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Cost-Effective Programming of Electric Demand in the University of the Philippines Diliman

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We analyze the electric energy usage and improve the electric demand programming of the University of the Philippines Diliman which maintains more than a hundred separate agreements for the sale of energy by Meralco to its academic buildings. Each agreement covers a unique power-meter account and obligates UP Diliman to pay a monthly electric demand charge that depends only on guaranteed minimum billing demand (GMBD) and not on actual electric demand. In 2010, the actual monthly demand in 34 of 109 accounts always stayed below their GMBD ratings. UP Diliman and Meralco reviewed the agreements and modified the GMBD ratings of 26 accounts to depend on maximum actual monthly electricity consumption in the previous billing year. The new GMBD ratings were first applied in March 2012 and the total electricity bill for the 26 accounts from March to September 2012 was approximately 30% less than what would have been paid using the original GMBD ratings for the same consumption, electricity cost and overhead charges. The 2013 bill of UP Diliman was 2.5% higher than that in 2012 while those in the 2012 and 2011 were higher by 7% and 2.8%, respectively. In contrast, relative consumption increased by 5.6%, 4% and -1.9% in 2013, 2012 and 2011, respectively. A consumption-based GMBD rating scheme is essential if the adoption of more efficient devices and energy-saving measures is to actually lower the electricity bill. Our work illustrates the benefits of accurate demand programming and meaningful public-private partnership in the operation of a public academic institution.

Key words: campus operations, electricity consumption pattern, energy usage programming, guaranteed minimum billing demand, public-private partnership

INTRODUCTION

Electricity prices in Metro Manila (MM) are the third highest among fourteen major cities in North and Southeast Asia plus Australia and New Zealand in January 2013 - third in overall residential tariff, third in generation cost, third in grid charges, and third in tax rates (The Lantau Group HK Limited 2013). Given tight budget allocations for campus operations and maintenance, higher education institutions (HEIs) are increasingly pressured to predetermine accurately the energy cost of running their academic buildings and facilities. The accurate programming of the electric demand of a single building can result in considerable savings that may be utilized to provide more and better services to stakeholders while keeping matriculation at highly affordable levels.

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The Manila Electric Company (Meralco) is the sole electric power distributor in 36 cities and 75 municipalities in MM, Bulacan, Cavite, Rizal and Laguna (except the 4th district) with a market size of 5.8 million customers (Meralco 2016). Meralco energizes several of the leading HEIs in the country including the three largest constituent universities (CUs) of the University of the Philippines (UP) together with seven other state universities and colleges (SUCs) in MM, and another five in the aforementioned provinces. The three CUs - UP Diliman (43.6%), UP Los Baños (24%) and UP Manila (16.4%), together employed 84% of all regular UP faculty members in April 2011 (Saloma 2016). In AY 2011 - 2012, 59% and 43.9% of all UP graduate and undergraduate students respectively, were enrolled in UP Diliman where its scientists and researchers also produced 51.8% of all SCOPUS-indexed publications of UP from 2009 to 2015. The output of UP accounts for 35.6% of all SCOPUS publications emanating from the Philippines within the said period.

Here we analyze the electricity consumption of UP Diliman and describe the outcome of our effort to enhance the cost-effectiveness of the electric demand programming of its key academic buildings and R&D infrastructures in a manner that is compliant with Meralco billing procedures for computing the monthly electric demand charge. Because of its pivotal role in implementing publicly funded R&D projects in the country as well as in the training of future Filipino scientists and researchers, efforts that tangibly improve campus operational efficiency are valuable not only to UP Diliman but also to other HEIs.

UP Diliman operates the National Science Complex and the Engineering Complex, which are critical in the success of the Advanced Science and Technology Human Resource and Development Program (ASTHRDP) and the Engineering Research and Development for Technology Program (ERDT). The ERDT and the ASTHRDP were established by the Department of Science and Technology in 2007 and 2009 respectively, to increase the number of PhD and MS graduates in the sciences, technology, engineering and mathematics by pooling together the expertise of qualified PhD faculty members and by broadening access to existing R&D facilities in the country. Only ten out of the 1,935 HEIs accredited by the Commission on Higher Education in AY 2014 - 2015 were assessed to have the wherewithal to participate in either program.

We point out that foreign education institutions have long been actively engaged in formulating more reliable electric demand programs and measures to reduce operational cost and to minimize the carbon footprints of their key academic and research infrastructures (Askounis & Psarras 1998; Butala & Novak 1999; Darby 2006; Demanuele et al. 2010; Desideri & Proietti 2002; Dimoudi & Kostarela 2009; Hong et al. 2014; Petersen et al. 2007; Sadeghi Keyno et al. 2009; Santamouris et al. 2007; Stuart et al. 2007). The adoption of such practices in the Philippines is long overdue particularly by the financially challenged public HEIs.

Our presentation proceeds with the second section explaining briefly the key concepts of contracted capacity (CC), guaranteed minimum billing demand (GMBD), actual electric demand and the electric demand charge. The third section describes the methodology employed to obtain the electricity consumption and billing information of UP Diliman buildings from 2005 to 2012. The retrieved information is presented in the fourth section. The fifth section describes five alternative schemes for reducing the difference between actual electric demand of an account and its GMBD rating. It also narrates the joint effort undertaken by UP Diliman and Meralco to reduce the cost of energizing the campus buildings. The sixth section discusses possible ways of enhancing the electric demand programming in an SUC setting while the seventh and last section concludes the presentation of work. Supplementary data on the electricity consumption and bills of various buildings are presented in the Appendix.

PRELIMINARIES

Agreement for the Sale of Electric Energy

The electricity consumption [in kilowatt-hour (kWh)] of an electrical load is monitored monthly from a power-meter that is tagged with a unique Meralco account number. The account is covered by a service contract called the Agreement for the Sale of Electric Energy (ASEE). An ASEE account is classified either as: (1) Residential Service, (2) General Service, (3) General Power, (4) Hospital and Charitable Institution, (5) Streetlight or (6) Generator account (Meralco 2016). General Service accounts are for non-industrial and industrial customers with a maximum electric energy demand of less than 40 kW for general power, heating and/or lighting while General Power accounts are for those with a minimum demand of 40 kW. Residential Service accounts are assigned to single-meter family dwellings.

A new ASEE is forged when a new load (e.g. newly commissioned building) is connected to the electric grid or when a new meter is installed. It is valid for several years and is renewed periodically upon mutual consent of the load-owner and Meralco. The cost of energizing a load is indicated in a monthly billing statement (electricity bill) that is distinguished with a unique Service Identification

Number (SIN). The monthly billing statement contains information about previous monthly meter readings, base rate as well as the price and breakdown of the various charges that are imposed on the consumer. The charges include those that are related to energy generation, transmission and distribution loss, distribution cost, government taxes, and others.

Guaranteed Minimum Billing Demand and Minimum Monthly Electric Demand Charge

The monthly electric demand charge (MEDC) that Meralco imposes on an account depends on the specifications of the duly approved general electrical design that specifies the type (power ratings) and number of equipment and fixtures found inside the edifice. The MEDC does not depend on the usage-frequency of the equipment or on the number of users.

Electric demand (in kW) is the rate of energy influx required for a load to work properly. Electricity consumption (in kWh) is the actual electric demand over a period of time (e.g. one month), which translates to the amount of energy consumed by the load. Electric demand increases with the number of equipment and fixtures that can be used independently. To illustrate, ten 100-watt bulbs that are lighted simultaneously for one hour would consume the same amount of energy (in kWh) as that of a single 100-watt bulb powered for ten hours. However, the electric demand (in kW) of the 10-bulb load is ten times larger because its proper operation would require more components and materials than a single-bulb load.

In terms of electricity distribution, Meralco assumes that a building is operated at its contracted capacity (CC), which is equal to seventy percent (70%) of the total load being applied. The guaranteed minimum billing demand (GMBD) is computed from CC as follows:

$$\text{CC (kW)} = 0.70 \times \text{Total Applied Load} \quad (1)$$

$$\text{GMBD (kW)} = 0.70 \times \text{CC} \quad (2)$$

The value of the total applied load is determined from the general electrical design of the building-load while the GMBD represents the minimum electric demand of the load at any given time.

Meralco computes the MEDC in the following manner - if the actual monthly electricity consumption is less than or equal to (GMBD times one hour) then:

$$\text{MEDC (PhP)} = \text{GMBDh} \times \text{Generation Cost (PhP/kWh)} \quad (3)$$

where: GMBDh = GMBD x 1-hour. Otherwise,

$$\text{MEDC} = \text{Actual monthly electricity consumption} \times \text{Electricity Cost} \quad (4)$$

Equation (3) defines the minimum MEDC that an account owner is obliged to pay even when the actual monthly electricity consumption is less than GMBDh. The total monthly electricity bill is the sum of the MEDC together with other types of charges mentioned previously in the Preliminaries.

