38	131.49%
ABUBOT	2	33.00	22.08	72.47%
IMUS	1	33.00	25.01	77.02%
IMUS	2	83.00	58.35	71.46%
LOS BAÑOS	1	33.00	23.03	78.68%
LOS BAÑOS	2	25.00	17.38	70.64%
SILANG	1	33.00	24.39	81.52%
TAGAYTAY	1	33.00	30.34	97.97%
BOLBOK (MERALCO)	1	20.00	21.29	119.62%
BOLBOK (MERALCO)	2	33.00	43.99	135.49%
BOLBOK (NPC)	1	10.00	7.28	85.99%
STA. CRUZ	2	20.00	19.80	102.14%
BALIWAG	1	33.00	28.08	86.47%
BALIWAG	2	33.00	36.84	113.47%
CALUMPIT	1	12.50	12.15	98.79%
CALUMPIT	2	12.50	15.68	127.51%
CALUMPIT	4	33.00	32.84	101.14%
MALOLOS II	3	33.00	29.73	96.56%
SAN MIGUEL	1	20.00	33.16	179.74%
SAN MIGUEL	2	5.00	7.62	165.15%
TABANG	1	33.00	29.24	90.07%
CRUZ NA DAAN	1	10.00	6.94	70.53%
CRUZ NA DAAN	2	12.50	9.20	74.80%
AYALA ALABANG	1	83.00	97.91	119.89%
AYALA ALABANG	2	83.00	80.10	98.09%
ROSARIO (NPC owned)	1	50.00	31.91	71.19%
TERNATE (NPC)	1	50.00	34.95	71.72%

Substation Name	Bank No	Maximum Continuous MVA 2006	UTILIZATION 2017	
			MW	%
PACO	1	83.00	75.96	93.02%
BAGBAGUIN	1	83.00	75.84	92.87%
CARMELRAY	2	83.00	61.04	74.74%
LISP	1	83.00	60.91	74.59%
BACOR	1	83.00	60.43	74.00%
PARANG	1	83.00	62.25	76.23%
GRACE PARK	1	83.00	57.66	70.61%
GRACE PARK	2	83.00	58.83	72.04%
HILLCREST	1	83.00	67.35	82.47%
NEW MAUBAN	1	50.00	40.65	82.63%
CBP1A	1	83.00	76.69	93.91%
LEGAZPI	1	83.00	66.37	81.27%
LEGAZPI	2	83.00	58.86	72.07%
NAIA	1	83.00	90.16	110.40%
BATANGAS	1	33.00	41.74	128.56%

It can be seen from the Table above, that there is only one transformer bank that will not meet the required 70% loading at the end of the 10 year planning horizon. However this transformer is a 25MVA capacity and while there is scope theoretically to optimise the transformer to a smaller size, the reduction in value is not material to the valuation.

Accordingly, PB Associates has determined that there is no scope for optimizing power transformers.

Network Optimisation – Substation Topology

The standard configuration of Meralco substations is depicted in Figure 2.

The common configuration employed is an outdoor high tension switchyard (115 or 69 kV) with either an outdoor switchyard or an indoor low tension switchboard at 34.5 or 13.8 kV.

The most common HV substation topology used by Meralco is the 'breaker and a half' scheme and the single bus scheme. These substation topologies are employed in almost all Meralco substations. There are a small number of ring bus configurations.

A breaker and a half switching arrangement offers the highest reliability performance of all substation configurations.

The question to be addressed in terms of optimization is whether such high reliability is optimal?

The most commonly used busbar arrangements for the industry in Australia and New Zealand are as follows:

- A single configuration is used for non-critical substations;
- A Selectable Double Bus configuration is used where increased operational flexibility is required; and

- A Breaker and a Half configuration is mainly used for voltages above 200kV.

A breaker and a half configuration can be optimised to an alternative busbar configuration at least for all non-critical load substations.

Where a breaker and a half busbar configuration cannot be adequately justified, PB Associates proposes to optimise the substation configuration as follows:

Table 8: Busbar Configurations

Substation Function	Busbar Configuration
Urban (without back up)	Single Bus (unfolded bus), Ring bus CBs
Urban (some back up)	Single Bus (unfolded bus), Ring bus CBs
Rural	Single Bus (unfolded bus), Ring bus CBs
Critical Substation - Major Customer / Load or Switching Station	Ring Bus CBs, 1 ½ CB, Double CB
Generator	1 ½ CB

The adjustments in terms of modular components relative to the 1 ½ CB configuration would be as follows:

Table 9: Busbar Components

Component	1 ½ CB per bay	Single Bus per bay	Increase / Decrease ³	RC Adjustment
115 kV Circuit Breaker Module	3	1	-1	-7,247,906
115 kV Bus Structures				-1,705,070

Meralco has adopted a breaker-and-a half scheme for its 115 kV and 69 kV systems as a network backbone that supplies power to 115 kV-34.5 kV, 115 kV-13.8 kV and 69 kV-13.8 kV substations.

