



# Strategic Management of Electrical Distribution Infrastructure for the Valley Village Affordable Housing Development



Ricardo Jr. De La Cruz Corujo  
 Advisor: Héctor J. Cruzado, PhD, PE  
 Graduate School – Master of Engineering Management

## Abstract

This project developed a strategic electrical distribution infrastructure solution to support the interconnection of the Valley Village affordable housing development in Santa Isabel, Puerto Rico, consisting of approximately 300 residential units with a projected demand of 2,150 kVA. Operational studies confirmed that the existing 4.16 kV feeder operated at approximately 90% of its loading capacity, resulting in thermal loading and voltage regulation limitations that restricted additional load integration. Engineering analyses, including load flow simulations, voltage drop evaluations, and distribution design validation, were conducted to identify feasible interconnection alternatives. The methodology followed the PMBOK framework and incorporated a structured decision matrix based on technical feasibility, reliability, cost efficiency, and operational risk. The selected 13.2 kV feeder extension was developed to an execution-ready level within the established \$800,000 project budget. The resulting solution is expected to improve system capacity, enhance voltage performance, and support long-term reliability and future load growth.

## Introduction

- Puerto Rico's electrical distribution system continues facing challenges associated with load growth, aging infrastructure, and new development interconnections.
- These conditions require rigorous engineering evaluations to maintain system reliability, operational continuity, and regulatory compliance.
- Distribution Engineering plays a critical role in supporting the safe and efficient integration of new developments into the electrical grid.
- Data-driven and sustainable engineering solutions are essential to improve long-term system performance and operational efficiency.

## PROJECT OVERVIEW

- Project: Valley Village Affordable Housing Development
- Location: PR-545 Int. PR-52, Descalabrado Ward, Santa Isabel P.R.
- Total Development Size: 300 residential units
- Construction Approach: Phased Private Development
- Electrical Demand: 2,150 kVA
- Funding Support: PR Housing Finance Authority (AVF) – CDBG-DR/MIT
- Regulatory Context: Puerto Rico Executive Order OE-2025-052

## Objective

Develop a technically feasible, reliable, and cost-effective electrical distribution infrastructure solution for the Valley Village interconnection project designed to support:

- System Capacity
- Voltage Performance
- Operational Reliability
- Future Load Growth & Expansion
- Infrastructure Sustainability

## Problem

System Constraints:

- Existing distribution infrastructure operates at 4.16 kV through Feeder 4601-04 (Substation 4601 – Useras).
- Feeder is operating near capacity limits (~90% loading).
- Thermal overloading and conductor limitations reduce circuit ampacity and available capacity.
- Voltage drops and regulation issues impact system reliability.
- System cannot support the additional 2,150 kVA demand of Valley Village development.

## Methodology

The methodology for this project was based on the Project Management Body of Knowledge (PMBOK) framework, which integrated structured project management principles with detailed electrical engineering analysis to ensure a technically sound and execution-ready solution. This approach combined PMBOK process groups with data-driven evaluation methods to support informed decision-making and facilitate the transition to the construction phase.

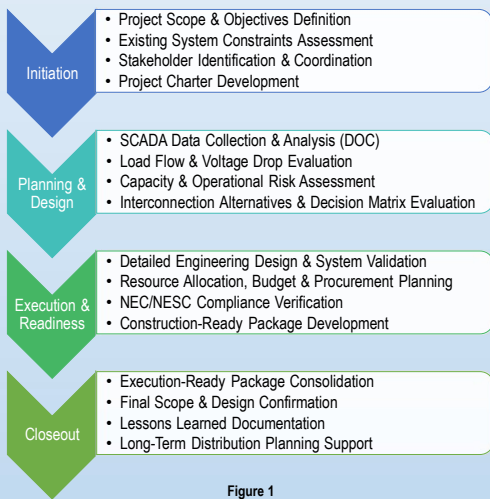


Figure 1  
 PMBOK-Based Engineering Project Flow by Phase

## Results

The proposed interconnection alternatives were systematically evaluated using a weighted decision matrix based on technical feasibility, reliability, cost efficiency, schedule feasibility, and operational risk criteria. The alternatives assessed included a new 13.2 kV feeder extension (Option A), 4.16 kV feeder reconfiguring (Option B), and a voltage conversion system (Option C). Based on the overall engineering evaluation, Option A achieved the highest weighted score and was identified as the most technically feasible, reliable, and strategically suitable solution for the Valley Village interconnection project.

Table 1  
 Weighted Decision Matrix for Interconnection Alternatives

Criteria	Weight	Option A	Option B	Option C
Technical Feasibility	30%	5 (1.50)	2 (0.60)	4 (1.20)
Reliability	20%	5 (1.00)	2 (0.40)	4 (0.80)
Cost Efficiency	20%	4 (0.80)	3 (0.60)	2 (0.40)
Schedule Feasibility	15%	4 (0.60)	2 (0.30)	3 (0.45)
Operational Risk	15%	4 (0.60)	2 (0.30)	3 (0.45)
<b>Total Weighted Score</b>	<b>100%</b>	<b>4.50</b>	<b>2.25</b>	<b>3.35</b>

The results obtained from the engineering analyses and system validation studies confirmed the technical feasibility and operational reliability of the proposed 13.2 kV interconnection solution for the Valley Village development.