In general, only General Power ASEE accounts are given non-zero GMBD ratings that may vary from one account to another. For safety and economic reasons, a building must be operated below its assigned CC but above its GMBD rating. Meralco imposes the minimum MEDC requirement in order to recoup the cost of constructing and maintaining the distribution infrastructure needed to energize a building safely and properly. The said infrastructure usually includes an electric transformer, wires, posts and other appurtenances that are installed before the power-meter location. It allows Meralco to consistently provide the same power output to the load regardless of the time of day or month. Buildings that are designed to operate at larger applied loads are assigned higher GMBD ratings since they require an infrastructure base with a higher power capacity.

METHODOLOGY

We extracted the information about the GMBD and CC ratings, actual monthly electric demand and billings of all General Power accounts of UP Diliman from the monthly Meralco billing statements that were issued from January 2005 to September 2012, and are kept by the Utilities Management Team of the Office of the Vice Chancellor for Administration. We secured proper authorization to scrutinize the said records from the Office of the Chancellor. Table 1 summarizes the types of accounts held by UP Diliman in 2010.

Table 1. Classification of campus buildings based on contracted capacities. Only General Power accounts are assigned non-zero GMBD ratings.

ASEE Account Classification	Contracted Capacity Range (kW)	Examples
General Power	40 and above	Majority of campus buildings (109)
General Service B	5 to less than 40	Campus Maintenance Office Generator House, College of Home Economics, Kapitbalay
General Service A	0 to less than 5	UP Administration Commercial Center, Department of Citizens Military Training-Vanguard
Others		(DZUP Transmitter (residential), UP Health Service (hospital), Streetlights, Flat-rate streetlights, Charitable Institutions

Table A1 in the Appendix enumerates the 109 General Power accounts held by UP Diliman in 2010. Forty-two (42) are categorized as typical accounts with GMBD ratings that are computed using Equation (2). Seventeen (17) accounts have GMBD ratings that are still CC dependent but do not follow Equation (2). Their corresponding MEDCs are still computed using Equations (3) and (4). The rest (50) are given GMBD ratings of zero and are not subject to a minimum MEDC.

Equation (2) was first applied in March 2010 - a month after Meralco issued separate letters to inform various end-users (colleges, institutes, departments, etc.) about the modification of their service contracts in accordance with Energy Regulatory Commission Case Nos. 2008-004RC and 2008-018RC. Until February 2010, the GMBD rating was fixed at 40 kW for each of the 59 accounts with non-zero GMBD ratings. The application of Equation (2) generally resulted in a higher MEDC for the same actual electric demand and has discouraged the adoption of more efficient devices and measures that could reduce electric demand to less than the GMBD rating since such measures would not affect the MEDC.

ACTUAL ELECTRIC DEMAND AND ELECTRIC DEMAND CHARGE

Electricity Cost in UP Diliman

From fiscal year 2005 to 2012, electricity consumption in UP Diliman increased at an average yearly rate of 1.35% with the corresponding electricity bill rising at a faster rate of 6.28%. The annual bills of UP Diliman from 2010 to 2012 are: PhP 175.67M (total consumption: 16.46M kilowatt-hours), PhP 180.58M (16.12M kWh) and PhP 193.203M (16.8 kWh) (Saloma 2014). Consumption growth is mainly driven by the integration of additional infrastructure loads like the new buildings and research facilities in the National Science Complex and the Engineering Complex.

Electricity cost is paid with public funds that are earmarked for the maintenance, operations and other expenses (MOOE) of UP Diliman. The following were the allocations of UP Diliman from the annual UP Budget: PhP 2.47B (33.97% of UP Budget) in 2010, PhP 1.8995B (30.76%) in 2011 and PhP 1.624B (26.28%) in 2012 (Saloma 2016). The UP Budget features specific allocations for personnel services, MOOE, capital and equipment outlays. In the 2011 UP Budget for example, only PhP 98.243M was allotted for the MOOE of UP Diliman, which was insufficient to pay for the cost of electricity (PhP 180.58M) and water (PhP 76.85M) consumption not to mention the cost of the janitorial (PhP 52M) and security (PhP 88.16M) services for the said year. UP Diliman supplements its MOOE budget with income generated from tuition fees and use of its campus land and infrastructure assets by third parties.

GMBD Ratings and Actual Electric Demand of UP Diliman Accounts

Table A2 (Appendix) tabulates the CC and GMBD ratings, actual electric demand and the electricity bills of 109 General Power accounts in 2010. Highlighted are thirty-four (34) accounts where the minimum MEDC exceeds the average monthly MEDC computed via Equation (4) using the average monthly electricity consumption. Table 2 indicates that the thirty-four (34) accounts had a total average actual monthly electric demand of 2,542.5 ± 302.60 kW that is equivalent to only 56.86% of their combined GMBD rating of 4,471.22 kW. The total minimum MEDC of UP Diliman in 2010 exceeds the MEDC that is computed using the actual electricity consumption of the thirty-four (34) accounts.

The Dynamo Testing Laboratory of the Department of Mechanical Engineering produced the largest difference of 235.92 kW between its GMBD and average actual monthly demand. Following are the National Institute of Geological Sciences (NIGS) Building and the NBS Building with average differences of 163.50 kW and 127.40 kW, respectively. Throughout the year 2010, the actual monthly demand remained relatively steady with peaks and troughs not exceeding ±12% from the monthly average.

The Math Building in the National Science Complex is a good example of a high-usage academic building with many classrooms, offices and support facilities that cater to the needs of a large number of mathematics faculty and students. It is operated by the Institute of Mathematics which is mandated to offer mathematics courses for both undergraduate and graduate students in UP Diliman.

Figure 1 plots monthly electric demand of the Math Building in 2010 against the assigned CC (250 kW) and GMBD (175 kW) ratings. Its actual monthly demand (average: 115 ± 13.63 kW) always remained below its GMBD rating to produce an unused average difference of 60.56 kW per month. At a rate of PhP 247 per kWh UP Diliman paid a total of PhP 179,499.84 in unused contracted power supply in the said year for the Math Building.

Also listed in Table 2 is the Dynamo Testing Laboratory that was built as a research and service facility. Its average monthly demand in 2010 was 9 ± 0.79 kW, which is significantly lower (at only 3.67%) than its assigned GMBD rating of 245 kW. The unused monthly GMBD is 236 kW that cost PhP 699,504.00 for the entire year. The thirty-four (34) accounts listed in Table 2 produced a total unused GMBD of 1,958.98 kW per month that costs PhP 5.81M in 2010.

Table 2. The thirty-four (34) accounts with GMBD ratings that exceeded the average actual monthly demand in 2010.

Account	CC (kW)	GMBD (kW)	Average Monthly Demand (kW)			Unused GMBD (kW)	Unused GMBD as percentage (%) of GMBD
ME LAB DYNAMO TESTNGLAB	350	245	9.08	±	0.00	235.92	96.29
NIGS GEOLOGY BLDG	400	280	116.5	±	13.77	163.50	58.39
NBS	210	147	19.6	±	0.00	127.40	86.67
CS SCIE COMPUTER ADMIN	212	148.4	56	±	0.00	92.40	62.26
ENGG LIB & COMP SCIE	319.8	223.86	135.28	±	9.90	88.58	39.57
PALMA HALL OLD MTR	204	142.8	60.87	±	18.95	81.93	57.37
ISMED NLRC BLDG	388	271.6	192.17	±	40.46	79.43	29.25
GT TOYOTA ASIAN CTR	253.4	177.38	98.41	±	15.26	78.97	44.52
COLLEGE OF SCIENCE	284	198.8	120.07	±	14.03	78.73	39.60
CSWCD NEW BLDG	240	168	95.53	±	14.21	72.47	43.14
CMC MEDIA CTR	190.4	133.28	67.26	±	8.88	66.02	49.53
MATH BLDG	250	175	114.44	±	11.85	60.56	34.61
TECHNO MGT (ASTI)	119	83.3	26.77	±	0.00	56.53	67.86
RESHALL KAMAGONG DORM	99.4	69.58	18.18	±	4.32	51.40	73.87
DIL INFO OFFICE	154.7	108.29	58.62	±	0.00	49.67	45.87
RESHALL MOLAVE	117.25	82.08	32.84	±	0.00	49.24	59.99
RESHALL KAMIA	107.8	75.46	26.85	±	0.00	48.61	64.42
CAL NEW BLDG	240	168	119.24	±	18.92	48.76	29.02
FACULTY CTR	400	280	235.32	±	22.03	44.68	15.96
UNIV FOOD SERVICE NEW	80.5	56.35	12.77	±	3.28	43.58	77.34
CENTENNIAL DORM PH 1	62.3	43.61	0.81	±	0.00	42.80	98.14
OVCRD RESEARCH & DEVT	100.75	70.53	30.37	±	0.00	40.16	56.94
GERMAN YIA NEW MTR	70	40	40	±	0.00	0.00	0.00
CENGG OFFICES NEW MTR	480.2	336.14	297.45	±	35.52	38.69	11.51
PALMA HALL NEW MTR	400	280	248.1	±	41.39	31.90	11.39
ARCHITECTURE 1	63	44.1	12.33	±	4.26	31.77	72.04
AISAN INST OF TOURISM	157.5	110.25	80.12	±	11.40	30.13	27.33
BALAY KALINAW	86	60.2	32.2	±	0.00	28.00	46.51
COL OF ARCHI NEW BLDG	135.8	95.06	68.57	±	12.83	26.49	27.87
BIOLOGY INSTITUTE	116	81.2	59.77	±	0.00	21.43	26.39
COMM AFFAIR CTR BLDG	76	53.2	43.54	±	0.00	9.66	18.16
COLL OF HOMECONOMICS	18.21	12.75	7.74	±	0.00	5.01	39.29
DCMT ROTC BARRACKS	7	5	1.14	±	0.00	3.86	77.20
MINING & MET	38.5	5	4.56	±	1.33	0.44	8.80
TOTAL	**6,431.51**	**4,471.22**	**2,542.5**	**±**	**302.60**	**1,928.72**	**43.14**