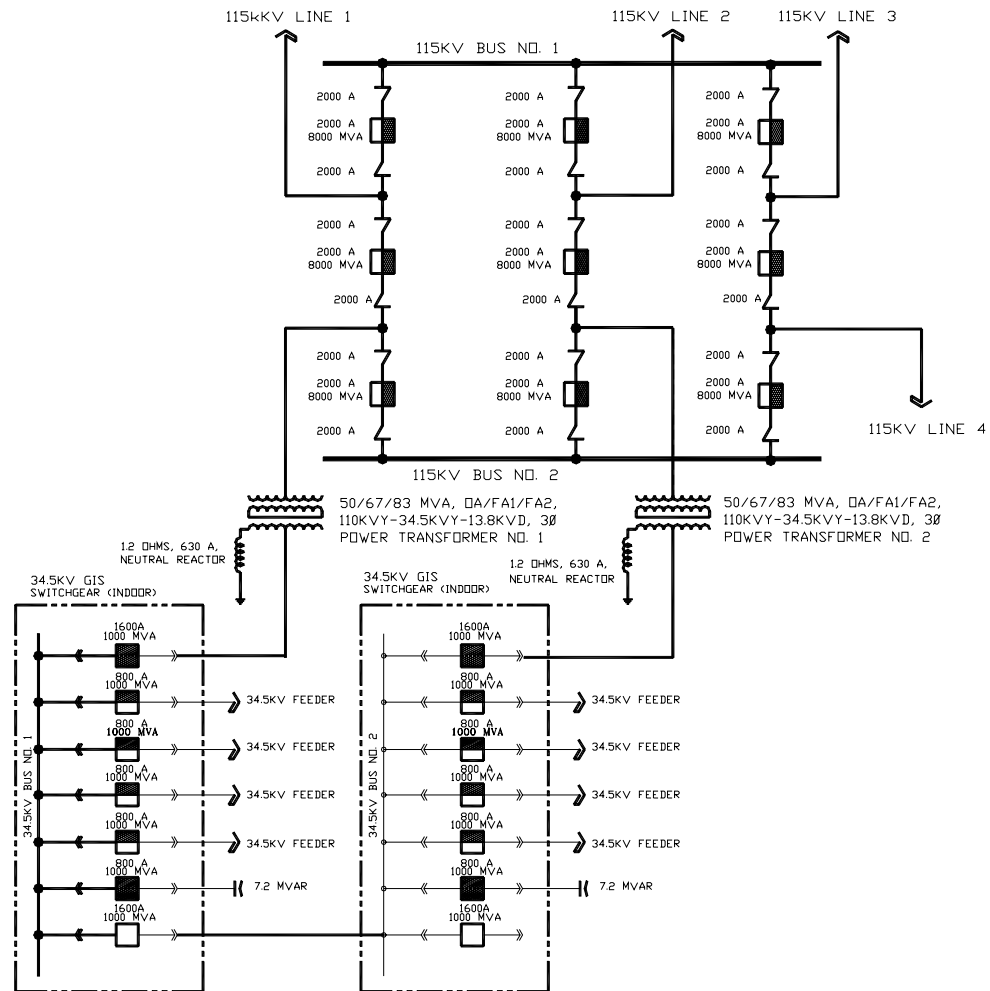
Meralco develops each substation initially as a ring bus scheme until a fifth termination, either a line or a bank, is added. The cost difference of the breaker-and-a-half scheme, ring-bus and a single-bus scheme is almost the same up to the two line-two bank configuration since there is only one breaker for one termination. Upon the addition of a 3rd line or 3rd bank, the ring bus is converted to a breaker-and-a-half scheme. With three banks, the substation is considered as a major distribution substation with at least 150 MVA load. With three lines, the substation is considered as a major switching point substation.

³ It should be noted that to get the same connectivity two single bus bays are required for every one breaker and a half bay.

Meralco reported that there are operational advantages to the breaker-and-a-half scheme since the need arises to split the breaker-and-a-half switchyard to two single bus switchyards to meet operational system requirements.

PB Associates considers that Meralco’s design philosophy is acceptable given that the subtransmission system must be designed for N-1 contingencies (per ERC Guidelines⁴). The breaker-and-a-half configuration is implemented as the substation is fully developed in keeping with the increase in the load at risk, and this is an approach that is economically sound.

Figure 1: Meralco – Standard Substation Configuration (Fully Developed)



Network Engineering Optimisation – Substations

The following table contains proposals to optimise substations from a network engineering perspective.

⁴ The trend in other jurisdictions is to move away from deterministic N-1 principles towards probabilistic planning approaches that predict customer minutes lost for various configurations prior to selecting the optimal arrangement.

Table 10: Substation Engineering Optimisation

Substation	Optimisation Proposal	Potential Optimization ('000 Pesos)	Rationale	Optimize (Yes/No)
Cubao, Diliman, Kamuning, Masinag, Meycauayan, New Teresa, San Pablo, San Pedro, Sunvalley, Tutuban	All 34.5 kV SF6 Insulated MetalClad switchgear be optimised to AIS Metalclad switchgear.	359,659,987	Space limitations require the use of gas insulated switchgear at 34.5 kV. The use of GIS was recommended by the consultant hired as part of the KFW and World Bank loan	Yes – AIS and GIS MetalClad switchgear at 34.5 kV are approximately the same dimensions.
Grace Park, Hillcrest, Legazpi, Rockwell, SM Shangrila, Urdaneta	All 34.5 kV SF6 Insulated MetalClad switchgear be optimised to AIS Metalclad switchgear.		Space limitations require the use of gas insulated switchgear at 34.5 kV. Also aesthetics is very important given that said substations are located inside central business districts of Makati, Pasig/Mandaluyong and Calocan.	Yes – AIS and GIS MetalClad switchgear at 34.5 kV are approximately the same dimensions. AIS MetalClad switchgear can easily be installed indoors.
Abubot	This substation has a transformer with offload tapchangers and a three phase set of voltage regulators between the 34.5 / 13.8 kV transformer and the 13.8 kV switchboard. It is proposed to optimize to a 34.5 / 13.8 kV transformer with an OLTC. The number of 13.8 kV CB's is excessive.		Not Material	
Angat	It is proposed to optimize the substation to a single		Not Material	

