# Transformer Loading Management for Residential Transformers of a Barangay in Arayat, Pampanga

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**Abstract: -** Proper rating of transformer is important in maximize the useful life and efficiency of the equipment. A higher or lower rating of the transformer can provide either a higher system loss or disconnection of consumer connectivity of electricity. In this study, assessment of residential transformer of a barangay was considered. The percent loading of each transformer was evaluated by the used of the standard set by National Electrification Administration (NEA). Software used in the study is Microsoft Excel 2016 for determining the percent loading of each residential transformers. After the percent loading was identified, clustering of transformers was made according to the loading conditions. Changing of Rating were also performed to corrected the percent loading of the transformer. From 2017 to 2019, 13 transformers or 48.14 % were underloaded while 6 or 22.22% were found to be overloaded. Changing of the rating of the transformer in the barangay, the percent loading of the 6 overloaded transformers were corrected. For the 13 underloaded, 12 of which were corrected. Also, in the underloaded there is still a unit RT19 that is in underloaded even changing the rating due to the available lowest rating of the transformer was reach. Installing the proper rating of the transformer can save 303,955.30 Php by comparing the old rating to the new rating. The researchers recommend to use load centering to minimize the number of the transformer. Another is the monitoring of kWHr of consumer in a daily basis by the use of Automated Mapping/Facility Management/ Geographical Information System or AM/FM/GIS to identify the peak load of each transformer, compare to the monthly kWhr.

**Key Words: —** ***KVA Rating, Residential Transformers, Overload, Underload.***

## I. INTRODUCTION

Distribution system is a process in which electricity is transform for utilized by consumer. One particular equipment used for this process is transformer. Distribution Transformer were classified into two:

a. Sole Used Distribution Transformer where only one consumer is connected
b. Commonly Used or Residential Distribution Transformer where multiple consumers are connected

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Distribution transformer loading for consumer connectivity is vital in this modern time. Appropriate rating of transformer is important for its proper utilization. Failure of transformer may cause power interruption or oversizing of transformer may result to higher losses [1]. Rapid growing of economic development in some areas may cause distribution transformer overloaded or in some where underloaded due to availability of the equipment and it is a must to give attention of the utility for proper utilization [2]. Some common problems occur in the transformer were: unbalanced loading and usage of repaired distribution transformer [3]. For a distribution transformer to fully utilize it needs 40% to 70% loading conditions and achieving the maximum efficiency of it must be near 50% loading of its rated rating [4-5].

Quantifying the connected loads in each distribution transformer is important. Knowing the number of consumers using the transformer for its loading condition is vital for continuous consumer connectivity. Proper rating of transformer

for the demand of electrical energy can help the transformer to maximize its utilization and useful life [6].

Transformer loading can classify into three conditions:

- Underloaded – below 40% percent loading
- Normal Loaded – 40% to 70% percent loading
- Overloaded – higher than 70% loading

To avoid the conditions of transformer to become overloaded or underloaded, proper loading conditions and adapting the increasing demand of energy is must be taken for considerations [7-8]. Loading conditions of the transformer exceeding the normal loading condition stresses the equipment to a point of destroying the connection of the wires both in the primary and secondary side [9].

Transformer loading management is a process that will reduce the cost of transformer installation, reduce system loss, increase the efficiency of the equipment and improve service to customer [10]. Evaluation of loading factors of distribution transformers to prevent the burn out of transformers caused by overloading problem. Normal loading of residential transformer can be helpful in operating the equipment efficiently [11].

Pampanga is one of the provinces in Central Luzon Region in the Philippines subdivided to 3 cities and 19 municipalities. One of the municipalities of Pampanga is Arayat which has 30 barangays. The municipality also served by an Electric Utility with 3 distribution feeders which are Feeder number 1,2,3. As seen in Figure 1 the number of residential consumers of the 3 feeders.