TOWARDS A COST-EFFECTIVE ELECTRIC DEMAND PROGRAMMING

Alternative GMBD Rating Schemes

The information in the previous section indicates a compelling need to improve the electric demand programming of a number of existing General Power accounts in UP Diliman. Hence, we proceed to develop alternative GMBD rating schemes for minimizing, if not eliminating, the possibility of the minimum MEDC exceeding the actual MEDC based on actual monthly consumption. Table 3 lists five alternative schemes

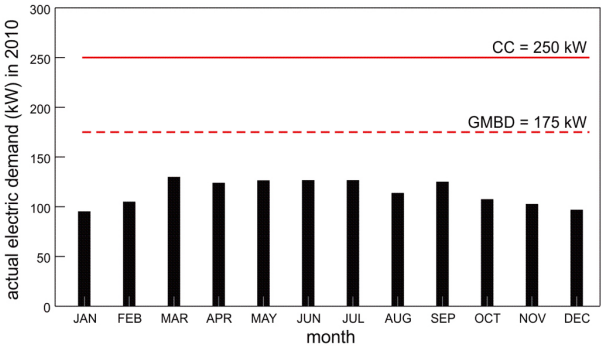

Figure 1. Actual monthly electric demand of Math Building plotted relative to its constant CC (250 kW) and GMBD (175 kW) ratings in 2010. Actual demand (average: 115 ± 13.63 kW) always stayed below the GMBD line at an average unused difference of 60 kW per month.

that abandon the use of CC-dependent Equation (2) in computing for the GMBD rating of an account.

In the $GMBD_{max}$ scheme, the GMBDh is made equal to 70% of the highest monthly electricity consumption in the preceding billing year (12-month period). In the $GMBD_{ave}$ scheme, the GMBDh is equal to 70% of the average monthly consumption while in the $GMBD_{min}$ scheme, the GMBDh corresponds to 70% of the lowest monthly consumption. In the $GMBD_{40}$ scheme, the GMBD rating is held equal to 40 kW – the policy of Meralco prior to March 2010 as mentioned in the Methodology. In the four aforementioned schemes, General Power accounts are still subject to paying a minimum MEDC that is computed via Equation (3). In the $GMBD_0$ scheme, a zero GMBD rating is imposed and the MEDC is always computed using Equation (4).

Table 4 presents the hypothetical total electricity bills of UP Diliman in cases when the five GMBD rating schemes are applied on the actual monthly electric demand data in 2010. The bills are estimated using the same electricity cost (PhP 247/kWh) and other overhead charges for transmission, distribution and system loss, taxes, etc. The $GMBD_{max}$ scheme produces the least possible reduction of 3.86% (PhP 6.585M) relative to the actual bill paid (PhP 175.08M) in 2010 while the $GMBD_0$ scheme offers the largest reduction of 9.13% (PhP 15.99M).

Figure 2 illustrates the possible effect of the $GMBD_{max}$ scheme when applied to the 2010 monthly electric demand data of the Math Building. The scheme would shift the actual monthly demand to relative positions that are always above the $GMBD_{max}$ line but still below the CC line for safe operation. Its hypothetical adoption would reduce the 2010 electricity bill of the Math Building by PhP 250,000.

Table 3. Alternative schemes for reducing the possibility that the minimum MEDC exceeds the actual consumption-based MEDC in an account. Until February 2012, the GMBD rating was computed equal to 70% of CC. GMBDh = GMBD x 1 hour.

Scheme	Formula for GMBD computation
$GMBD_{max}$	GMBDh = 70% of maximum monthly electricity consumption in previous billing year
$GMBD_{ave}$	GMBDh = 70% of average monthly consumption in previous year
$GMBD_{min}$	GMBDh = 70% of lowest monthly consumption in previous year
$GMBD_0$	GMBDh = 0
$GMBD_{40}$	GMBDh = 40kWh

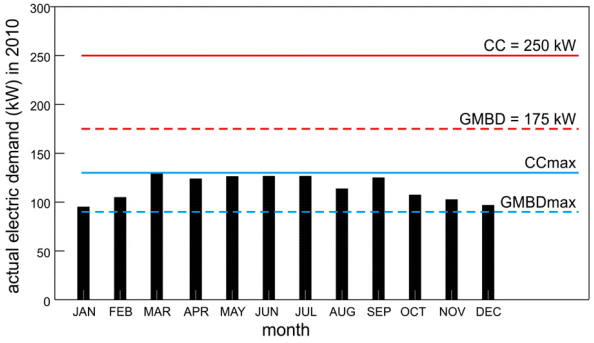

Figure 2. Hypothetical application of GMBDmax scheme to 2010 electric demand data shifts the actual monthly demand of the Math Building to locations that are always above the GMBDmax line (dotted blue line). Maximum actual demand (103.6 kW) happened in March 2010. The GMBDmax is equal to 70% of CCmax. The GMBDmax scheme yields the smallest possible reduction in average MEDC among the five proposed.

Table 4. Comparison of actual electricity bill (2nd column) of UP Diliman with bill estimates produced by the proposed GMBD rating schemes when applied to the same 2010 actual electric demand data from 109 accounts. Also presented are the relative savings (2nd row) and the equivalent percentage reductions (3rd row) generated. The bills are estimated using the same actual electric demand, electricity cost (PhP 247/KWh) and other overhead charges as the one used in the actual 2010 bills.

	$GMBD_{actual}$	$GMBD_{max}$	$GMBD_{ave}$	$GMBD_{min}$	$GMBD_{40}$	$GMBD_0$
Total (in PhP)	175,084,385	168,499,525	167,499,057	166,527,122	163,945,253	159,091,834
Cost Difference (in PhP)		6,584,860	7,585,327	8,557,263	11,139,131	15,992,550
Cost Reduction		3.86%	4.45%	5.02%	6.53%	9.13%

Table A3 presents an itemized comparison of the bills projected to result when the alternative GMBD schemes are applied to the monthly electric demand data of 109 General Power accounts in 2010. The simulations reveal that the five schemes would all lower if not eliminate the possibility of the minimum MEDC exceeding the actual MEDC as computed via Equation (4). UP Diliman would benefit best with a possible shift to the $GMBD_0$ scheme.

Negotiations with Meralco

Implementing a change in the GMBD rating formula would require the concurrence of Meralco since it involves revising the terms of reference used in the original General Power ASEEs. Bilateral meetings were conducted between the authors on behalf of the Office of the Chancellor, and key Meralco representatives from October 2011 until March 2012.

We note that the use of a GMBD rating formula that does not follow Equation (2) has precedents. Our inspection of the billing statements has revealed that before March 2010 Meralco already applied different multiplicative factors (not equal to 70%) to CC in certain accounts that are labeled as atypical cases in Table A1. Examples are those for the National Institute of Physics Building and the College of Music Annex that have lower GMBD ratings equal to 19% and 13% of CC, respectively.

We first negotiated for the adoption of the $GMBD_0$ scheme, which Meralco immediately ruled out citing the need to recover the cost of constructing and maintaining the support infrastructure required to energize properly a building-load. Meralco eventually agreed to adjust the CC and GMBD rating formulas using the $GMBD_{max}$ scheme. For its consideration we proposed a set of new $GMBD_{max}$ ratings for the thirty-four (34) accounts listed in Table 2. Our proposal is based on the application of the $GMBD_{max}$ scheme on the 2010 actual electric demand data.