Substation	Optimisation Proposal	Potential Optimization ('000 Pesos)	Rationale	Optimize (Yes/No)
	<p>transformer (with OLTC) and a single 13.8 kV switchboard, provided there is sufficient backstopping via the 13.8 kV network in case of a transformer outage.</p> <p>If backstopping is not available only the number of 13.8 kV breakers can be optimized.</p>			
Bocaue	<p>It is proposed for the transfer bus to be optimized out since N-1 at distribution is not allowed under the Asset Valuation Guidelines.</p> <p>It is proposed for an OLTC to be installed on the 115 / 34.5 kV transformers (this is standard for these size transformers) so that the voltage regulators on the 34.5 kV line to Malolos can be optimized out.</p>		Not Material	
Botocan	<p>It is proposed to optimize out the 115 kV CB - 62D4 and the 115 / 34.5 kV transformer and to replace it with a 34.5 kV CB and 34.5 / 13.8 kV transformer of</p>	18,446,973	<p>Generators do not allow DU's to tap directly to the generator busses. Power could also come from the 115 kV Caliraya line instead of coming directly from the power plant. There will be</p>	No

Substation	Optimisation Proposal	Potential Optimization ('000 Pesos)	Rationale	Optimize (Yes/No)
	same rating.		operational problems with the plant since it will be on island operation.	
Cainta	It is proposed to optimize out the spare 2000A 34.5 KV breaker.		Not Material	
Calumpit	It is proposed to optimize the No 1 and No 2 12.5 MVA transformers to a single 25 MVA transformer. It is proposed to optimize 13.8 kV switchboards 1 and 2 into a six panel board (2 incomers + 4 feeders).		Not Material	
Cavite	If sufficient backstopping is available via the 6.24 kV network, it is proposed to optimize to a single 33 kV CB, a single 25 MVA transformer and a single seven panel 6.24 kV switchboard.		Not Material	
CBP1A	It is proposed to optimize out three 115 kV CB's (2 transformer and one line)	124,655,482	A third line will be needed by 2009 if NAI3 115 kV line right-of-way is not finalized. Final setup is considered in the purchase of equipment to prevent compatibility problems in the future.	Yes – ODRC valuations do not allow for the purchase of equipment for compatibility issues. If the equipment is not to be used within the planning period it is to be optimised. This also applies to the extra line

Substation	Optimisation Proposal	Potential Optimization ('000 Pesos)	Rationale	Optimize (Yes/No)
				breakers because if the ROW is finalised this breaker will not be required. Until the line breaker is utilised it should remain optimised.
Cruz Na Daan	It is proposed to optimize to a single 20 MVA 69 / 13.8 kV transformer and single 13.8 kV bus with 4 feeders and one incomer breaker.		Not Material	
Forbes Park	If backstopping is available via the 6.24 kV network, it is proposed to optimize to a single 25 MVA transformer and a seven panel 6.24 kV switchboard		Not Material	
Hillcrest	It is proposed to optimize out 2 transformer CB's on 115 kV GIS switchgear	38,871,034	For GIS, Meralco purchase the ultimate scheme to prevent equipment compatibility problems in the future.	Yes – ODRC valuations do not allow for the purchase of equipment for compatibility issues. If the equipment is not to be used within the planning period it is to be optimised.
Legazpi	It is proposed to optimize out two 115 kV CB's	44,144,364		
Malabon	It is proposed to optimize out the transfer buses in the 34.5 kV switchyard		Not Material	
Meralco Bolboc	It is proposed to optimize the 13.8 kV outdoor switchgear to Metalclad switchgear		Not Material	
Paranaque	It is proposed to		Not Material	

Substation	Optimisation Proposal	Potential Optimization ('000 Pesos)	Rationale	Optimize (Yes/No)
	optimize the regulator and transformer to a OLTC transformer			
San Juan	It is proposed to optimize regulators and transformers to OLTC transformers		Not Material	
Silang	It is proposed to optimize outdoor 13.8 kV and Metalclad switchgear to a single 13.8 kV Metalclad AIS switchboard		Not Material	
Sta. Cruz	It is proposed to reconfigure the 13.8 kV feeder connections to optimise out the requirement for the 34.5 kV equipment and connection from Los Banos provided sufficient backstopping capacity is available		Not Material	
Sta. Mesa	It is proposed to optimize the existing five 34.5/6.24 kV transformers to 3 x 34.5/6.24 20 MVA transformers It is proposed to optimize the existing 4 x 6.24 kV switchboards 3 x 7 panel switchboards		Not Material	
Zapote	It is proposed to optimise out 3 line and 3 transformer	152,741,933	7 breakers are presently used, 3 for the 3 x 300 MVA banks, 3 for	Partial Yes – ODRC valuations do not allow for the purchase of