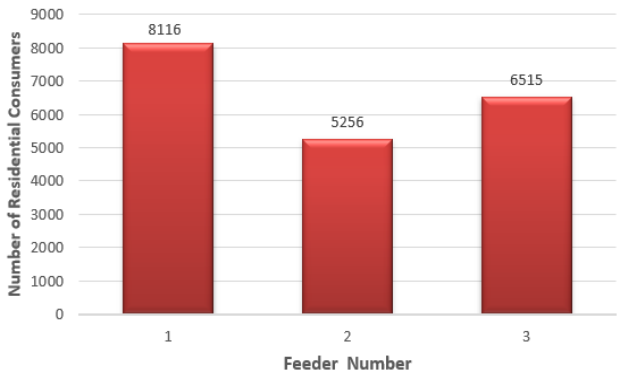


Fig.1. Number of Residential Consumers per Feeder

Also, the residential consumers were connected to a distribution transformer for utilization of electricity. In figure 2 shows the number of residential distribution transformer per feeders.

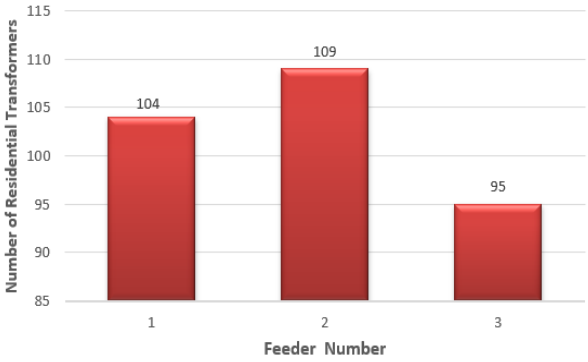


Fig.2. Number of Residential Transformers per Feeder

From the three feeders, Feeder 1 is the highest number of residential consumers and second highest in the number of residential transformers. The kWh demand of the feeder 1 from 2017 to 2019 was shown in figure 3.

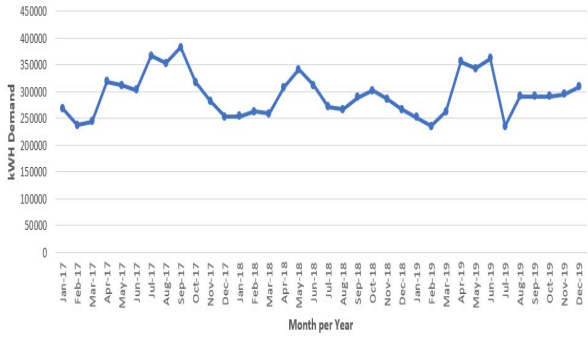


Fig.3. kWh of Feeder 1

For the past 3 years there is an increasing trend of demand in the feeder and it experienced from the month of April, Amy and June. Feeder 1 serves the barangays of Cacutud (0414), Matamo (0413), Plazang Luma West (0412), Plazang Luma East (0411), San Agustin Sur (0409), Paralaya (0408), Guemasan (0407), Riverside (0406), Poblacion (0405), Manga (0404), Cupang (0403), San Jose Mesulo (0402) and San Nicolas (0401). In Figure 4 represents the number of consumers per barangay. As well as the subdivision of the 104 residential transformer per barangay were shown in Figure 5.