Meralco agreed to apply the $GMBD_{max}$ scheme to twenty-six (26) accounts (out of the 34) that were mutually identified to produce the largest differences between the original GMBDh values and the maximum actual monthly consumption in 2010. The application of the $GMBD_{max}$ scheme to the other eight (8) accounts would lower their GMBD ratings towards threshold values that necessitate the installation of new support infrastructures to replace existing ones in accordance with Meralco policies. The use of the new $GMBD_{max}$ ratings would not yield substantial MEDC reductions to offset the cost of putting up new installations. Hence the old GMBD ratings were retained for the aforementioned accounts.

Table 5 compares the original GMBD ratings and the new $GMBD_{max}$ and CC_{max} ratings that would be used by Meralco for the concerned twenty-six (26) accounts. The new ratings are slightly different from our original proposal to Meralco that was based on actual electric demand data in 2010. The $GMBD_{max}$ rating per account is calculated as equal to 70% of the CC_{max} rating.

The $GMBD_{max}$ scheme was first implemented in March 2012. In the first six months of application (March – September 2012), UP Diliman paid a total electricity bill of PhP 6.37M for the 26 accounts, which is approximately 30.4% lower than what would have been paid under the old GMBD rating scheme for the same actual electric demand, electricity cost (PhP 247/KWh) and other overhead charges. Table 6 compares the yearly electricity consumption and electricity bills of UP Diliman from 2010 to 2013. The 2013 bill was 2.5% higher than that in 2012. The relative increases in the 2012 and 2011 electricity bills were 7.0% and 2.8%, respectively. In contrast, electricity consumption increased by 5.6%, 4.0% and -1.9% in 2013, 2012 and 2011, respectively.

DISCUSSION

In 2010, the minimum MEDCs of thirty-four (34) General Power ASEE accounts never exceeded their actual MEDCs which meant the payment of PhP 5.59M for contracted but unused power supply. The CC rating of a load becomes unnecessarily high if it is calculated based on erroneous assumptions. A high CC rating requires the installation of a more expensive support infrastructure that includes a transformer with a power rating that is higher than what is actually needed. On the other hand, the underutilization of accurately computed CC rating could occur when a high-power facility or device is not operated near its intended full capacity, which is the case with the Dynamo Testing Laboratory that houses a massive chassis dynamometer.

Differences between the CC-dependent GMBD rating and actual monthly electric demand could arise from inaccuracies in projecting the future energy requirements of a new load. Long-term programming of actual electric demand is difficult to achieve accurately for a new academic building that is going to be utilized for both teaching, administrative and R&D activities. Within the useful life of a building that could easily span several decades, the number and expertise of its users (faculty, staff, researchers, students and guests) are likely to change as a result of unavoidable retirement, transfer, recruitment and graduation. Such changes are usually accompanied by the replacement or upgrade of facilities and equipment that affects the actual electric demand.

In many cases, the CC and the GMBD ratings are computed from the total applied load under an assumption that the building is operated immediately at full capacity.

Table 5. Twenty-six (26) accounts covered by the application of the GMBDmax scheme. Presented are the original CC and GMBD ratings and the new GMBDmax and CCmax ratings. Hypothetical application of GMBDmax scheme on 2010 actual demand data produces an average monthly reduction of PhP 528,449.36 relative to the actual bill. The bills are estimated using the same actual electric demand, electricity cost (PhP 247/KWh) and other overhead charges as the one used in the actual 2010 bills.

Account Name	Original CC (kW)	New CC (kW)	Original GMBD (kW)	GMBDmax (kW)	Average Monthly Cost Difference (PhP)
Asian Inst of Tourism	157.50	88.2	110.25	61.74	13,461.53
Balay Kalinaw	86.00	67.00	60.20	46.90	3,690.75
Biology Institute	116.00	67.00	81.20	46.90	9,518.25
Cal New Bldg	240.00	126.98	168.00	88.89	21,954.14
CENGG Offices New Mtr	480.20	316.82	336.14	221.77	31,736.57
CMC Media CTR	190.40	81.06	133.28	56.74	21,239.30
Col of Archi New Bldg	135.80	80.78	95.06	56.55	10,687.64
College of Science	284.00	109.20	198.80	76.44	1,748.25
Comm Affair Ctr Bldg	76.00	67.00	53.20	46.90	33,954.90
CS Scie Computer Admin	212.00	70.00	148.40	49.00	27,583.50
CSWCD New Bldg	240.00	119.00	168.00	83.30	23,504.25
DIL Info Office	154.70	70.00	108.29	49.00	16,452.98
Engg Lib and Comp Scie	319.80	142.38	223.86	99.67	34,463.84
Faculty Ctr	400.00	270.90	280.00	189.63	25,077.68
GT Toyota Asian Ctr	253.40	144.90	177.38	101.43	21,076.13
ISMED NLRC bldg.	388.00	169.61	271.60	118.73	42,422.26
Library Main	339.00	232.96	237.30	163.07	20,598.27
Math Bldg	250.00	148.00	175.00	103.60	19,813.50
ME Lab Dynamo Tstnglab	135.00	100.00	94.50	70.00	6,798.75
NIGS Geology bldg.	400.00	147.20	280.00	103.04	49,106.40
Ofc of the Registrar	130.90	96.00	91.63	67.20	6,779.33
OVCRD Research and Devt	100.75	67.00	70.53	46.90	6,555.94
Palma Hall New Mtr	400.00	216.80	280.00	151.76	35,586.60
Palma Hall Old Mtr	204.00	67.00	142.80	46.90	26,612.25
Reshall Kamia	107.80	67.00	75.46	46.90	7,925.40
Techno Mgt (ASTI)	119.00	67.00	83.30	46.90	10,101.00

Table 6. Electricity bills and actual electricity consumption of UP Diliman from 2010 to 2013. The GMBDmax scheme was first applied on twenty-six (26) accounts in March 2012. Percentage differences represent increases (+) or decreases (-) relative to the previous year with 2010 serving as baseline.

Year	Total Bill (in millions PhP)	Percentage Difference of Total Bill Relative to Previous Year	Average Monthly Bill (in PhP)	Total Consumption (in millions kWh)	Percentage Difference of Total Consumption Relative to Previous Year	Average Monthly Consumption (in kWh)
2013	198.053	+ 2.50%	16,504,439	17.739	+ 5.61%	1,478,333
2012	193.219	+ 7.00%	16,101,663	16.796	+ 4.01%	1,399,711
2011	180.581	+ 2.80%	15,048,479	16.149	- 1.88%	1,345,806
2010	175.665		14,638,831	16.458		1,371,570

From an administrative point of view, the said assumption is adopted since the operating and maintenance budget of a public building is difficult to increase from one fiscal year to the next. In practice however, a newly connected building needs a settling time before becoming fully operational. Typically, the equipment and facilities are installed and operated in phases after the building is inaugurated. Inaccuracies in electric demand programming are minimized if competent and experienced architects and engineers are involved in crafting the essential design aspects (structural, electrical and mechanical), who will work closely with the building management and resident researchers.

When a new building is proposed in the UP Diliman campus, the Office of the Campus Architect (OCA) is first tasked to develop its conceptual design together with the architectural, structural and electrical specifications in coordination with the end-user unit and in reference to the budget allocation. The OCA technical specifications are then used by UP Diliman to select via competitive bidding an architect-consultant and the construction company that will implement the duly approved project plan. The selection process satisfies the requirements set by Republic Act 9184 – the Government Procurement Reform Act. The accuracy of the initial electric demand programming depends critically on the expertise of the assigned OCA architects and engineers as well as on the information supplied to them by the end-user.

CONCLUSION AND RECOMMENDATIONS

We have shown the financial impact of utilizing a GMBD rating scheme that does not depend on actual monthly electric demand. In 2010, thirty-four accounts underutilized their assigned CCs resulting in UP Diliman paying for minimum MEDCs that exceeded their corresponding consumption-based MEDCs. From 2005 to 2012, electricity consumption increased at an average yearly rate of 1.5% while its corresponding electricity bill rose at a rate of 4.18%.

UP Diliman and Meralco agreed to adopt the consumption-based $GMBD_{max}$ scheme to twenty-six (26) accounts starting March 2012. In the first six months of its implementation ending September 2012, the total actual electricity bill for the twenty-six (26) accounts were estimated to be 30.37% lower than what would have been paid via Equations (1) and (2) for the same actual electric demand, electricity cost and other overhead charges.