Substation	Optimisation Proposal	Potential Optimization ('000 Pesos)	Rationale	Optimize (Yes/No)
	CBs on the 115 kV GIS switchgear		3 x 115 kV lines and 1 for 1 x bus tie. A new 115 kV line and a fourth 300 MVA bank is proposed in 2008 and 2009 respectively. The remaining 115 kV breakers were meant for three 83 MVA transformers to cater for the expected load at the reclamation area (Amari, Asiaworld) – this has yet to materialize. The ultimate scheme is considered in purchasing GIS equipment to prevent compatibility problems in the future.	equipment for compatibility issues. If the equipment is not to be used within the planning period it is to be optimised. The three CBs intended for the 83 MVA transformers will be optimised out. New optimised value is 65,975,720

This represents a total replacement cost reduction of Php 633,306,587.

2.3 PRIMARY & SECONDARY DISTRIBUTION FEEDERS

Network Optimisation - 34.5 and 13.8 kV Feeders

PB Associates has examined the feeder ratings, feeder and load forecasts to the end of a 5 year planning horizon.

The ratings of the feeder are determined by the conductor sizes employed by Meralco.

The standard conductor configuration and sizes of 115kV and 69kV overhead conductors are as follows:

Table 11: Standard Conductor Configuration & Ratings

Voltage	Conductor Type	Line Configuration	Theoretical Rating
34.5 kV	336.4 MCM ASCR	3-phase, Single Circuit	31.2MVA
34.5 kV	4/0 Copper	3-phase, Single Circuit	28.7MVA
13.8 kV	336.4 MCM ASCR	3-phase, Single Circuit	12.7MVA
13.8 kV	4/0 Copper	3-phase, Single Circuit	11.8MVA
6.24 kV	336.4 MCM ASCR	3-phase, Single Circuit	5.7MVA
6.24 kV	4/0 Copper	3-phase, Single Circuit	5.2MVA

Meralco reported that distribution feeders are planned and designed to operate under N-1 reliability criteria with 40 – 60% loading criteria under normal operating conditions.

In accordance with the ERC Asset Valuation Guidelines, PB Associates has not examined feeder configurations in detail. Operational needs change constantly, resulting in reconfiguration of the feeder network on a daily basis. Furthermore, as the feeder conductor varies along the length of the feeder and a feeder may be sub-optimal in some part of its length, and overloaded in another part. Such operational aspects work against optimising feeders on the basis of utilization only.

However, the ratings and conductor in use show that Meralco applies two standard feeder exit ratings at each voltage level. It is PB Associates professional opinion that these ratings and the system planning practices employed support the achievement of optimal feeder utilization.

Network Optimisation – Circuit Breaker Ratings

Bus-tie and feeder circuit breakers must be rated for the maximum fault level at the bus and feeder exits respectively.

Table 12 summarises the design fault level by voltage:

Table 12: Fault Level

Voltage	Design 3-Ph Fault Level (MVA)	Circuit Breaker 3-Ph Interrupting Capability (kA)
13.8 kV	500MVA	20 kA
34.5 kV	1000MVA	16 kA
69 kV	2500MVA	20 kA
115 kV	8000MVA	40 kA

Meralco provided fault level statistics for busses operating at each voltage level. The following charts summarise the 2006 and forecast 2022 performance:

Figure 2: Fault MVA – 13.8kV

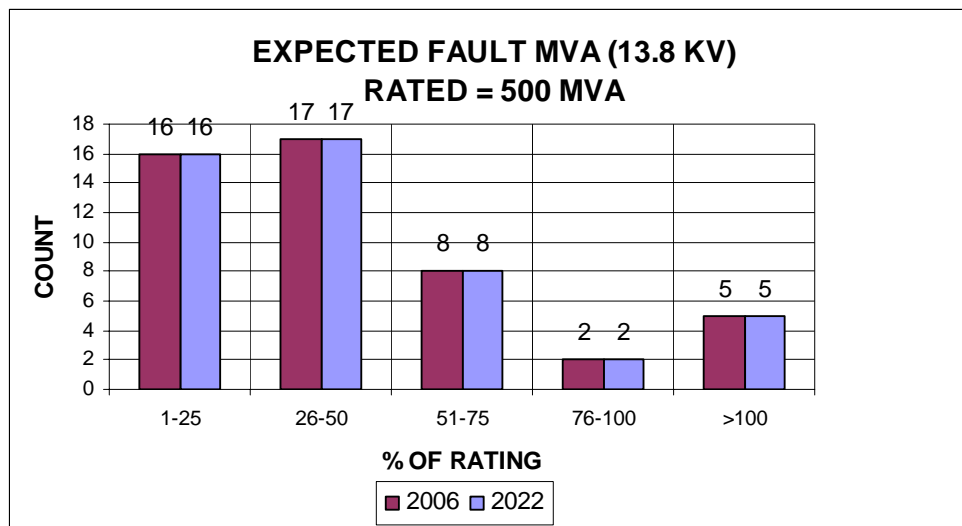


Figure 3: Fault MVA – 34.5kV

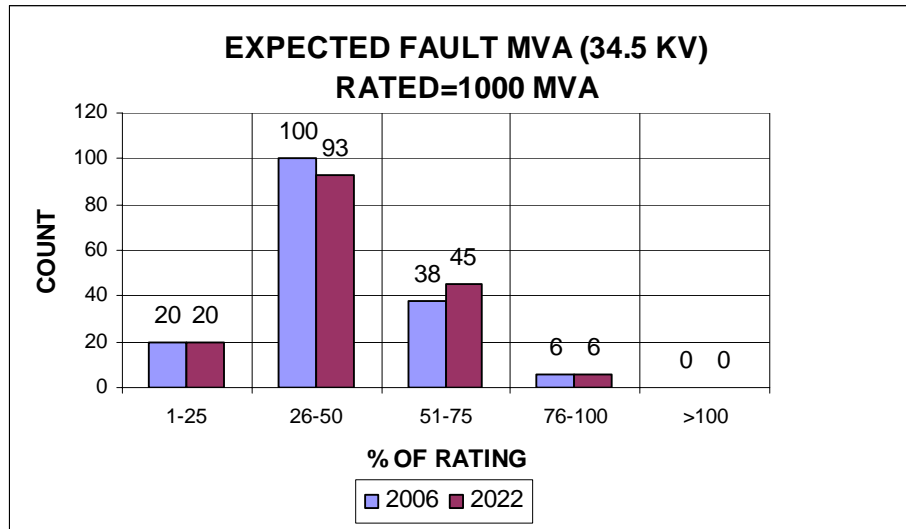


Figure 4: Fault MVA – 69kV

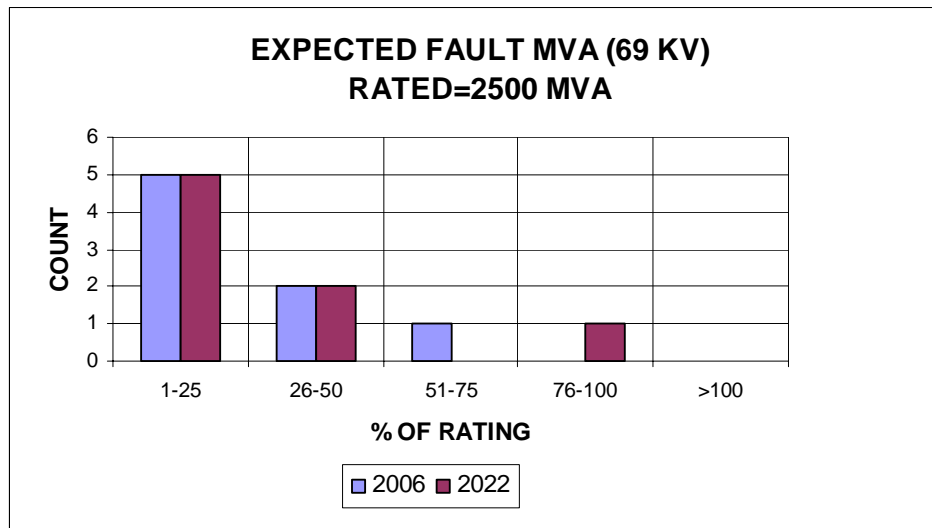
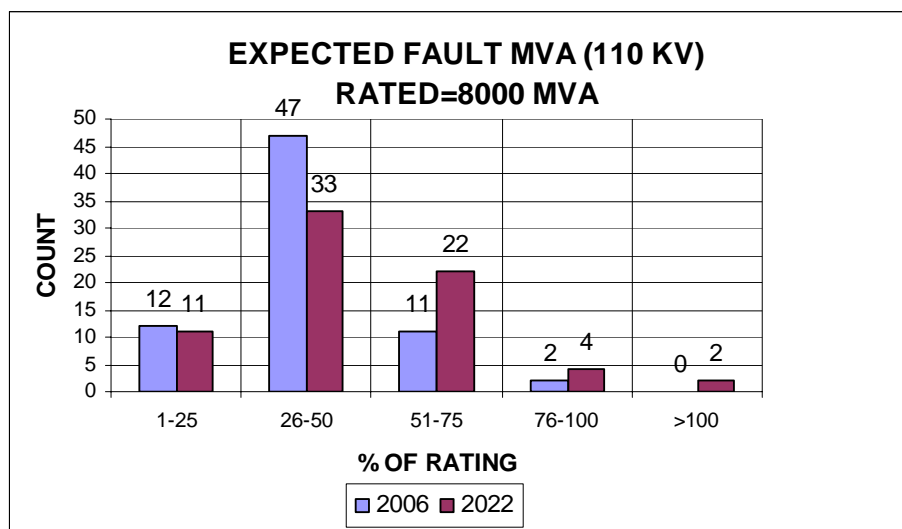


Figure 5: Fault MVA – 110kV



For the CB at 69 kV and below this is the lowest fault rating that is available in the market. However for the 115 kV circuit breakers a 25 kA and 31.5 kA breaker are available. These give a fault MVA of 5000 MVA and 6275 mVA respectively.

