Parsons Brinckerhoff Associates

OPTIMIZATION OF ASSETS OF CEPALCO

CONFIDENTIAL

FOR

ERC & CEPALCO

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EXECUTIVE SUMMARY

1. Background & Objectives

The objective of this report is to propose adjustments to the Cepalco ODRC asset register, in accordance with the principles espoused in the ERC Asset Valuation Guidelines. Optimization 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 optimization for Cepalco for purposes of an asset valuation:

Table 1 Proposed CEPALCO Optimization

DWRG Category		Optimization (Pesos)
A3	Station Equipment	
A3A	Power Transformers	Nil
A3B	Switchgear	Nil
A3C	Protective Equipment	4,944,705
A3D	Metering & Control	Nil

DWRG Category		Optimization (Pesos)
A3E	Communications Equipment	Nil
A3F	Other Substation Equipment	Nil
A4 & A5	Poles, Towers & Fixtures	Nil
A6 & A7	Overhead Conductors & Devices	Nil
A8 & A9	Underground Conduits	Nil
A10 & A11	Underground Conductors & Devices	Nil
A12 & A13	Line Transformers	9,159,647
A14	Power Conditioning Equipment	Nil
A15	Services	Nil
A16 & A17	Meters, Instruments & Metering Transformers	166,972,321
A20	Streetlights & Signalling	Nil

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 CEPALCO NETWORK

Cepalco receives power via a 138 kV transmission network at 3 major delivery points.

Power is sourced from the National Power Corporation (NPC).

From the delivery points, electricity is distributed through a sub-transmission network to major distribution substations throughout the supply area. This network operates at 69 kV and consists of approximately 67 km of lines.

The company operates 5 sub-transmission substations (with 7 power transformers). The total substation capacity is 110 MVA.

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

Electricity is conveyed through a primary distribution network of approximately 1296 km of overhead lines.

A total of 1959 distribution line transformers are used in the network to convert the distribution voltage levels to low voltage (220 V single phase and three-phase). Total line transformer capacity is 88 MVA.

There are approximately 3,000 kilometers of 220V line in use, including low voltage services and street light supplies.

1.2 ERC OPTIMIZATION 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
• Sub-transmission lines • Substations (excluding transformers) • Primary distribution circuits[1] • Points of connection to transmission network	15 years	2022
• Substation Transformers	10 years	2017
• Distribution Line Transformers[2] • 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 Cepalco by DWRG asset category;

Section 3 addresses spares optimization; and

Section 4 provides a verification of the robustness of Cepalco'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. OPTIMIZATION BY DWRG CATEGORY

2.1 SUBTRANSMISSION OPTIMIZATION

Network Optimization - Grid Exit Points (GXP)

Optimization 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 three (3) GXPs supplying Cepalco's network are shown in the following table:

Table 3: GXP Network Configurations

GXP	Network Configuration	Firm Capacity	Peak Load (MVA) at end of planning horizon	Optimal ? (Y/ N)
Aplaya	1 x 50 MVA 1 x 100 MVA	50 MVA	53.7 MVA	Y
CarmenLugait	1 x 50 MVA 1 x 75 MVA	50 MVA	Not Available	Y
Natumulan	1 x 100 MVA	70 MVA	72 MVA	Y

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 2.2, 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 Optimization - Subtransmission Lines

Optimization of the subtransmission network begins with the 69 kV subtransmission overhead lines.

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

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

Table 4: Subtransmission Standard

Voltage	Conductor	Conductor Configuration	Theoretical Rating
69 kV	1 x 795 MCM ASCR	3-phase, Single Circuit, Single Conductor	103 MVA[3]

Cepalco reported that their subtransmission lines do not meet N-1 criterion as there are no parallel paths at this time. Accordingly, PB Associates has made a simple test comparison of 100% of the theoretical line (conductor) rating against the peak load at the end of the 15 year planning horizon.