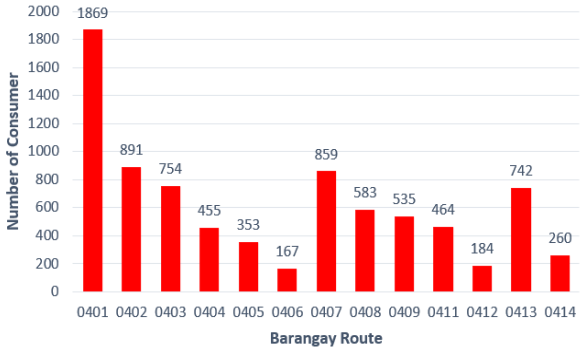


Fig.4. Number of Consumer per Barangay

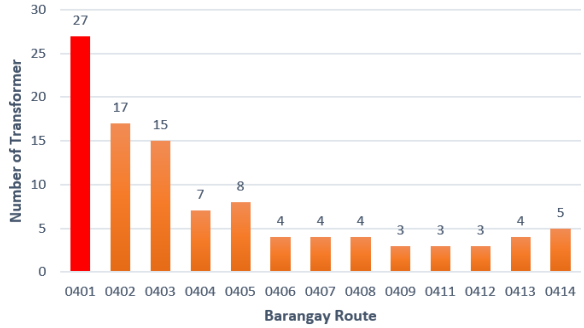


Fig.5. Number of Transformer per Barangay

In figure 4 and 5, barangay San Nicolas has the highest residential consumer and transformer. Indeed, the barangay San Nicolas was chosen for the study to assess the percent loading condition of the residential transformers.

Loading conditions transformer are affected by the increasing demand and the more the number of consumers connected the more increase in the percent loading. In the other way, if the loading is below the normal loading transformer utilization is affected. With this assessment of percent loading of residential used distribution transformer is needed.

Objective of the study is to assess the loading conditions of residential consumers of a barangay. To categorized residential transformer to the kind of loading into overloaded, normal loaded and underloaded: Also, to do an uprating for overloaded transformer or down rating for underloaded transformers [12].

This study will give an aid for monitoring the loadings of residential transformers. The use of these loading monitoring will increase the awareness to potential risks due to the transformer overheating. And it can be helpful in maximizing the utilization of the equipment used. It can also provide information on the present situation of the residential transformers.

The study will cover the 27 residential transformers and 1869 consumers of Barangay San Nicolas. The study will apply the percent loading condition of underloaded or below 40% loading, normal loaded or 40% - 70% loading, overloaded or higher 70% [4], and the residential power factor is 0.85 [6]. Uprating and Downrating will also be considered in the study.

## II. METHODOLOGY

### *2.1 Data Collection and Instrument*

kVA rating of each residential transformers and energy consumption in kWh per consumer connected in each transformer which are the data needed in the study were collected in the electric utility. These data will be used to assess the percent loading conditions of the residential transformers. The conceptual framework of the study is shown in figure 6.

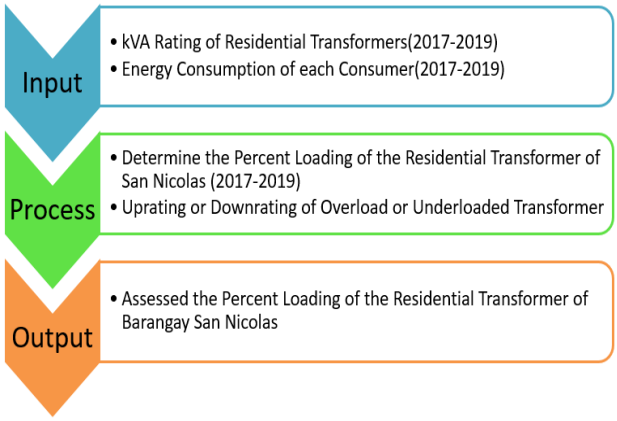


Fig.6. Conceptual Framework of the Study

### *2.2 Data Analysis for the Percent Loading*

Data gathered will be used to identify the loading conditions of the residential transformer of barangay San Nicolas and energy consumption (January 2017 – December 2019) of consumer connected using Microsoft Excel 2016 applying the standard formula set by National Electrification Administration (NEA) System Loss Reduction Manual [13].

$$\%\,\boldsymbol{Loading} = \frac{\mathbf{kWhrDemand(month)}}{(\mathbf{KVA_{TR}})\,(\mathbf{PF})\,(\mathbf{720H})} \qquad (\mathbf{1})$$

When the percent loading was identified, residential transformers were classified into three loading conditions:

- Underloaded – below 40% percent loading
- Normal Loaded – 40% to 70% percent loading
- Overloaded – higher than 70% loading

### *2.3 Changing of Rating of Transformer*

After the transformers loading condition were determined, changing the rating of the transformer by a higher rating of kVA rating for the overloaded transformer and replacing a lower rating for underloaded transformer in which the percent loading will become normal loading conditions. The transformer rating of the transformer used by the electric utility are 10kVA, 15kVA, 25kVA, 37.5kVA, 50kVA, 75kVA and 100kVA.