Therefore CB between 51-75% of maximum rating can be optimised to 31.5 kA breakers, with those between 0-50% of maximum rating can be optimised to a 25 kA breaker.

Table 13: CB Fault Level Optimisation

Description	Unit Difference	Units	Total
Optimisation from 40 kA to 31.5 kA CB	239,732	22	5,274,104
Optimisation from 40 kA to 25 kA CB	479,465	44	21,096,460

This represents a replacement cost reduction of 26,370,564 Peso.

System Optimisation - 34.5 and 13.8 kV Feeders

As previously discussed in Section 2.3.1, in accordance with the ERC Asset Valuation Guidelines, PB Associates has not optimised the distribution system. The distribution feeder network comprises an interconnected network with the capability to transfer load to meet operational requirements. A range of operating conditions and network constraints, e.g. voltage and thermal constraints, means that it is infeasible to optimise the network from an economic perspective.

2.4 OVERHEAD CONDUCTORS & DEVICES

Network Optimisation – Overhead Conductors

Optimisation of overhead conductors is dealt with under the Sections of this report addressing subtransmission and distribution lines.

Network Optimisation – Line Switches

In general terms, line switches are positioned for operational flexibility and for reliability of supply purposes i.e. for load transfer and supply restoration. PB Associates has examined the switch placements with reference to Meralco Single Line Diagrams and finds that there is no scope for optimising out Meralco line switches.

Network Optimisation – Overhead Devices

Overhead line devices are installed for specific purpose and experience suggests that such assets do not offer significant opportunities for optimisation.

2.5 LINE TRANSFORMERS (DT'S)

Optimisation of line transformers has been assessed in accordance with the ERC Asset Valuation Guidelines.

PB Associates has examined the DT utilisation statistics to the of a 5 year planning horizon. Meralco provided forecast utilisation statistics for each of its 10 Sectors.

As the loading data and forecast utilization was not considered robust to the level of individual DTs, the approach was taken to forecast utilization on a geographic sectoral basis.

This suits the way that Meralco track kWh sales and consumption, and the DT capacity in use, and PB Associates consider that the loading data available at the Sector level within Meralco is robust.

The summary of forecast utilisation figures against target is provided, and optimality is judged on a Sector by Sector basis as shown in Table 14, against a target utilization of 50% (as defined by the ERC Asset Valuation Guidelines).

Table 14: DT Forecast Utilization

Sector	Total DT Capacity In Use 2006 (kVA)	Energy Delivered in 2012 (kWh per annum)	Utilization at Load Factor of 1.0	Utilization at Load Factor of 0.4
Alabang	899,480	151,052,210	19.0%	62.4%
Balintawak	735,964	104,946,332	16.2%	55.1%
Dasmariñas	770,885	96,429,777	14.3%	46.5%
Manila	1,551,839	211,109,127	14.8%	55.5%

Sector	Total DT Capacity In Use 2006 (kVA)	Energy Delivered in 2012 (kWh per annum)	Utilization at Load Factor of 1.0	Utilization at Load Factor of 0.4
Pasig	2,490,373	361,567,828	15.7%	53.2%
Plaridel	654,713	96,934,276	17.0%	54.8%
Rizal	642,898	112,742,867	20.0%	64.3%
San Pablo	419,290	57,392,148	15.5%	52.1%
Sta. Rosa	722,460	110,181,655	17.5%	55.0%
Valenzuela	1,322,403	179,671,618	16.0%	51.6%
TOTAL	10,210,309	1,482,027,837	16.3%	54.7%

As it turns out, only one Sector will not achieve the 50% utilization target at the end of the 5 year planning horizon.

PB Associates propose to optimize DTs using an average replacement cost difference of Php1800 per kVA. This figure is an average cost per kVA replaced and was derived from the replacement cost differences related to DTs of various kVA capacities (for 13.8kV and 34.5kV).

Table 15: DT Forecast Utilization

Sector	% kVA Under-Utilised	kVA In Excess	Optimisation Value (Php)
Alabang	0%	--	--
Balintawak	0%	--	--
Dasmaringas	3.5%	26,981	48,565,800
Manila	0%	--	--
Pasig	0%	--	--
Plaridel	0%	--	--
Rizal	0%	--	--
San Pablo	0%	--	--
Sta. Rosa	0%	--	--
Valenzuela	0%	--	--

Sector	% kVA Under-Utilised	kVA In Excess	Optimisation Value (Php)
Total			48,565,800

Given that the accuracy of the utilization forecasts is likely to be of the order of 5%, and the optimization amount is not material, PB Associates has not optimised this capacity out.

2.6 POWER CONDITIONING EQUIPMENT

Line Capacitors

The optimization of line capacitors follows the optimization of line transformers because power factor adjustment is a function of the reactive power drawn by line transformers and load profile.

PB Associates observes that the total capacity of Meralco installed line capacitors is approximately 1566 MVar. This compares to around 11,152 MVA of installed line transformer capacity. Most of the reactive power support is achieved by the use of substation capacitors.

PB Associates finds that the penetration of line capacitors appears to be very low with no potential for optimization.

2.7 LV SERVICES

The optimization of low voltage services is a function of the number of customers per line transformer. Based on these statistics we would expect to find that the optimal count of LV Services per DT would be around 50 LV services per DT as per Section 2.5 of this report.