Table 5 below lists the subtransmission lines included in the test and the results in terms of spare capacity at the end of the planning horizon. Subtransmission lines that do not achieve a peak load greater than the 100% threshold on theoretical rating will qualify to be considered for a reduction of the line capacity to a smaller conductor size.

Table 5: Subtransmission Lines

Sub-trans Line	Voltage (kV)	Conductor	100 % of Rating MVA	Peak Load MW at end of planning horizon	Optimal ? (Y/N)
Cepalco M1	69 kV	1 x 795 MCM ACSR	103	10.5	Y
Cepalco M2	69 kV	1 x 795 MCM ACSR	103	33.5	Y
Cepalco M3	69 kV	1 x 795 MCM ACSR	103	60.8	Y

The table shows that at the end of the 15 year planning horizon not all of Cepalco's subtransmission line loading meets or exceeds the line rating.

However, it is understood that it is a Transco standard to employ 1 x 795 MCM ACSR for 69kV subtransmission lines. PB Associates considers this choice of conductor is appropriate for a 69kV voltage rating. Mechanical robustness is a necessary consideration from a security of supply perspective, particularly where subtransmission lines are not configured in a mesh or loop.

PB Associates has determined that the subtransmission lines cannot be optimised to lower standard ratings.

[3] 75^0C cond, 35^0C ambient

System Optimization – Subtransmission

Following consideration of equipment optimization of the GXPs and subtransmission lines, the subtransmission system is now considered holistically.

The subtransmission network is expected to comply with the Grid and Distribution Codes promulgated by the ERC:

i. Subtransmission lines shall be designed to operate under the N-1 reliability criterion, i.e. an outage of any subtransmission line or delivery point power transformer shall not cause overloading of remaining facilities;

ii. The loading level of the subtransmission lines shall be limited to 50% - 60% of their rated capacity under normal operating conditions and maximum 100% loading level under emergency operating conditions;

iii. Under the normal operating conditions the bus voltage level at the high-voltage side of all Cepalco substation transformers shall be within +/- 7% and +/- 10% under emergency conditions;

iv. The overall system losses on the subtransmission network shall be less than 2%;

v. The overall power factor at Transco connection or metering points shall not be lower than 90% lagging; and

vi. System fault level shall not exceed the equipment short circuit ratings.

As previously mentioned, the present configuration of Cepalco's subtransmission network does not meet the N-1 reliability criterion.

The subtransmission lines do not have parallel paths at this time, nor do any of the major substations have dual power transformers. PB Associates understands that there are plans to bring the subtransmission network to an N-1 standard in due course.

A schematic of the subtransmission system is provided in Appendix A.

PB Associates finds that the subtransmission system configuration cannot be further optimised without affecting system adequacy or security adversely, in the sense that there is no excess capacity built into the network and no realistic options to reconfigure the system to a more efficient arrangement.

2.2 SUBSTATIONS

Network Capacity Optimization – Power Transformers

In general terms, optimization 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:

- 69 / 34.5 kV Substations 10, 20 and 30 MVA
- 69 / 13.8 kV Substations 10 and 15 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. However, although in some cases Cepalco substations have dual transformers, each transformer is supplying load at a different secondary voltage – 34.5 kV and 13.8 kV. Accordingly, as a transformer loss cannot be backstopped by the adjacent transformer, PB Associates has made a test comparison of forecast average peak demand against a 100% utilization target criterion.

Peublo D'Oro and Macasandig substations are new substations yet to take load from adjacent Cepalco substations. These substations are energised but the 34.5 kV feeder networks will not be reconfigured until 2007.

Table 6 below lists the substations included in the test and the results in terms of spare capacity at the end of the planning horizon.

Table 6: Power Transformers

Substation	Transformer	Utilization Target	Forecast Average Peak Utilization[4]	Optimal? (Y / N)
Carmen	1 x 10 MVA 1 x 10 MVA	100%	119%	Y
Camaman-an	1 x 20 MVA 1 x 15 MVA	100%	124%	Y
Macasandig	1 x 15 MVA	Work in progress - ERC approved	N.A.	N.A.