## III. Results And Discussion

### *3.1 Transformer Assessment*

The graphical representation of the number of underloaded, normal loaded and overloaded residential transformer are shown in Figures 7-9 respectively. In Figure 7, as seen the months of March, April and May the number of underloaded was decreasing due to the increase of demand in electric usage while on the months of November to January increasing due to the less demand due to cold weather. The maximum number of underloaded transformer was 19 occur in December 2017.

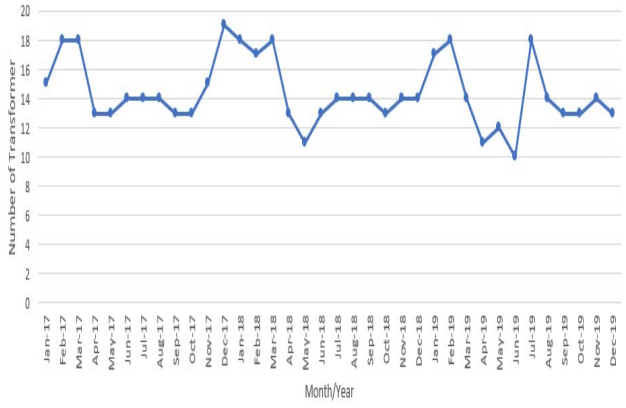


Fig.7. Number of Underloaded Transformers

Figure 8 shows that in April and June 2019 the maximum number of transformers was only 7 out of the 27 transformers that are installed in the barangay.

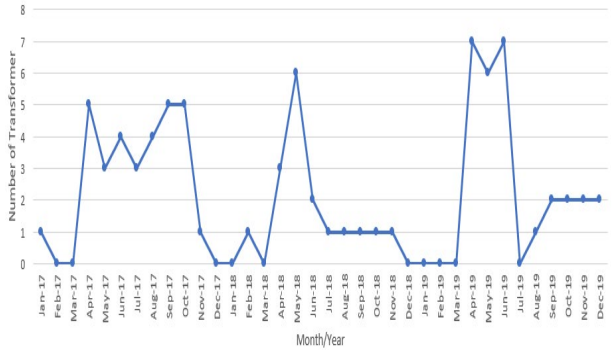


Fig.8. Number of Normal Loaded Transformers

Figure 9 shows the number of transformers in overloaded conditions from 2017-2019, the maximum overloaded transformers was 13 units.

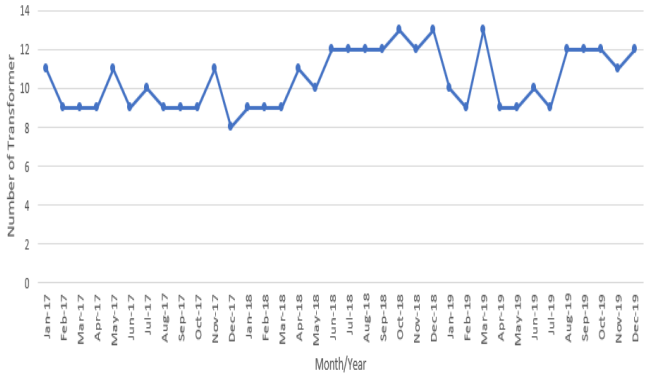


Fig.9. Number of Overloaded Transformers

The average performance of the transformers was shown in Figure 10. From 2017-2019, the overloaded transformer was 8, underloaded were 13 and normal loaded were 6.