The following figures illustrate the feeder capacity improvement, PoleForeman structural compliance analysis, and the selected 13.2 kV feeder routing and interconnection configuration for the recommended solution.

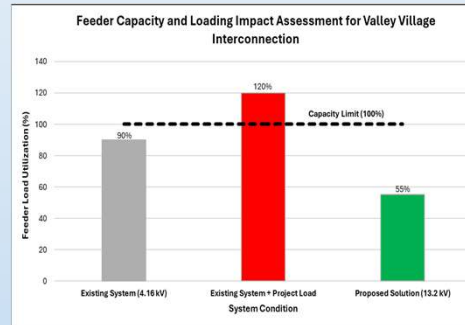


Figure 2  
 Feeder Capacity Assessment for Valley Village Interconnection

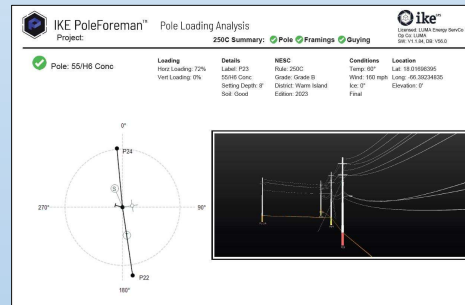


Figure 3  
 Pole Loading Analysis Results for the Proposed 13.2 kV Distribution Interconnection using PoleForeman

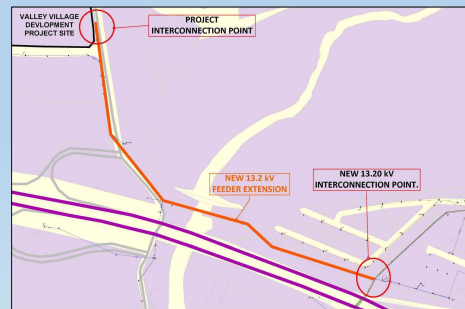


Figure 4  
 Selected 13.2 kV Feeder Routing and Interconnection Configuration

## Project Budget Allocation

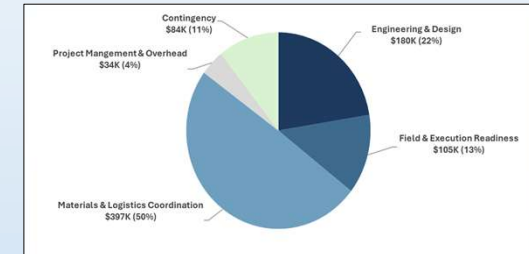


Figure 5  
 Estimated Project Budget Allocation

## Budget Summary

<b>Direct Costs (Engineering, Materials &amp; Execution)</b>	<b>\$682,000 (85%)</b>
Project Management & Overhead	\$34,000 (4%)
Contingency (Risk Allowance)	\$84,000 (11%)
<b>Total Estimated Budget</b>	<b>\$800,000</b>

## Conclusion

- The proposed 13.2 kV feeder extension demonstrated a technically feasible, reliable, and cost-effective solution for the Valley Village interconnection project.
- Engineering analyses and system validation studies confirmed improvements in feeder capacity, voltage performance, operational reliability, and long-term distribution system expansion capabilities.
- The project successfully developed an execution-ready package that included:
  - ✓ Final engineering design documentation
  - ✓ Technical specifications
  - ✓ Resource allocation planning
  - ✓ Material procurement coordination
  - ✓ Risk mitigation strategies
  - ✓ Permitting coordination activities
- Overall, the project demonstrated how engineering management and data-driven planning support reliable and sustainable electrical distribution growth.

## References

- [1] Baran, M. E., & Wu, F. F. (1989). *Network reconfiguration in distribution systems for loss reduction and load balancing*. IEEE Transactions on Power Delivery, 4(2), 1401–1407.
- [2] IEEE. (2012). *IEEE guide for electric power distribution reliability indices* (IEEE Std 1366-2012). IEEE.
- [3] Ryu, H., Chae, W., Kim, H., & Cho, J. (2025). Mid- to long-term distribution system planning using investment-based modeling. *Energies*, 18(14), 3702. <https://doi.org/10.3390/en18143702>
- [4] Romero Agüero, J., Takayesu, E., Novosel, D., & Masiello, R. (2017). *Modernizing the grid*. IEEE Power & Energy Magazine, 15(3), 74–83.
- [5] Central Office for Recovery, Reconstruction and Resiliency (COR3). (2019). *Grid modernization plan for Puerto Rico*.
- [6] Wang, S., & Bo, R. (2023). *A resilience-oriented multi-stage adaptive distribution system planning considering multiple extreme weather events*. IEEE Transactions on Sustainable Energy, 14(2), 1193–1205. <https://doi.org/10.1109/TSTE.2023.3234916>