[4] The peak utilization is forecast for year 2006 as Cepalco has provided load forecasts with projects including expansion of Carmen and Pueblo D'Oro substations in 2007 and construction of three new substations.

Peublo de Oro	1 x 10 MVA	Work in progress - ERC approved	N.A.	N.A.
Tagoloan	1 x 30 MVA	100%	109%	Y

The table shows that the utilization target is surpassed in 2006 for all established substations and for this reason additional substation capacity is required from 2007. The ERC has approved the construction of the Peublo D'Oro and Macasandig substations for the purpose of providing such loading relief.

PB Associates has determined that Cepalco power transformers cannot be further optimised.

Network Engineering Optimization – Substations

The standard configuration of Cepalco's established substations is shown in Appendix A.

The common configuration employed for the fully established substations is a single 69kV bus with a split bus on the LT side (34.5 and 13.8 kV busses), or a single LT bus.

The substation configuration chosen by Cepalco is known as a 'single bus' or 'H-bus' arrangement.

A single bus switching arrangement offers the lowest reliability performance of all substation configurations, and the lowest cost. It is commonly used in other countries. For example in Australia and New Zealand substation configuration is commonly chosen as follows:

- An H-bus configuration is used for non-critical substations.
- A Selectable Double Bus configuration is used where increased operational flexibility is required.
- A Breaker and a Half configuration is used for voltages above 200kV or for generator busses.

An H-bus configuration presents the least opportunity for optimization as it is the simplest configuration.

During site inspections the assets within the substations were found to be standard requirements for the type of substation configuration in use by Cepalco.

Accordingly, PB Associates has determined that Cepalco substations cannot be optimised from a network engineering perspective.

Network Optimization – Protective Equipment

Cepalco has 10 sets of power transformer differential protection, whereas there are only seven power transformers.

Accordingly PB Associates considers that protective equipment need to be optimised by 3 sets for a total of Php4,944,705.

2.3 PRIMARY & SECONDARY DISTRIBUTION FEEDERS

Network Optimization - 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 Cepalco.

The standard conductor configuration and sizes of 34.5kV and 13.8kV overhead conductors between the feeder exit and first DT or lateral are as follows:

Table 7: Standard Conductor Configuration & Ratings

Voltage	Conductor Type	Line Configuration	Theoretical Rating
34.5 kV	336.4 MCM ASCR	3-phase, Single Circuit	28.5 MVA
13.8 kV	477 MCM ASCR	3-phase, Single Circuit	13.4 MVA

Cepalco reported that for emergency purposes, there are typically interconnections between feeders providing multiple opportunities to resolve transformer or feeder failures through switching; allowing overhead feeders to be operated closer to the maximum full-time rating of the conductor.

With consideration of the N-1 planning criterion, and where there are two feeders emanating from a substation of the same voltage, PB Associates has made a test comparison of 50% of the theoretical line (conductor) rating against the peak load at the end of the 5 year planning horizon. In the case where there is only one feeder of a given voltage, a conservative test comparison of 100% is used.

Table 8 below lists the distribution feeders included in the test and the results in terms of spare capacity at the end of the planning horizon. Distribution feeders that do not achieve a peak load greater than the utilization threshold on theoretical rating would qualify to be considered for a reduction of the line capacity to a smaller conductor size.

However, as Table 8 shows, there are no feeders that are underutilised at the end of the planning horizon.