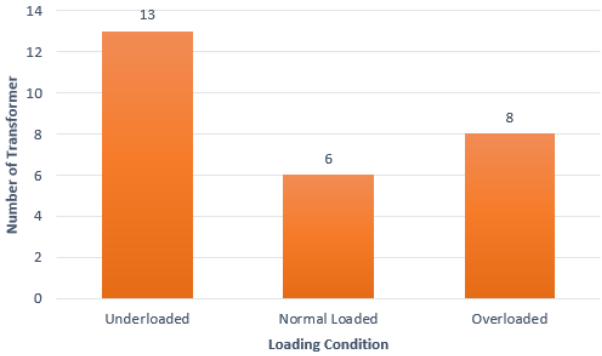


Fig.10. Loading Conditions of Residential Transformers (2017-2019)

### *3.2 Changing of Rating of Transformer*

#### *3.2.1 Under loaded Residential Transformer*

In Table 1, residential transformers in underloaded condition were presented. Also, the old rating of the transformer and percent loading were change to a lower rating with a percent loading that is in normal loading conditions which is between 40% to 70% loading.

Table.1. Under Loaded Residential Transformer

| No | Transformer Name | Old Rating (kVA) | New Rating (kVA) | Old Percent Loading | New Percent Loading |
|---|---|---|---|---|---|
| 1 | RT01 | 37.5 | **15** | 18.84 | **47.09** |
| 2 | RT03 | 75 | **15** | 12.34 | **61.70** |
| 3 | RT04 | 75 | **25** | 14.65 | **43.95** |
| 4 | RT05 | 75 | **37.5** | 22.36 | **44.71** |
| 5 | RT06 | 75 | **15** | 8.66 | **43.32** |
| 6 | RT07 | 75 | **37.5** | 29.32 | **58.64** |
| 7 | RT11 | 37.5 | **25** | 38.09 | **57.14** |
| 8 | RT14 | 25 | **15** | 26.79 | **44.66** |
| 9 | RT16 | 25 | **10** | 24.02 | **60.06** |
| 10 | RT19 | 25 | **10** | 4.17 | **10.44** |
| 11 | RT21 | 50 | **37.5** | 36.76 | **49.01** |
| 12 | RT22 | 50 | **37.5** | 39.41 | **52.55** |
| 13 | RT23 | 25 | **10** | 23.59 | **58.97** |

Among the 13 underloaded transformer, 1 of them is still in the underloaded, RT19 initially 25 kVA is installed and a percent loading of 4.17 even the rating was corrected to 10kVA the new percent loading is 10.44. It is not able to be corrected due to the lowest value of the rating was 10 kVA.

#### *3.2.2 Overloaded Residential Transformer*

The current rating and present percent loading of the transformers in the overloaded conditions are shown in Table 2. In the same way the corrected rating and percent loading were presented.

Table.2. Overloaded Residential Transformer

| No | Transformer Name | Old Rating (kVA) | New Rating (kVA) | Old Percent Loading | New Percent Loading |
|---|---|---|---|---|---|
| 1 | RT02 | 37.5 | **50** | 71.13 | **51.10** |
| 2 | RT10 | 37.5 | **50** | 79.45 | **59.59** |
| 3 | RT17 | 25 | **37.5** | 72.50 | **45.74** |
| 4 | RT18 | 15 | **25** | 76.66 | **45.99** |
| 5 | RT20 | 15 | **25** | 95.39 | **57.24** |
| 6 | RT24 | 25 | **37.5** | 73.50 | **46.34** |
| 7 | RT25 | 50 | **75** | 74.53 | **49.69** |
| 8 | RT26 | 50 | **75** | 76.27 | **50.85** |

As seen, all the overloaded residential transformer was corrected to a normal loading condition.

### *3.3 Comparison of Cost in Residential Transformer Installed.*

To installed a certain rating of transformer it varies depending on the kVA. In Table 3 and 4 the cost of the old and the new transformer was presented.