The ODRC register contains 30,888,116 meters of service cables, and the DT count is 126,511.

A count of 50 LV services per DT, would equate to an average of 5 metres of LV service cable per service. This compares to an average of 29 for Cepalco and 22 for Decorp. PB Associates considers that 5 metres per service cable is relative short and not excessive. The shorter average length, when compared to Cepalco and Decorp, is probably due to smaller dwellings and household footprints.

Accordingly, PB Associates do not propose to optimise LV service cables.

2.8 METERING

When it is not possible to locate an individual item for optimization, such as is the case for metering assets, optimization is applied to the major asset types within the subcategory.

To achieve this, the following formula is used.

$$Opt(\%) = \frac{Qty_{opt}}{Qty_{org}} \left[\frac{(RC_{org} - RC_{opt})}{RC_{org}} \right]$$

where,

Opt(%) is the percentage that the RC is to be reduced by

Qty_{opt} is the total number of items to be optimised

Qty_{org} is the total number of items in the asset category

RC_{org} is the replacement cost of the asset to be optimised

RC_{opt} is the replacement cost of the new asset category.

When an item is to be optimised out RC_{opt} is set to zero, therefore the equation reduces to:

$$Opt(\%) = \frac{Qty_{opt}}{Qty_{org}}$$

Meralco Meter Optimisation

Meralco categorises customers and meters using Metering Class IDs. These classes along with estimated customer numbers are given in the following table.

Table 16: Meter Class & Estimated Customers

Metering Class	Description	Capacity	Estimated⁵ Customers
Single-Phase Plain Residential Meters	For residential customers	230 V, 1 ph, 3 wire, line to line, < 19 kW residential	3,917,338
Low Voltage Self-Contained Meters	For residential & commercial customers with controlled capacity from 5 to 39 kW	230 V, 3 ph, 4 wire, < 61 kW load residential and commercial	384,904
Low Voltage Secondary Meters	For commercial & industrial customers with controlled capacity of more than 39 kW	230 V, 3 ph, 4 wire, 500 - 1000 kW, residential/commercial/industrial	10,550
High Voltage and Transmission Voltage Primary Meters	For customers with high voltage service of 6.24 to 115 kV	Instrument Transformer Rated Meter	4,272

Based on a categorisation provided by Meralco, the total numbers of meters included in the asset register in each asset class are estimated to be:

⁵ The estimated customer numbers from information provided by Meralco as part of a general presentation

Table 17: Estimated Breakdown of Meters By Class

Metering Class	Meter Totals
Single-Phase Plain Residential Meters	5,104,273
Low Voltage Self-Contained Meters	351,874
Low Voltage Secondary Meters	229,848
High Voltage and Transmission Voltage Primary Meters	797

Given the total numbers of customers and the stock requirement calculations (estimated at 7.75% based on figures provided by other DU's) it was calculated that the total number of meters required for each class are:

Table 18: Optimal Meter Requirements

Metering Class	Customers	Stock	Total
Single-Phase Plain Residential Meters	3,917,338	303,594	4,220,932
Low Voltage Self-Contained Meters	384,904	29,830	414,734
Low Voltage Secondary Meters	10,550	818	11,368
High Voltage and Transmission Voltage Primary Meters	4,272	331	4,603

Comparing the count of meters included in the register and the meter requirements, it can be seen that Single-phase Residential Meters and Low Voltage Self Contained Meters have an excess of meters while the count of other metering classes is insufficient.

Optimisation Details

High Voltage and Transmission Voltage Primary Meters

No optimisation is required. There is a shortfall of 3,806 meters.

Low Voltage Secondary Meters

As each metering point requires a meter it is assumed that lower class meters are used to make up the short fall of Primary Class meters. Therefore an additional 3,806 meters can be included in the valuation.

This means that at present there is an excess of 214,673 meters (229,847-11,368-3,806).

62,860 of these meters will be optimised to Low Voltage Self-Contained Meters. This will result in a reduction in the RC of Php2,162,069,700.

In total 151,814 meters (214,673 – 62,860) can be optimised out. This will result in a reduction in the RC of Php6,222,596,021.

Low Voltage Self-Contained Meters

No optimisation is required.

Single-Phase Plain Residential Meters

At present there is an excess of 883,341 meters (5,104,273 – 4,220,932). All of these meters shall be optimised out. This will result in a reduction in the RC of Php2,176,552,224.

In summary, PB Associates proposes an optimization adjustment for metering of Php10,561,217,945.

2.9 OTHER ASSET SUBCATEGORIES

PB Associates does not propose to optimise other asset subcategories as the decision to install such assets is determined by customer needs or community standards e.g. street lights. Accordingly there is minimal scope for optimisation.

3. SPARES

PB Associates was not provided with a separate spares register.

3.1 SUBSTATION ASSETS

We have not optimized substation equipment spares as they have not been included in the valuation.

3.2 REPETITIVE ASSETS

In summary, PB Associates considers that the stockholding of repetitive assets is appropriate and does not find that spares should be optimized out, with the exception of meters.

Meters

Meters spares were dealt with in Section 2.8 above.

Line Transformers

The following calculations were used to set the levels for line transformer spares.