Table 8: Distribution Feeders

Substation	Feeder Exit Rating	Utilization Target	Forecast Average Peak Utilization	Optimal? (Y / N)
Carmen				
CAMF1	7.5 MVA	50%	168%	Y
CAMF2	7.5 MVA	50%	184%	Y
CAMF3	10 MVA	100%	225%	Y
Camaman-an				
CARF1	7.5 MVA	50%	96%	Y
CARF2	7.5 MVA	50%	113%	Y
CARF3	10 MVA	100%	222%	Y
Tagoloan				
TAGF1	10 MVA	50%	240%	Y
TAGF2	10 MVA	50%	129%	Y

Network Optimization – 69kV, 34.5 and 13.8 kV Circuit Breakers

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

The following table summarises the breaker rating and fault level:

Table 9: Fault Levels

By Transco	3Ø Bus fault level	1Ø Bus fault level	CB fault rating	Optimal? (Y / N)
Natumulan feeders				
CAMF1	3701	4488	25kA	Y
CAMF2	3700	4487	25kA	Y
CAMF3	1513	1800	25kA	Y
CARF3	1370	1613	25kA	Y
Carmen Feeders				

CARF1	2126	2569	25kA	Y
CARF2	2125	2569	25kA	Y
Aplaya Feeders				
TAGF1	2629	3345	25kA	Y
TAGF2	2629	3345	25kA	Y
Carmen Subs				
Cepalco M1	1042	974	25kA	Y
Aplaya Subs				
Cepalco M2	2890	3187	25kA	Y
Natumulan Subs				
Cepalco M3	3002	3315	25kA	Y

The minimum breaker rating available generally in the market from switchgear manufacturers at 34.5kV and below is 25kA. At 69kV the minimum breaker rating is 40kA. Accordingly PB Associates finds that the existing switchgear is optimal.

System Optimization - 34.5 and 13.8 kV Feeders

In accordance with the ERC Asset Valuation Guidelines, PB Associates has not optimised the distribution feeders beyond the first line transformer or tee-off point. 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 feeder network from an economic perspective. However, PB Associates has examined the Cepalco feeder network and concludes that there is no scope for optimisation.

2.4 OVERHEAD CONDUCTORS & DEVICES

Network Optimization – Overhead Conductors

Optimization of overhead conductors is dealt with under Section 2.1.2 and 2.3.1.

Network Optimization – 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 Cepalco Single Line Diagrams and finds that there is no scope for optimising out Cepalco line switches.

Network Optimization – Overhead Devices

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

2.5 LINE TRANSFORMERS (DT'S)

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

From an engineering design perspective, the number of customers per line transformer is an indicator of the efficient matching of load and location. The number of customers per line transformer is shown in Table 10:

Table 10: Customers per Line Transformer

Sector	Customers per Line Transformer
Cepalco	49.1

This figure is at the high end of the range observed amongst the Philippines DUs – a range of between 40 to 50 customers per DT.

Accordingly, PB Associates finds that there is no scope to optimise DTs from an engineering design perspective i.e. the location of DTs is optimal.

From the perspective of capacity optimization, the relevant utilization targets for DTs are taken from the ERC Asset Valuation Guidelines as follows:

Table 11: ERC Utilization Targets

Existing DT Capacity	Class Assumption	Utilization at 5 yr planning horizon	Actual kVA loading	Optimise to RC[5] of DT with capacity of
15kVA	Residential	> 0%	Up to 15kVA	15kVA
25kVA	Residential	< 50%	<12.5kVA	15kVA
37.5kVA	Residential	<50%	<18kVA	25kVA

[5] RC – Replacement Cost

Existing DT Capacity	Class Assumption	Utilization at 5 yr planning horizon	Actual kVA loading	Optimise to RC[5] of DT with capacity of
50kVA	Residential	<50%	<16kVA	25kVA
75kVA	Commercial	<50%	<37.5kVA	50kVA
100kVA	Commercial	<50%	<50kVA	75kVA
167kVA	Industrial	<50%	<70kVA	100kVA
333kVA	Industrial	<50%	<167kVA	167kVA

The Cepalco asset register holds a total of 1959 DTs in use.