In 2013 the electricity bill of UP Diliman was 2.5% higher than that in 2012 (see Table 6). The relative annual increase in its bills was 7.0% in 2012, and 2.8% in 2011, respectively. On the other hand, electricity consumption increased by 5.6%, 4.0% and -1.9% in 2013, 2012 and 2011, respectively. The adoption of a GMBD rating scheme that depends on actual electric demand is essential so that the installation of more efficient electrical devices (e.g. LED lighting systems and variable refrigerant volume air-conditioning units) as well as the adoption of other cost-saving measures, can result in an actual reduction of the electricity bill. Before March 2012, there was no real incentive to improve energy efficiency since the minimum MEDC was independent of the actual electric demand. The impact of the $GMBD_{max}$ scheme is immediate, long-term and pervasive with additional infrastructures being integrated into the electric grid.

We caution that when a new building is first connected to the grid, its initial GMBD rating is computed using Equation (2) because of the need to build an initial 12-month record of actual monthly electric demand values. Hence the adjustment towards the demand-based $GMBD_{max}$ scheme becomes possible only a year after the building is first energized. Due diligence on the part of the Office of the Chancellor is crucial in effecting the said rating adjustment. Failure to adjust promptly to the $GMBD_{max}$ scheme means the continued payment of an electric demand charge that does not depend on actual electric demand.

Our work illustrates the immediate and significant benefit of accurate demand programming and meaningful public-private partnership in the operation of a state university in the Philippines. Publicly funded HEIs could partner with their electric power distributors to rationalize their electricity cost through efficient electric demand programming of their ASEE accounts. Our approach is reproducible and applicable to other public HEIs especially those that are serviced by Meralco.

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APPENDIX – SUPPLEMENTARY DATA

Table A1. Classification of 109 ASEE accounts based on their GMBD ratings in 2010. Account names appear as shown on their billing statements. Electricity consumption of a building complex may be given by the sum of two or more accounts. Classified as atypical accounts are those with GMBD ratings not equal to 70% of CC. For example, International Residence Hall account has a GMBD rating equal to 13% of CC.

Typical GMBD (70% of Contracted Capacity) - 42 Buildings		
BOCOBO, MALCOLM HALL	CSWCD NEW BLDG	CMC MEDIA CTR
EEE VELASQUEZ ST	CAL NEW BLDG	RESHALL KAMAGONG DORM
CENGG OFFICES NEW MTR	OFC OF THE REGISTRAR	TECHNO MGT (ASTI)
MARINE SCIENCE BLDG	RESHALL MOLAVE	OFC OF THE CAMPUS ARCHI
PALMA HALL NEW MTR	MUSIC THEATER (NEW MTR)	RESHALL SANGUMAY
NATL ENGG CTR	CS SCIE COMPUTER ADMIN	UNIV FOOD SERVICE NEW
FACULTY CTR	BIOLOGY INSTITUTE	OVCRD RESEARCH & DEVT
NIGS GEOLOGY BLDG	RESHALL KAMIA	BALAY KALINAW
MBBP ALBERT HALL	COLL OF FINE ARTS	NBS
ISMED NLRC BLDG	AISAN INST OF TOURISM	UPIS INTE SCH K-2
MATH BLDG	PALMA HALL OLD MTR	ARCHITECTURE 1
COLLEGE OF SCIENCE	COL OF ARCHI NEW BLDG	CENTENNIAL DORM PH 1
ENGG LIB & COMP SCIE	COMM AFFAIR CTR BLDG	ME LAB DYNAMO TESTNGLAB
DIL INFO OFFICE	GT TOYOTA ASIAN CTR	COLL OF HOMECONOMICS
Atypical GMBD – 17 Buildings		
RESHAL INTERNATIONAL 13%	PHYSICS NEW BLDG 19%	GERMAN YIA NEW MTR 57%
COLL OF MUSIC ANNEX 13%	COLL OF MASSCOM MAIN 34%	DCMT ROTC BARRACKS 71%
CPDMO MAIN 13%	COLL OF PUBLIC ADMIN 34%	CORPS OF CADETS 89%
MINING & MET 13%	CHEMICAL ENGG 42%	SOLAIR EXT NEW BLDG 93%
CSSP PHAN BLDG NEW MTR 16%	ROMULO HALL NEW MTR 57%	TRACK & FIELD OVAL 95%
UPIS INTEG SCH OLD BLDG 16%	UPIS INTEG SCH MAIN 18%	
Without GMBD – 50 Buildings		
COLLEGE OF EDUCATION	RESHALL YAKAL	VILLAMOR HALL
CHE ALONZO LIBRARY	JVM VARGAS MUSEUM	SURP MAIN PRE-FAB
CS CHEM PAV 1 &11	CHK MAIN GYM	UNIV HEALTH SERVICE X-RAY
NSRI MAIN BLDG	THEATER ACU	DCMT VANGUARD BLDG
ISMED VIDAL TAN	NCTS TRANSPORT TRNG CTR	BENTON HALL OLD OUR
ECONOMICS MAIN	ACCOUNTING/CASHIER	MSI SEAWEED (VILLADOLID)
ISSI MAIN	COMPUTER CENTER	EXEC HOUSE TSANSELOR
COLL OF BUSINES ADM 3RD	SUR MINUTE BLDG	SOLAIR BONIFACIO ACU
RESHALL KALAYAAN	MUSIC ABELARDO HALL	DZUP TRANSMITTER
ST LIGHT	RESHALL ILANG ILANG	SHOPPING ADMIN CTR
UNIV HEALTH SERVICE MAIN	CENGG PROCUREMENT	CHE HOMECONOMICS EXT
FILM CENTER	SOLAIR BONIFACIO HALL	HARDIN NG DONA AURORA
ECONOMICS LIBRARY	RESHALL SAMPAGUITA	UP KAPITBALAY ADMIN
UFS VINZONS HALL OLD	RESHALL IPIL	CMO GEN HOUSE
COLL OF BUSINES ADM MAIN	ACAD OVAL ST LIGHTS	KALINGA DAY CARE
CS BIOLOGY DEPT	CSWCD C/0	VISITORS INFO CT
PHYSICS PALMA PAV	STATTISTICALTHEATER	

Table A2. Accounts (109) with their CC and GMBD ratings, minimum MEDC, and the average MEDC based on actual monthly demand in 2010. The MEDC is computed at PhP 247 per kWh. In the last column is the percentage difference between the minimum MEDC and the average electricity cost based on actual demand. Highlighted are accounts (34 in all) where the minimum MEDC exceeds the average actual demand cost (with positive percentage-difference values). Not all accounts are required to pay a minimum MEDC.

General Power Account	CC (kW)	GMBD (kW)	Average Monthly Actual Demand (kW)	Contract Cost (PhP)	Minimum MEDC (PhP)	Average Actual Demand Cost (PhP)	Percentage of Cost Difference to Minimum Charge
30,000 kw-h and above							
BOCOBO, MALCOLM HALL	540	378	422.33	9,281,326.19	1,077,062.24	1,203,384.35	-11.73
EEE VELASQUEZ ST	175	122.5	172.58	4,679,068.64	349,047.95	491,730.20	-40.88
CENGG OFFICES NEW MTR	480.2	336.14	297.45	6,807,633.70	957,787.57	848,579.30	+11.40

