Dominguito Transformer Overload

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Abstract *— Assessments were made in Arecibo, Puerto Rico, between 2021 and 2023 to determine the root cause for loading issues that were occurring in this area. From this investigation, it was found that Dominguito substation has an overload on the 8010-distribution transformer. This type of transformer is no longer produced on the market. The purpose of this project is to eliminate the overload on the Dominguito 8010 transformer. Three alternatives were identified to evaluate the overall situation on Dominguito substation. It was analyzed and discussed with the departments of Engineering, Operations, Asset Management and Project Management. The plan was to replace three transmission poles and enable the Arecibo Rural substation 8003.*

Key Terms *— Overload, Substation, Transformer, Underground*

INTRODUCTION

Assessments were made in Arecibo, Puerto Rico, between 2021 and 2023 to determine the root cause for loading issues that were occurring in this area. From this investigation, it was found that Dominguito substation has an overload on the 8010-distribution transformer. This type of transformer is no longer produced on the market.

The objective of this project is to eliminate the overload on the Dominguito 8010 transformer. To solve this issue, a plan was established. The article has the details of the plan and its execution.

LITERATURE REVIEW

Emergency Transformer Overload in a Substation

The protection of a transformer against the overloads is performed by a dedicated protection usually called thermal overload relay. "A transformer overload is always due to an increase of the apparent power demand of the installation." This rise in demand may result from gradually adding loads or expanding the installation. In double winding transformers, protection is provided from the supply side through a single relay in one phase that activates upon receiving a signal. [1].

A transformer can be expected to fail at least once every 15 years. This could depend on external configurations made in the substation such as underground cable, protection settings, etc. The three factors that need to be considered in a transformer overloading are: the magnitude of the overload, the duration of the overload and frequency of occurrence [2].

The utility treats the lumped load as the overall power demand at a substation, essentially viewing it as a single entity that draws power and is connected to the substation's switchgear bus via a distribution cable. The primary goal in designing a substation is to prevent a complete shutdown. When a substation houses two transformers, there might be a need to temporarily de-energize one transformer for maintenance due to a failure or fault along the line. This necessitates the selection of the most appropriate bus scheme for the substation, as the ease of maintenance, operational flexibility, and overall reliability of the substation significantly hinge on the chosen bus configuration.[3].

In general, the loss of one transformer and overloading of the remaining only transformer in the substation requires an in-depth understanding of the customer's loading types, maximum rated capacity of the bus of the only switchgear, asymmetric fault currents on the bus, arc flash incident energy, and arc flash boundary to ensure the workforce's safety and comfortability. "Whenever the total dynamic loading amount is relatively higher among the customers of substation service territory, then the transformer output needs to be brought down by prioritizing the customers it needs to serve. Finally, the substation design must consider the maximum dynamic loading of the customers" [3].

Standard Practice of Transformer Overload in a Substation

When a transformer in the power system fails, it can result in the severe outcome of a widespread power outage. The rise in a transformer's load causes an increase in the temperature of its windings, adversely impacting the transformer's insulation quality and ultimately reducing its lifespan. Hence, it's crucial to implement strategies for the effective monitoring of the transformer's load to maintain it within manageable limits. [4].

The American Institute of Electrical Engineers (AIEE) standards for transformers have primarily focused on defining a standard rated output based on specific assumed conditions, aiming for uniformity in design and testing. These standards have contributed to transformers generally achieving a long and useful service life under normal operating conditions. However, these guidelines do not set performance standards that can be guaranteed and verified through acceptance testing when ambient temperatures deviate from those specified by the rating standards. Instead, they serve as a recommendation for safely managing the transformer's load beyond its rated capacity under certain conditions. The critical factor to be taken into account when determining allowable overloading is the degradation of the transformer's insulation, as this is crucial to the transformer's longevity and operational safety. So, there was some uncertainty behind this topic due to new technologies and designs that are upcoming, the different voltage class, and types of transformers that exist back then. These stills apply today but there are guides that can help the transformer perform in the highest reliability and as long as possible [5].