The most common (standard) sizes of DTs used by Cepalco are as follows:

Table 12: Cepalco Standard DTs

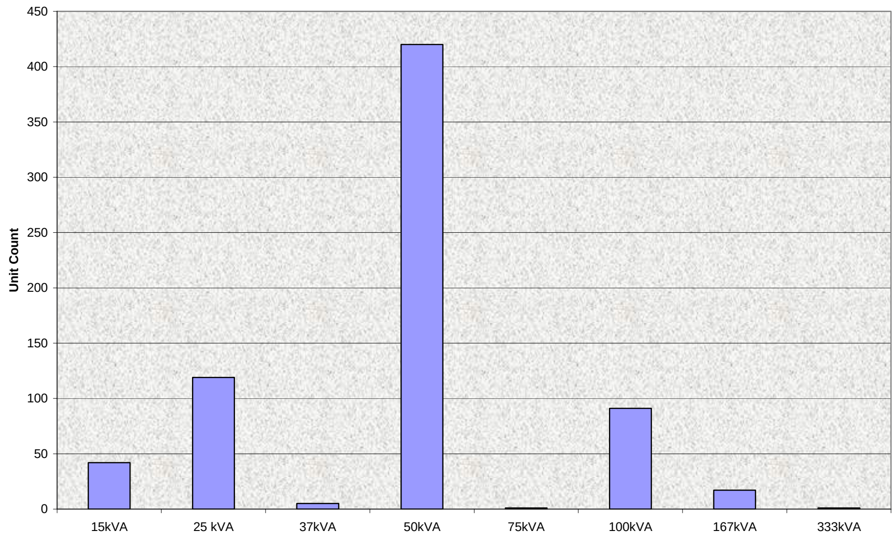
DT Type by Voltage	DT Rating
34.5kV / 19.92kV-240/120V; 1PH; Pole Mounted	25kVA
34.5 / 19.92kV-240/120V; 1PH; Pole Mounted	50kVA
34.5 / 19.92kV-240/120V; 1PH; Pole Mounted	100kVA
13.8 (13.2) kV-240/120V; 1PH; Pole Mounted	15kVA

Cepalco provided PB Associates with DT utilization statistics from current day to the end of a 5 year planning horizon (2012). PB Associates reviewed the basis for forecasting and is satisfied that the approach is robust. Cepalco assume an annual load growth of 4.16% which is within World Bank estimates as shown in Section 6 of this valuation report.

Cepalco statistics show that thirty six percent of DTs (710) will achieve a loading of less than 50% by the year 2012. Of this count, 15 are considered as stranded (0% utilization).

Figure 1 shows the breakdown by capacity and count.

Figure 1: Capacity and Count of DTs < 50% Utilised by 2012



The following table provides the revised count. The replacement cost of each suboptimal size is reduced by the difference between the larger size and the next lowest size replacement cost for each capacity of DT:

Table 13: Suboptimal DTs

Existing DT Capacity	SubOptimal Count	Optimal Size	Unit Cost Difference (Pesos)	Total ORC Adjustment (Pesos)
Stranded DTs	15	Varied[6]	Various	1,431,891
34.5kV 10kVA	4	34.5kV 10kVA	0	0
13.8kV 10kVA	3	13.8kV 10kVA	0	0
34.5 kV 15kVA	19	34.5kV 15kVA	0	0
13.8 kV 15kVA	22	13.8kV 15kVA	0	0

[6] Stranded 34.5kV DTs as follows: - 10kVA – 0; 15kVA – 0; 25kVA – 4; 37.5kVA – 0; 50kVA – 9; 75kVA – 0; 100kVA – 0; 167kVA – 2; 250kVA – 0; 333kVA - 0.