MARINE SCIENCE BLDG	196	137.2	187.73	5,710,898.96	390,933.70	534,921.92	-36.83
COLLEGE OF EDUCATION	191.8	0	222.92	5,379,004.84	0	638,415.28	n.a.
PALMA HALL NEW MTR	400	280	248.1	5,078,359.50	797,823.88	700,580.27	+12.19
NATL ENGG CTR	223	156.1	197.93	4,834,549.12	444,786.81	563,985.50	-26.80
FACULTY CTR	400	280	235.32	4,891,603.82	797,823.88	669,801.35	+16.05
30,000 kw-h and below							
PHYSICS NEW BLDG	210	40	163.96	3,455,387.85	113,974.84	467,182.87	-309.90
CHE ALONZO LIBRARY	39	0	169.07	3,409,525.76	0	481,531.97	n.a.
CS CHEM PAV 1 &11	114.8	0	117.33	3,079,226.17	0	334,307.20	n.a.
NSRI MAIN BLDG	58.8	0	35.74	3,013,110.34	0	101,836.52	n.a.
NIGS GEOLOGY BLDG	400	280	116.5	2,933,647.25	797,823.88	331,112.20	+58.50
ISMED VIDAL TAN	84.53	0	104.23	2,863,332.50	0	296,999.44	n.a.
MBBP ALBERT HALL	131	91.7	105.43	2,734,580.95	261,287.32	300,399.69	-14.97
ECONOMICS MAIN	145.2	0	134.88	2,876,112.17	0	383,517.21	n.a.
ISSI MAIN	127.5	0	112.81	2,728,943.98	0	323,103.49	n.a.
20,000 kw-h and below							
COLL OF BUSINES ADM 3RD	106.8	0	132.13	2,765,642.74	0	376,532.49	n.a.
ISMED NLRC BLDG	388	271.6	192.17	3,395,524.33	773,889.16	547,728.62	+29.22
MATH BLDG	250	175	114.44	2,616,480.07	498,639.93	326,549.01	+34.51
RESHALL KALAYAAN	62.67	0	49.55	2,098,358.37	0	141,176.84	n.a.
ST LIGHT	50.6	0	-	2,851,683.69	0	0	n.a.
COLLEGE OF SCIENCE	284	198.8	120.07	2,530,869.71	566,454.95	343,581.42	+39.34
ENGG LIB & COMP SCIE	319.8	223.86	135.28	3,603,418.05	637,860.19	386,047.57	+39.48
COLL OF MASSCOM MAIN	119	40	126.91	2,356,285.99	113,974.84	361,623.17	-217.28
UNIV HEALTH SERVICE MAIN	81	0	-	1,830,958.22	0	250,825.74	n.a.
15,000 kw-h and below							
DIL INFO OFFICE	154.7	108.29	58.62	1,801,897.64	308,558.39	167,030.13	+45.87
CSWCD NEW BLDG	240	168	95.53	2,050,308.14	478,694.33	272,171.88	+43.14
CAL NEW BLDG	240	168	119.24	2,187,550.80	478,694.33	341,434.85	+28.67
LIBRARY MAIN				1,889,131.84	0	0	n.a.
FILM CENTER	145	0	135.03	2,333,350.18	0	384,760.06	n.a.
ECONOMICS LIBRARY	81	0	109.27	2,105,066.58	0	312,158.05	n.a.
UFS VINZONS HALL OLD	99.2	0	71.83	1,777,508.46	0	205,046.03	n.a.
OFC OF THE REGISTRAR	130.9	91.63	89.43	1,831,849.82	261,087.86	272,663.08	-4.43
COLL OF BUSINES ADM MAIN	264	0	106.82	1,822,967.49	0	304,241.82	n.a.
CS BIOLOGY DEPT	93	0	76.63	1,738,007.09	0	218,954.98	n.a.
PHYSICS PALMA PAV	72	0	47.67	1,365,721.69	0	135,816.93	n.a.
RESHALL YAKAL	32	0	42.27	1,411,228.41	0	120,433.41	n.a.
RESHALL MOLAVE	117.25	82.08	32.84	1,485,026.86	233,862.12	93,582.84	+59.98
JVM VARGAS MUSEUM	62.13	0	45.27	1,418,213.14	0	128,991.03	n.a.
CHK MAIN GYM	62.2	0	52.78	1,488,488.08	0	150,389.80	n.a.

MUSIC THEATER (NEW MTR)	150.5	105.35	136.68	2,030,663.29	300,181.23	389,452.03	-29.74
CS SCIE COMPUTER ADMIN	212	148.4	56	1,480,277.84	422,846.66	159,564.78	+62.26
COLL OF PUBLIC ADMIN	116	40	149.21	3,278,327.86	113,974.84	425,164.14	-273.03
BIOLOGY INSTITUTE	116	81.2	59.77	1,394,676.49	231,368.93	170,306.90	+26.39
THEATER ACU	354	0	317.39	2,950,809.38	0	897,702.91	n.a.
NCTS TRANSPORT TRNG CTR	57.87	0	35.4	1,476,544.34	0	100,867.73	n.a.
RESHALL KAMIA	107.8	75.46	26.85	1,282,056.79	215,013.54	76,505.61	+64.42
COLL OF FINE ARTS	70	49	73.99	1,447,923.90	139,619.18	210,834.46	-51.01
15,000 kw-h and below							
ACCOUNTING/CASHIER	88.67	0	49	1,284,368.68	0	139,619.18	n.a.
COMPUTER CENTER	94.53	0	35.49	1,154,280.98	0	101,133.67	n.a.
AISAN INST OF TOURISM	157.5	110.25	80.12	1,462,993.86	314,143.15	228,170.01	+27.37
ROMULO HALL NEW MTR	70	40	53.54	1,194,171.15	113,974.84	152,564.82	-33.86
PALMA HALL OLD MTR	204	142.8	60.87	1,288,600.04	406,890.18	169,576.98	+58.32
COL OF ARCHI NEW BLDG	135.8	95.06	68.57	1,266,437.06	270,861.21	195,943.81	+27.66
RESHAL INTERNATIONAL	39.9	5	24.13	932,465.70	0	68,764.82	n.a.
COLL OF MUSIC ANNEX	38.5	5	51.7	1,171,113.78	14,246.86	147,321.98	-934.07
SUR MINUTE BLDG	108.8	0	60.16	1,182,137.89	0	171,418.16	n.a.
MUSIC ABELARDO HALL	58	0	56.34	1,173,724.97		160,533.56	n.a.
COMM AFFAIR CTR BLDG	76	53.2	43.54	1,065,981.85	151,586.54	124,061.61	+18.16
RESHALL ILANG ILANG	37.6	0	23.77	879,644.46	0	67,720.05	n.a.
CENGG PROCUREMENT	39	0	26.94	855,552.30	0	76,774.64	n.a.
SOLAIR BONIFACIO HALL	141.73	0	42.93	1,079,173.13	0	122,323.50	n.a.
GT TOYOTA ASIAN CTR	253.4	177.38	98.41	1,560,646.78	505,421.43	280,872.82	+44.43
RESHALL SAMPAGUITA	20.33	0	18.93	774,814.16	0	53,948.09	n.a.
SOLAIR EXT NEW BLDG	42.9	40	56.54	1,012,254.26	113,974.84	161,103.44	-41.35
RESHALL IPIL	32.53	0	27.2	798,458.27	0	77,502.89	n.a.
CSSP PHAN BLDG NEW MTR	248.5	40	62.23	1,022,516.77	113,974.84	177,306.86	-55.57
ACAD OVAL ST LIGHTS	15	0	-	397,279.98	0	35,457.06	n.a.
CMC MEDIA CTR	190.4	133.28	67.26	1,000,058.70	379,764.17	191,423.87	+49.59
RESHALL KAMAGONG DORM	99.4	69.58	18.18	693,506.96	198,259.23	51,228.13	+74.16
5,000 kw-h and below							
CSWCD C/0 STATTISTICAL	57.87	0	35.4	722,228.39	0	100,867.73	n.a.
CORPS OF CADETS	5.6	5	9.87	336,787.95	0	28,125.67	n.a.
TECHNO MGT (ASTI)	119	83.3	26.77	566,815.36	237,352.60	76,277.66	+67.86
OFC OF THE CAMPUS ARCHI	27.3	19.11	25.07	529,665.62	0	71,421.62	n.a.
RESHALL SANGUMAY	14	9.8	12.07	427,709.70	0	34,382.41	n.a.
UNIV FOOD SERVICE NEW	80.5	56.35	12.77	561,042.47	160,562.06	36,292.18	+77.40
UPIS INTEG SCH MAIN	28	5	27.94	492,604.10	0	79,601.93	n.a.
CPDMO MAIN	39.9	5	12.23	374,936.98	0	34,838.31	n.a.
OVCRD RESEARCH & DEVT	100.75	70.53	30.37	606,283.16	200,951.89	86,525.90	+56.94
UPIS INTEG SCH OLD BLDG	31.5	5	23.5	420,437.82	0	66,960.22	n.a.

BALAY KALINAW	86	60.2	32.2	600,689.61	171,532.13	91,749.75	+46.51
THEATER VILLAMOR HALL	152	0	61.45	612,425.57	0	175,103.35	n.a.
NBS	210	147	19.6	656,558.97	418,857.54	55,847.67	+86.67
SURP MAIN PRE-FAB	39.2	0	18.6	341,225.66	0	52,998.30	n.a.
UNIV HEALTH SERVICE X-RAY	39	0	15.77	308,337.42	0	44,925.08	n.a.
IPIS INTE SCH K-2	11.9	8.33	10.25	200,882.90	0	29,216.74	n.a.
DCMT VANGUARD BLDG	19.6	0	17.73	314,115.73	0	49,871.64	n.a.
BENTON HALL OLD OUR	73.2	0	31.45	612,444.10	0	89,603.22	n.a.
MSI SEAWEED (VILLADOLID)	19.2	0	16.66	285,987.53	0	47,470.52	n.a.
EXEC HOUSE TSANSELOR	16.73	0	8.71	221,472.23	0	24,804.49	n.a.
CHEMICAL ENGG	12	5	8.7	187,233.10	0	24,789.53	n.a.
SOLAIR BONIFACIO ACU	39	0	10.76	185,509.21	0	30,649.73	n.a.
1,000 kw-h and below							
ARCHITECTURE 1	63	44.1	12.33	285,911.45	125,657.26	34,902.06	+72.22
DZUP TRANSMITTER	0.75	0	-	132,996.40	0	0	n.a.
SHOPPING ADMIN CTR	7.6	0	5	110,192.14	0	13,455.85	n.a.
CHE HOMECONIMICS EXT	39	0	5.91	116,896.07	0	16,789.44	n.a.
HARDIN NG DONA AURORA	17	0	9.42	130,651.22	0	26,841.07	n.a.
TRACK & FIELD OVAL	5.25	5	8.94	125,796.92	0	25,471.48	n.a.
UP KAPITBALAY ADMIN	0.75	0	-	69,904.22	0	0	n.a.
DCMT ROTC BARRACKS	7	5	1.14	65,638.11	0	3,253.03	n.a.
CMO GEN HOUSE	3.5	0	3.33	48,608.62	0	9,497.90	n.a.
CENTENNIAL DORM PH 1	62.3	43.61	0.81	511,284.00	124,261.07	2,317.49	+98.13
MINING & MET	38.5	5	4.56	67,719.17	0	12,978.16	n.a.
ME LAB DYNAMO TESTNG LAB	350	245	9.08	735,165.25	698,095.90	25,862.79	+96.30
GERMAN YIA NEW MTR	70	40	-	11,284.01	113,974.84	0	+100.00
KALINGA DAY CARE	1.5	0	-	1,397.70	0	0	n.a.
VISITORS INFO CTR	26	0	5	2,220.00	0	14,246.86	n.a.
COLL OF HOMECONOMICS	18.21	12.75	7.74	15.85	0	22,039.88	n.a.