EVALUATION OF ALTERNATIVES

Figure 1 shows the Dominguito 8010 transformer. Three alternatives were established to eliminate the Dominguito overload. The first alternative was to replace three transmission poles and enable the Arecibo Rural substation 8003. The estimated cost is $21,000. The second alternative was to make an underground repair between the feeders 8007-1 (Mirador Azul) and 8010-3 (Dominguito) to transfer the load from 8010-03 to 8007-3. The estimated cost is $59,000. The third option was to make a transformer convention on 8015-09 (Arecibo SECT). Instead of installing a step-down transformer, the best option is to change the lateral loads to a direct conversion of 13.2 kV. Feeder 8015-09 (Arecibo SECT) passing across the majority of Sub 8010 feeders. It can cost $100,000 or more.

Figure 1
Dominguito Transformer

The first alternative could take between 4 to 8 weeks (the execution can accomplish the course goal or extend a little bit). The second alternative could take 6 to 16 weeks and needs to be subdivided in 3 phases. The third option could take 12 months to execute. At this point, the third alternative was eliminated due to the complications it presented.

The supervisors of Engineering, Operations, Asset Management, Capital Programs and Project Management reviewed the alternatives to make a decision. The importance of this revision was to ensure IEEE (The Institute of Electrical and Electronics Engineers) Standards compliance, material availability, availability of capable resources to perform the job, outages available to perform the jobs, and the safety/training required to this project. The first alternative was selected.

Figure 2 shows the Arecibo Distribution Diagram. The feeders are marked with yellow triangles. The plan was to use the backbone (336 SPACER, 556 ACSR) of the feeder 8007-01 through the PR 129 to transfer the loads from feeder 8010-03 to the Arecibo Rural 8003 substation. In parallel, the underground section under the Highway PR-22 Bridge was going to be completed. The availability of the materials for this job needs to be verified in the warehouse. Finally, circuit 8007-01 will be sectionalize such that the load can be transferred from the Dominguito 8010 substation.

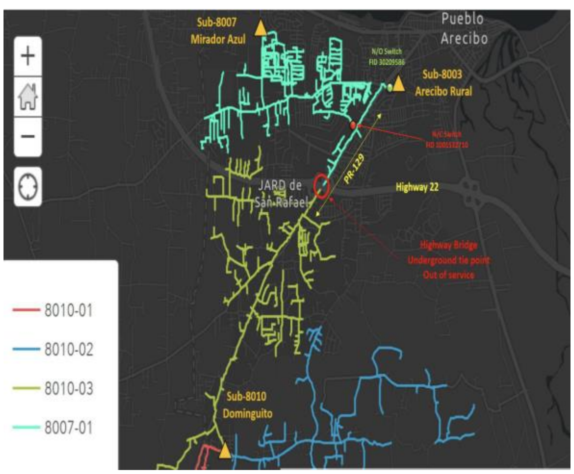

Figure 2
Arecibo Distribution Diagram

RESULTS

The crews went to Highway PR-22 Bridge to install an underground cable. They blocked the road for 4 days to perform the works. Solid system was applied in this area. The cable was laid off in open troughs and covered with asphalt. The connection was tested and monitored closely an additional to ensure the reliability and compliance.

They replaced three transmission poles that pass-through Arecibo Rural 8003 substation. Machinery and logistics to install the poles took 1 week to execute properly. Therefore, 480 customers were impacted 27 hours of service during this timeframe (not consecutive hours).

Visual assessment was made on the substation to identify materials and actions required to enable it. Five current transformers, three power transformers, and two disconnect switches were replaced. However, a breaker replacement and relocation of transformer is required and it could take more than expected.

CONCLUSIONS

The approach for this paper was to explain the execution to eliminate the overload on the Dominguito 8010 transformer. Three alternatives were identified to evaluate the overall situation on Dominguito substation. It was analyzed and discussed with departments of Engineering, Operations, Asset Management and Project Management. The plan was to replace three transmission poles and enable the substation 8003 Arecibo Rural.

The project has been delayed due to lack of resources. This problem is common in a lot of industries due to catastrophic events occurred in the last decade. Material availability has been a huge factor in this industry because the raw material is insufficient for the demand worldwide. Other factor is the lack of capable personnel to execute the job properly. The learning curve is too slow in this industry and the impact is been reflected negatively.

This implies that the overload is still in effect. The transformer is deteriorating each day it is overloaded. The substation needs to be rebuilt or relocated within the next decade. The challenge of the next couple of years is to monitor a transformer that has been damaged and create an RFP (Request for Proposal) to this substation so that can be imposed as part of the budget or part of a FEMA (Federal Emergency Management Agency) project.

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