Existing DT Capacity	**SubOptimal Count**	**Optimal Size**	**Unit Cost Difference (Pesos)**	**Total ORC Adjustment (Pesos)**
34.5kV 25kVA	60	34.5kV 15kVA	6,400	384,000
13.8kV 25kVA	58	13.8kV 15kVA	27,600	1,600,800
34.5kV 37.5kVA	0	34.5kV 25kVA	2,472	0
34.5kV 50kVA	0	34.5kV 25kVA	0	0
13.8kV 50kVA	343	13.8kV 25kVA	3,554	1,219,022
34.5kV 75kVA	0	34.5kV 50kVA	0	0
34.5kV 100kVA	21	34.5kV 75kVA	41,700	875,700
13.8kV 100kVA	69	13.8kV 75kVA	45,400	3,132,600
34.5kV 167kVA	3	34.5kV 100kVA	36,078	108,234
13.8kV 167kVA	14	13.8kV 100kVA	29,100	407,400
			Total	9,159,647

Accordingly PB Associates considers that in total, distribution line transformers need to be optimised by a total of Php9,159,647.

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.

PB Associates observes that the total capacity of Cepalco installed line capacitors is only 12.9 MVAr. This compares to around 160MVA of installed line transformer capacity.

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

2.7 METERS

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

Table 14: Metering Class ID by count

Metering Class ID	Description	Reported Count
Schedule 16	Street Lighting	46
Schedule 26	Residential	79,670
Schedule 36	General Service – Small	14,449
Schedule 46	General Service – Large	1,867
Schedule 56	General Power – Small	334
Schedule 66	General Power – Large	1
Schedule 76	Bulk Power	11
Schedule 86	Bulk High Voltage	1
Schedule 96	Bulk HV Wheeling	1
Total		**96,380**

During the process of converting Cepalco's Fixed Asset Register to an ODRC register, the meters were re-allocated to a new asset type using the following conversion table:

Table 15: ODRC Metering Class IDs

Metering Class ID	ODRC Meter Description
16 or 26	1 phase, 15A or Class 100
36	1 phase, 30A or Class 200
46	3 phase, 15/30A, Class 100/200
56 to 96	3 phase, 2.5A, instrument rated

Following the re-categorisation the total numbers of meters included in the asset register in each asset class was:

Table 16: Total Count After Re-Allocation

Metering Class ID	Meter Totals
16 or 26	123,191
36	1,139
46	5,722
56 to 96	1,300

Given the total numbers of customers and the stock requirement calculations (provided by Cepalco), PB Associates has determined that the optimal number of meters required for each class are as follows:

Table 17: Optimal Meter Counts

Metering Class ID	Customers	Stock	Meter Totals
16 or 26	79,716	5,986	85,702
36	14,1449	1,151	15,600
46	1,867	246	2,113
56 to 96	348	9	357

Comparing the last columns in Tables 16 and 17, it can be seen that Metering classes 16 or 26, 46 and 56 to 96 have excessive meter counts, while Metering Class 36 does not contain sufficient meters.

Optimization Principle

When it is not possible to locate an individual item for optimization, such as is the case for repetitive assets, optimization should be applied across an entire standard asset category

To achieve this, the following formula can be used.

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

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:

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

Cepalco Meter Optimization

i) Class 56 to 96 meters

943 of these meters (1,300 – 357) are to be optimised to Class 36 meters. This amounts to a total reduction of Php91,926,469.

ii) Class 46 meters

3,609 of these meters (5,722 – 2,113) are to be optimised to Class 36 meters. This amounts to a total reduction of Php8,921,448.

iii) Class 36 meters

No optimisation is required. When taking into account the Class 46 and 56 to 96 meters being optimised to Class 36 meters, there is still a short fall of 9,909 meters.

iv) Class 16 or 26 meters

At present there is and excess of 37,489 meters (123,191-85,702). However as each metering point requires a meter it is assumed that lower class meters are used to make up the short fall of Class 36 meters. Therefore in total only 27,580 meter (37,489 – 9,909) can be optimised out. This amounts to a total reduction of Php66,124,404.

Accordingly PB Associates considers that in total, meters need to be optimised by a total of Php166,972,321.

2.8 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.

Cepalco has 93,032 LV service cables.

The ODRC register contains 2,700,109 meters of LV service cables.

With a DT count of 1959, the count of LV services per DT is 47.4, compared to Cepalco’s reported score of 49.1.