Total cost difference of minimum charge to actual cost (total of highlighted accounts) = PhP 5,589,683.45

Table A3. Projected annual electricity bills (in PhP) produced by the five alternative GMBD rating schemes. The bills are calculated using their 2010 actual electric demand and the same overhead charges for generation, transmission, distribution and system loss, taxes, etc. The actual 2010 electricity bill is based on GMBD ratings that are equal to 70% of CC.

Account Name	Actual Electricity Bill	$GMBD_{max}$	$GMBD_{ave}$	$GMBD_{min}$	$GMBD_{40}$	$GMBD_{0}$
30,000 kw-h and above						
BOCOBO, MALCOLM HALL	9,281,326.19	9,046,633.00	9,046,633.00	9,046,633.00	8,318,238.79	8,204,263.95
EEE VELASQUEZ ST	4,679,068.64	4,674,231.83	4,674,231.83	4,674,231.83	4,443,995.53	4,330,020.69
CENGG OFFICES NEW MTR	6,807,633.70	6,591,822.34	6,443,127.91	6,366,836.01	5,963,820.97	5,849,846.13
MARINE SCIENCE BLDG	5,710,898.96	5,694,410.60	5,694,410.60	5,694,410.60	5,433,940.10	5,319,965.26
COLLEGE OF EDUCATION	5,379,004.84	5,379,004.84	5,379,004.84	5,379,004.84	5,379,004.84	5,379,004.84

PALMA HALL NEW MTR	5,078,359.50	4,906,428.45	4,775,385.88	4,671,868.23	4,394,510.46	4,280,535.62
NATL ENGG CTR	4,834,549.12	4,784,552.16	4,784,552.16	4,784,552.16	4,503,737.15	4,389,762.31
FACULTY CTR	4,891,603.82	4,630,236.72	4,563,139.73	4,473,544.11	4,207,754.78	4,093,779.94
30,000 kw-h and below						
PHYSICS NEW BLDG	3,455,387.85	3,455,387.85	3,455,387.85	3,455,387.85	3,455,387.85	3,341,413.01
CHE ALONZO LIBRARY	3,409,525.76	3,409,525.76	3,409,525.76	3,409,525.76	3,409,525.76	3,409,525.76
CS CHEM PAV 1 &11	3,079,226.17	3,079,226.17	3,079,226.17	3,079,226.17	3,079,226.17	3,079,226.17
NSRI MAIN BLDG	3,013,110.34	3,013,110.34	3,013,110.34	3,013,110.34	3,013,110.34	3,013,110.34
NIGS GEOLOGY BLDG	2,933,647.25	2,417,056.29	2,368,189.58	2,321,317.42	2,249,798.21	2,135,823.37
ISMED VIDAL TAN	2,863,332.50	2,863,332.50	2,863,332.50	2,863,332.50	2,863,332.50	2,863,332.50
MBBP ALBERT HALL	2,734,580.95	2,683,573.41	2,683,573.41	2,683,573.41	2,587,268.47	2,473,293.63
ECONOMICS MAIN	2,876,112.17	2,876,112.17	2,876,112.17	2,876,112.17	2,876,112.17	2,876,112.17
ISSI MAIN	2,728,943.98	2,728,943.98	2,728,943.98	2,728,943.98	2,728,943.98	2,728,943.98
20,000 kw-h and below						
COLL OF BUSINES ADM 3RD	2,765,642.74	2,765,642.74	2,765,642.74	2,765,642.74	2,765,642.74	2,765,642.74
ISMED NLRC BLDG	3,395,524.33	3,116,285.97	3,004,923.06	2,877,736.63	2,735,610.01	2,621,635.17
MATH BLDG	2,616,480.07	2,371,548.14	2,346,097.56	2,306,445.71	2,231,814.99	2,117,840.15
RESHALL KALAYAAN	2,098,358.37	2,098,358.37	2,098,358.37	2,098,358.37	2,098,358.37	2,098,358.37
ST LIGHT	2,851,683.69	2,851,683.69	2,851,683.69	2,851,683.69	2,851,683.69	2,851,683.69
COLLEGE OF SCIENCE	2,530,869.71	2,233,440.97	2,203,894.89	2,150,467.28	2,078,389.60	1,964,414.76
ENGG LIB & COMP SCIE	3,603,418.05	3,276,390.04	3,235,381.89	3,199,160.69	3,079,532.70	2,965,557.86
COLL OF MASSCOM MAIN	2,356,285.99	2,356,285.99	2,356,285.99	2,356,285.99	2,356,285.99	2,242,311.15
UNIV HEALTH SERVICE MAIN	1,830,958.22	1,830,958.22	1,830,958.22	1,830,958.22	1,830,958.22	1,830,958.22
15,000 kw-h and below						
DIL INFO OFFICE	1,801,897.64	1,610,260.34	1,610,260.34	1,610,260.34	1,607,314.09	1,493,339.25
CSWCD NEW BLDG	2,050,308.14	1,802,982.74	1,762,160.75	1,712,349.94	1,685,588.65	1,571,613.81
CAL NEW BLDG	2,187,550.80	2,033,411.23	1,946,687.77	1,894,270.74	1,822,831.31	1,708,856.47
LIBRARY MAIN	1,889,131.84	1,889,131.84	1,889,131.84	1,889,131.84	1,889,131.84	1,889,131.84
FILM CENTER	2,333,350.18	2,333,350.18	2,333,350.18	2,333,350.18	2,333,350.18	2,333,350.18
ECONOMICS LIBRARY	2,105,066.58	2,105,066.58	2,105,066.58	2,105,066.58	2,105,066.58	2,105,066.58
UFS VINZONS HALL OLD	1,777,508.46	1,777,508.46	1,777,508.46	1,777,508.46	1,777,508.46	1,777,508.46
OFC OF THE REGISTRAR	1,831,849.82	1,784,282.42	1,762,578.76	1,723,465.45	1,684,736.80	1,570,761.96
COLL OF BUSINES ADM MAIN	1,822,967.49	1,822,967.49	1,822,967.49	1,822,967.49	1,822,967.49	1,822,967.49
CS BIOLOGY DEPT	1,738,007.09	1,738,007.09	1,738,007.09	1,738,007.09	1,738,007.09	1,738,007.09
PHYSICS PALMA PAV	1,365,721.69	1,365,721.69	1,365,721.69	1,365,721.69	1,365,721.69	1,365,721.69
RESHALL YAKAL	1,411,228.41	1,411,228.41	1,411,228.41	1,411,228.41	1,411,228.41	1,411,228.41
RESHALL MOLAVE	1,485,026.86	1,316,672.72	1,316,672.72	1,316,672.72	1,365,139.58	1,251,164.74
JVM VARGAS MUSEUM	1,418,213.14	1,418,213.14	1,418,213.14	1,418,213.14	1,418,213.14	1,418,213.14
CHK MAIN GYM	1,488,488.08	1,488,488.08	1,488,488.08	1,488,488.08	1,488,488.08	1,488,488.08
MUSIC THEATER (NEW MTR)	2,030,663.29	2,003,098.47	2,003,098.47	2,003,098.47	1,844,456.90	1,730,482.06
CS SCIE COMPUTER ADMIN	1,480,277.84	1,169,126.53	1,169,126.53	1,169,126.53	1,171,406.02	1,057,431.18
COLL OF PUBLIC ADMIN	3,278,327.86	3,278,327.86	3,278,327.86	3,278,327.86	3,278,327.86	3,164,353.02
BIOLOGY INSTITUTE	1,394,676.49	1,282,522.40	1,282,522.40	1,282,522.40	1,277,282.40	1,163,307.56
THEATER ACU	2,950,809.38	2,950,809.38	2,950,809.38	2,950,809.38	2,950,809.38	2,950,809.38
NCTS TRANSPORT TRNG CTR	1,476,544.34	1,476,544.34	1,476,544.34	1,476,544.34	1,476,544.34	1,476,544.34