New line transformers: Average load growth over the last five years based on energy sales figures (excluding losses) provided by Meralco is 2.31%. This equates to an increase in line transformers of 3,380 per year.

Failure rates: In India the rates is as high as 17-20%. In first world countries the failure rates is around 2-3%. PB Associates considers that 10% is a suitable failure rate in the Philippines (particularly given the impact of typhoons). Accordingly, we would expect that on average 12,859 line transformers will fail per annum.

A stock buffer is allowed for delivery of line transformer orders. Based on a delivery time of 3 months, a quarter of all requirements will be needed as a buffer. This equates to 3,993 (25% of (12,859+3,380)).

Adding all the above requirements gives a total of 20,232 (12,859+3,380+3,993) line transformers.

This figure is 15% of the in-service population is 134,702. The total allowable line transformer population is 154,934. The verified ODRC register contains a count of 146,252 line transformers (category A12) and therefore no optimization is required.

Poles & Conductor

The verified ODRC register contain a count of 704,876 poles (above 6.24kV in Cat A6) and 43,902,400 metres of conductor. These figures suggest an average span length of 62 metres, or 16 poles per kilometre. PB Associates is satisfied that the assets in use are optimal.

4. MERALCO LOAD FORECAST

This Section is a verification of the robustness of the Meralco load forecasting techniques.

4.1 GENERAL

Meralco uses a planning tool known as Foresite. This tool is a software package designed to support load forecast studies. Foresite software uses a Micro-Area Load Forecasting technique to compute the future load forecasts of the Meralco power system.

Foresite utilises a spatial database taking input data from Meralco's Geographic Information System (GIS) as well as development data collected from various development agencies in the area.

The application of micro area load forecasting techniques is based on land use data. In this approach the service area is divided into different zones based on development activities e.g. commercial, domestic, industrial etc. The demands per unit area for respective zones are computed based on the existing data and future requirements. The future electricity requirements are then determined by integrating land use and demand data.

Accordingly, load growth depends on two factors;

- a. the rate of growth of power demand of existing Meralco customers; and
- b. the future development plans for the vacant land in the Meralco franchise area.

The details of the load forecasting computations for the planning horizon are given in the next section.

4.2 LOAD FORECAST CALCULATIONS

Meralco's Electric System Planning (ESP) unit calculates the system demand forecast by using Foresite software, based on the data described above.

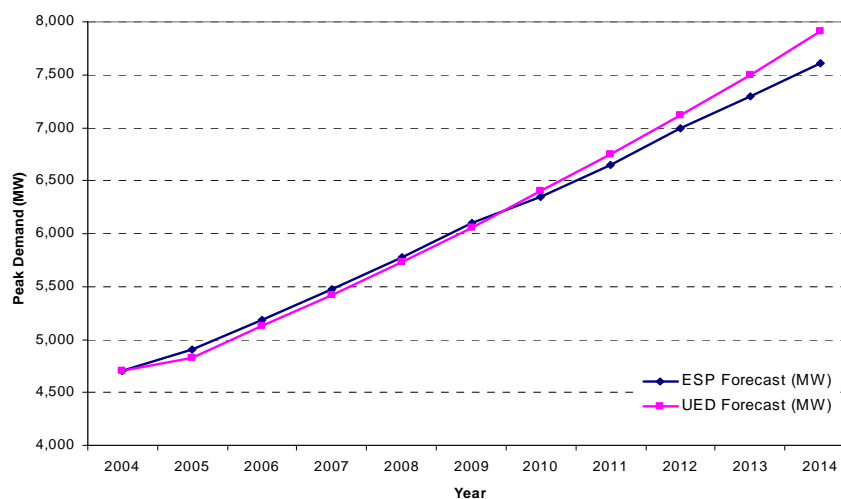
Meralco's Utility Economics Department (UED) releases forecasted system peak demands annually, based on market research. The ESP forecasted demand figures compare against the UED forecasted demand figures for accuracy. If the deviation is within +/- 8% the forecast is considered robust by Meralco and the ESP load forecast is adopted.

Table 16 below shows the ESP and UED calculated demand forecasts for the Meralco power system from 2005 to 2014.

Table 16: ESP and UED Demand Forecasts⁶

Year	ESP Forecast (MW)	ESP Demand Growth	UED Forecast (MW)	UED Demand Growth
2004	4709		4709	
2005	4906	4.2%	4832	2.6%
2006	5185	5.7%	5123	6.0%
2007	5475	5.6%	5423	5.9%
2008	5780	5.6%	5732	5.7%
2009	6095	5.4%	6057	5.7%
2010	6343	4.1%	6397	5.6%
2011	6643	4.7%	6754	5.6%
2012	6999	5.4%	7121	5.4%
2013	7300	4.3%	7500	5.3%
2014	7606	4.2%	7906	5.4%

Figure 6 shows that the long term growth rate has been approximately 6%.

Figure 6: System Demand Forecast from 2005 to 2014

The ESP load forecast for the planning horizon is within the acceptable limits of deviations from the UED market forecast.

These techniques were applied to develop the load forecasts for GXPs, subtransmission lines and substations (including individual power transformers).

Accordingly, PB Associates considers the load forecasting method applied by Meralco to be robust.

⁶ Source of the data: Substation Load Forecast and Strategic Expansion Plan from 2005 to 2014.