A count of 47.4 LV services per DT, would equate to an average of 29 metres of LV service cable per service. (This compares to an average of 22 for Decorp). PB Associates considers this to be a reasonable average.

Accordingly, PB Associates finds there is no case to further optimise LV service cables.

2.9 OTHER ASSET SUBCATEGORIES

PB Associates does not propose to optimise minor or specialised asset subcategories as the decision to install such assets is determined by customer needs. Such needs relate to reliability of supply considerations - reclosers, line switch placements are examples - or community needs - streetlights are an example. Experience shows that there is minimal scope for optimization and in any case materiality is not affected.

3. SPARES

3.1 SUBSTATION ASSETS

PB Associates has examined the spares holding reported by Cepalco in spreadsheet “SubstationSpares_inventory051230.xls”.

We find that the following spares held in store and at substations should be allowed in the valuation:

Spare	Spare for	Value (Pesos)
Transformer Bushing	Spare for 30MVA transformer	118,191
Transformer Bushing	Spare for 30MVA transformer at Tagoloan	82,444
Bushing for Oil CB	Spare for 2000A, 69kV OCB	82,114
Station Type 60kV Arrester	Spare for Tagoloan & Camaman-an Substations	56,871
Power Fuse Refill	Spare for Carmen substation	9,843
Interrupter	Spare for 69kV OCB	7,500
Trip Coil	Spare for Camaman-an Substation	2,984
Bushing Studs various	Spare connectors	57,000
Gould Battery Charger	Spare for Camaman-an Substation	77,699
Outdoor CT	Spare for Camaman-an Substation	71,460
Outdoor VT	Spare for Camaman-an Substation	22,108
Station Post Insulator	Spare for Camaman-an Substation	6,973
Spares in use at Tagoloan Substation	PT, VT, various spare parts – spares for Tagoloan and Camaman-an Substations	330,204
Spares in use at Camaman-an Substation	VT, various spare parts – spares for Tagoloan and Camaman-an Substations	191,743
Spares in use at Carmen Substation	Gould Battery Charger – spare for Tagoloan and Camaman-an Substations	77,700

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.

The following sections provide details in support of this position, drawn from records as recorded in spreadsheets –

- "Dist_items_inventory051230.xls";
- "KWHMETER_SPARES060623.xls"; and
- "KWHMeterSpares_Justification060623.xls".

Meters

Meters spares and optimization was addressed in Section 2.7.

Line Transformers

Line transformer spares were reported to amount to 29 units, or 1.4% of the total population installed. This implies an average failure rate of 6 units per annum.

Included in the spares is a mix of line transformers with non-standard and standard secondary voltage ratings. PB Associates considers that this spares holding is optimal.

Switches, Capacitors and Line Breakers

Cepalco holds a range of spare line switches, capacitors and Automatic Voltage Regulators. In fact, the inventory listing suggests that many of these items are under-stocked.

PB Associates considers that the re-order level for the major items and current stockholding is appropriate.

Poles

Pole spares were reported to amount to 18 concrete poles (0.2% of 8360 poles in use), and 40 steel poles (11% of the 377 steel poles in use).

PB Associates considers that the stockholding is based on local supply of concrete poles, while steel poles are fabricated outside Mindanao.

In both cases, the poles in stock cover the full range of poles sizes and for any individual category there is no scope for optimization.

Conductor

Cepalco has approximately 132,000 meters of conductor in stock spread evenly across the most common sizes. Included are smaller amounts of the less common sizes.

Cepalco has approximately 3,000,000 meters of conductor in use (including service lines and streetlights). The stockholding amounts to less than 5%.

If this conductor was to be replaced at say 3% - 5% per annum (20-30 year life), without accounting for network expansion or typhoon damage, the spare conductor would be consumed in one to two years.

Accordingly, PB Associates considers that the stock holding of conductor is appropriate.

Other Line Hardware

Cepalco has 93,000 items of line hardware. Such items include bolts pole bands, clamps etc.