Table.3. Cost of Underloaded Residential Transformer Old Rating

| KVA Rating | Quantity | Cost (Php)/Transformer | Cost |
|---|---|---|---|
| 25 | 4 | ₱56,922.80 | ₱ 227,691.20 |
| 37.5 | 2 | ₱78,578.50 | ₱157,157.00 |
| 50 | 2 | ₱87,319.10 | ₱174,638.20 |
| 75 | 5 | ₱129,800.00 | ₱649,000.00 |
| | | **Total** | **₱1,208,486.40** |

Table.4. Cost of Underloaded Residential Transformer New Rating

| KVA Rating | Quantity | Cost (Php)/Transformer | Cost |
|---|---|---|---|
| 10 | 3 | ₱41,134.50 | ₱123,403.50 |
| 15 | 4 | ₱46,684.00 | ₱186,736.00 |
| 25 | 2 | ₱56,922.80 | ₱113,845.60 |
| 37.5 | 4 | ₱78,578.50 | ₱314,314.00 |
| | | **Total** | **₱738,299.10** |

The cost of installing of transformer of the overloaded and the new transformer were shown in Table 5 and 6.

Table.5. Cost of Overloaded Residential Transformer Old Rating

| KVA Rating | Quantity | Cost (Php)/Transformer | Cost |
|---|---|---|---|
| 15 | 2 | ₱46,684.00 | ₱ 93,368.00 |
| 25 | 2 | ₱56,922.80 | ₱113,845.60 |
| 37.5 | 2 | ₱78,578.50 | ₱157,157.00 |
| 50 | 2 | ₱87,319.10 | ₱174,638.20 |
| | | **Total** | **₱539,008.80** |

Table.6. Cost of overloaded residential transformer new rating

| KVA Rating | Quantity | Cost (Php)/Transformer | Cost |
|---|---|---|---|
| 25 | 2 | ₱56,922.80 | ₱113,845.60 |
| 37.5 | 2 | ₱78,578.50 | ₱157,157.00 |
| 50 | 2 | ₱87,319.10 | ₱174,638.20 |
| 75 | 2 | ₱129,800.00 | ₱ 259,600.00 |
| | | **Total** | **₱705,240.80** |

Table.7. Savings in installation of the transformers

| Percent Loading | Old Ratings | New Ratings | Difference |
|---|---|---|---|
| | Cost | Cost | |
| Underload | ₱1,208,486.40 | ₱738,299.10 | ₱470,187.30 |
| Overload | ₱539,008.80 | ₱705,240.80 | -₱166,232.00 |
| | | **Total Savings** | **₱303,955.30** |

Though in the part of overloaded additional value is needed form the original cost of 166, 232.00 Php, the underloaded transformer can saved as much 470,187.3 Php which can cater the addition cost for the overloaded. In table 7 as seen, if proper rating was installed there is an amount of 303, 955.30 Php that can be saved.

## IV. Conclusion

From the past 3 years starting 2017-2019, residential transformer of barangay San Nicolas out of 27 transformers, 13 transformer or 48.15 % were underloaded and 6 of it or 22.22% were found out to be overloaded. Overall, 19 transformers from 27 transformer or 70.37 % must be take into account.

Considering the results obtained from this study by changing the rating of the residential transformer, all residential transformers in the overloaded condition were in the normal percent loading (40 to 70 %). On the other hand, for the underloaded transformers 12 of which were corrected, but there is still one (1) unit, RT19 due to the corrected rating is the lowest value of transformer that I used by the utility.

### *Recommendations:*

For future works, the researchers recommend the use of proper load centering to minimize the number of the transformer. For further improvement, monitoring of kWHr of consumer must be done daily by the use of Automated Mapping/Facility Management/ Geographical Information System or AM/FM/GIS to identify the peak load of each transformer, compare to the monthly kWhr that was used in the study.

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