RESHALL KAMIA	1,282,056.79	1,120,597.18	1,120,597.18	1,120,597.18	1,181,018.09	1,067,043.25
COLL OF FINE ARTS	1,447,923.90	1,447,923.90	1,447,923.90	1,447,923.90	1,422,279.56	1,308,304.72
15,000 kw-h and below						
ACCOUNTING/CASHIER	1,284,368.68	1,284,368.68	1,284,368.68	1,284,368.68	1,284,368.68	1,284,368.68
COMPUTER CENTER	1,154,280.98	1,154,280.98	1,154,280.98	1,154,280.98	1,154,280.98	1,154,280.98
AISAN INST OF TOURISM	1,462,993.86	1,338,653.01	1,308,654.83	1,276,183.40	1,262,825.55	1,148,850.71
ROMULO HALL NEW MTR	1,194,171.15	1,186,991.68	1,186,991.68	1,186,991.68	1,194,171.15	1,080,196.31
PALMA HALL OLD MTR	1,288,600.04	1,075,740.63	1,003,112.06	975,853.08	995,684.70	881,709.86
COL OF ARCHI NEW BLDG	1,266,437.06	1,171,416.24	1,132,336.16	1,079,347.36	1,109,550.69	995,575.85
RESHAL INTERNATIONAL	932,465.70	932,465.70	932,465.70	932,465.70	932,465.70	918,218.85
COLL OF MUSIC ANNEX	1,171,113.78	1,171,113.78	1,171,113.78	1,171,113.78	1,171,113.78	1,156,866.93
SUR MINUTE BLDG	1,182,137.89	1,182,137.89	1,182,137.89	1,182,137.89	1,182,137.89	1,182,137.89
MUSIC ABELARDO HALL	1,173,724.97	1,173,724.97	1,173,724.97	1,173,724.97	1,173,724.97	1,173,724.97
COMM AFFAIR CTR BLDG	1,065,981.85	1,001,238.44	1,001,238.44	1,001,238.44	1,028,370.15	914,395.31
RESHALL ILANG ILANG	879,644.46	879,644.46	879,644.46	879,644.46	879,644.46	879,644.46
CENGG PROCUREMENT	855,552.30	855,552.30	855,552.30	855,552.30	855,552.30	855,552.30
SOLAIR BONIFACIO HALL	1,079,173.13	1,079,173.13	1,079,173.13	1,079,173.13	1,079,173.13	1,079,173.13
GT TOYOTA ASIAN CTR	1,560,646.78	1,296,806.42	1,251,516.62	1,192,770.19	1,169,200.19	1,055,225.35
RESHALL SAMPAGUITA	774,814.16	774,814.16	774,814.16	774,814.16	774,814.16	774,814.16
SOLAIR EXT NEW BLDG	1,012,254.26	1,011,051.83	1,011,051.83	1,011,051.83	1,012,254.26	898,279.42
RESHALL IPIL	798,458.27	798,458.27	798,458.27	798,458.27	798,458.27	798,458.27
CSSP PHAN BLDG NEW MTR	1,022,516.77	1,022,516.77	1,022,516.77	1,022,516.77	1,022,516.77	908,541.93
ACAD OVAL ST LIGHTS	397,279.98	397,279.98	397,279.98	397,279.98	397,279.98	397,279.98
CMC MEDIA CTR	1,000,058.70	778,263.66	754,448.62	719,623.61	734,269.37	620,294.53
RESHALL KAMAGONG DORM	693,506.96	543,196.94	531,502.17	512,879.63	609,222.57	495,247.73
5,000 kw-h and below						
CSWCD C/0 STATTISTICAL	722,228.39	722,228.39	722,228.39	722,228.39	722,228.39	722,228.39
CORPS OF CADETS	336,787.95	336,787.95	336,787.95	336,787.95	336,787.95	322,541.10
TECHNO MGT (ASTI)	566,815.36	382,857.12	382,857.12	382,857.12	443,437.60	329,462.76
OFC OF THE CAMPUS ARCHI	529,665.62	525,209.27	525,209.27	525,209.27	529,665.62	475,214.14
RESHALL SANGUMAY	427,709.70	423,853.55	423,853.55	423,853.55	427,709.70	399,785.86
UNIV FOOD SERVICE NEW	561,042.47	429,999.90	425,957.59	406,224.75	514,455.25	400,480.41
UPIS INTEG SCH MAIN	492,604.10	492,604.10	492,604.10	492,604.10	492,604.10	478,357.25
CPDMO MAIN	374,936.98	374,936.98	374,936.98	374,936.98	374,936.98	360,690.13
OVCRD RESEARCH & DEVT	606,283.16	465,899.40	465,899.40	465,899.40	519,306.11	405,331.27
UPIS INTEG SCH OLD BLDG	420,437.82	420,437.82	420,437.82	420,437.82	420,437.82	406,190.97
BALAY KALINAW	600,689.61	493,382.30	493,382.30	493,382.30	543,132.32	429,157.48
THEATER VILLAMOR HALL	612,425.57	612,425.57	612,425.57	612,425.57	612,425.57	612,425.57
NBS	656,558.97	656,558.97	656,558.97	656,558.97	656,558.97	656,558.97
SURP MAIN PRE-FAB	341,225.66	341,225.66	341,225.66	341,225.66	341,225.66	341,225.66
UNIV HEALTH SERVICE X-RAY	308,337.42	308,337.42	308,337.42	308,337.42	308,337.42	308,337.42
IPIS INTE SCH K-2	200,882.90	197,599.36	197,599.36	197,599.36	200,882.90	177,147.64
DCMT VANGUARD BLDG	314,115.73	314,115.73	314,115.73	314,115.73	314,115.73	314,115.73
BENTON HALL OLD OUR	612,444.10	612,444.10	612,444.10	612,444.10	612,444.10	612,444.10
MSI SEAWEED (VILLADOLID)	285,987.53	285,987.53	285,987.53	285,987.53	285,987.53	285,987.53
EXEC HOUSE TSANSELOR	221,472.23	221,472.23	221,472.23	221,472.23	221,472.23	221,472.23

CHEMICAL ENGG	187,233.10	187,233.10	187,233.10	187,233.10	187,233.10	172,986.25
SOLAIR BONIFACIO ACU	185,509.21	185,509.21	185,509.21	185,509.21	185,509.21	185,509.21
1,000 kw-h and below						
ARCHITECTURE 1	285,911.45	201,501.68	184,847.11	175,652.19	274,229.03	160,254.19
DZUP TRANSMITTER	132,996.40	132,996.40	132,996.40	132,996.40	132,996.40	132,996.40
SHOPPING ADMIN CTR	110,192.14	110,192.14	110,192.14	110,192.14	110,192.14	110,192.14
CHE HOMECONIMICS EXT	116,896.07	116,896.07	116,896.07	116,896.07	116,896.07	116,896.07
HARDIN NG DONA AURORA	130,651.22	130,651.22	130,651.22	130,651.22	130,651.22	130,651.22
TRACK & FIELD OVAL	125,796.92	125,796.92	125,796.92	125,796.92	125,796.92	111,550.07
UP KAPITBALAY ADMIN	69,904.22	69,904.22	69,904.22	69,904.22	69,904.22	69,904.22
DCMT ROTC BARRACKS	65,638.11	53,668.38	53,668.38	53,668.38	65,638.11	51,391.26
CMO GEN HOUSE	48,608.62	48,608.62	48,608.62	48,608.62	48,608.62	48,608.62
CENTENNIAL DORM PH 1	511,284.00	511,284.00	511,284.00	511,284.00	511,284.00	511,284.00
MINING & MET	67,719.17	67,514.02	62,567.51	58,578.39	67,719.17	53,472.32
ME LAB DYNAMO TESTNGLAB	735,165.25	55,173.31	55,173.31	55,173.31	151,044.20	37,069.35
GERMAN YIA NEW MTR	11,284.01	11,284.01	11,284.01	11,284.01	11,284.01	11,284.01
KALINGA DAY CARE	1,397.70	1,397.70	1,397.70	1,397.70	1,397.70	1,397.70
VISITORS INFO CTR	2,220.00	2,220.00	2,220.00	2,220.00	2,220.00	2,220.00
COLL OF HOMECONOMICS	15.85	15.85	15.85	15.85	15.85	15.85

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