PB Associates considers that while some items may appear excessive in quantity, the value of such items means that the stockholding is not material to the valuation. Volume purchasing of these items is likely to result in favorable prices as well. Accordingly PB Associates does not propose to optimize stores holding for this category.

4. CEPALCO LOAD FORECASTING TECHNIQUES

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

4.1 GENERAL

Cepalco forecasts electric load growth based upon the analysis of historical system load data, known major load addition plans (such as incoming bulk power customers, new commercial and industrial customers and large residential or subdivision customers), and city planning proposals.

Load forecasts are normally derived from system peak distribution substation readings. The majority of the substation demand data was reported to be recorded with digital meters read and manually logged by substation tenders. The development of accurate and coincident system data collection is recognized as an important factor for future improvement of distribution system analysis and planning.

Major load additions and load transfers that could result in inaccurate feeder load projections are addressed as “block loads and transfers”, independent of the load growth trend analysis for each feeder area.

Load growth trends are developed for each feeder planning area utilizing five years of adjusted historical peak data according to the best-fit linear equation:

$$y(x) = \text{load}(x) = b_0 + b_1 * x$$

where, x represents a consecutive year in which load data has been provided or load is forecast beginning with the year x = 0,

y(x) is the load predicted in year x by the linear trend,

$$b_0 = \left(\sum y \sum x^2 - \sum x \sum xy\right) / \left(n \sum x^2 - \left(\sum x\right)^2\right),$$

$$b_1 = \left(n \sum xy - \sum x \sum y\right) / \left(n \sum x^2 - \left(\sum x\right)^2\right),$$

and n is the total number of years of load data (typically 5).

The “fit” of the data to the linear trend is represented by a regression coefficient defined by:

$$r = \left(n \sum xy - \sum x \sum y\right) / \left(\left(n \sum x^2 - \left(\sum x\right)^2\right)^{1/2} \left(n \sum y^2 - \left(\sum y\right)^2\right)^{1/2}\right)$$

The regression coefficient cannot be greater than one. Regression coefficients greater than 0.8 are considered to be sufficient for short-range distribution planning efforts.

The feeder area load forecasts are generated by superimposing existing and predicted major load additions and system load transfers on the derived linear trend. These feeder area forecasts provide an appropriate perspective for the analysis of distribution system performance and the development of system operating and capital construction proposals.

The 24-hour peak load profiles of feeders are being used to get the approximate coincident peak load projection for the distribution substation transformers. Cepalco reported that feeder load forecasts are provided for a five-year time frame.

PB Associates considers that the sophisticated forecasting techniques in use by Cepalco are robust.

4.2 LOAD FORECAST CALCULATIONS

Table 17 below shows the electricity growth forecasts for the Cepalco power system from 2005 to 2022.

Table 17: Cepalco Electricity Growth Forecasts[7]

Year	Cepalco Forecast Energy Growth (GWhrs)	Cepalco Forecast Demand Growth (kW)	Demand Growth
2005	598	112,900	
2006	659	131,900	4%
2007	711	140,170	4%
2008	731	144,780	4%
2009	751	149,470	4%
2010	782	156,000	4%
2011	804	161,260	4%

Table 18 is a World Bank forecast for Region 10 which includes Cepalco's service territory.

Table 18: World Bank System Growth Forecast from 2005 to 2014

CEPALCO	2005	2006	2010	2014
System Loss (%)	7.7	7.7	7.7	7.7
Electricity Growth (GWH)	669	709	897	1133
Electricity Sales (GWH)	616	654	826	1044

[7] Source of the data: Cepalco Load Forecast: FeederForecast_PBR_Final_Draft_060627.

The World Bank forecast for Region 10 is 6% per annum. Cepalco's load forecast for the planning horizon is a flat 4%. Therefore Cepalco is taking a conservative position.

PB Associates considers the load forecasting technique provided by Cepalco as robust and the forecasts as verified.