Proceedings of the 11th World Congress on Electrical Engineering and Computer Systems and Sciences (EECSS'25)
Paris, France - August, 2025
Paper No. EEE 111
DOI: 10.11159/eee25.111

Underground Installation of Low Voltage Distribution Boxes

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Abstract - This study covers an R&D project that focuses on the underground integration of low voltage distribution cabinets (LVDCs) in urban areas. The primary goal of relocating LVDCs underground is to mitigate issues such as visual pollution, space occupation, and safety risks caused by existing above-ground cabinets. The project aims not only to preserve urban aesthetics but also to enhance pedestrian mobility by removing physical obstacles. Additionally, this solution offers significant benefits such as reducing technical losses, modernizing the distribution network, and improving energy supply reliability, ultimately enhancing citizen satisfaction [1]. Overall, the underground LVDC solution represents an innovative approach designed to make urban electrical distribution infrastructure safer, more aesthetic, and more efficient.
Keywords: Distribution Cabinet, Low Voltage, Underground Network, Energy Supply, Grid Infrastructure.

1. Introduction

Low voltage distribution cabinets (LVDCs), also known as distribution cabinets, are essential infrastructure components that play a critical role in modern urban underground electrical distribution networks. These cabinets enable the localization of low voltage faults within smaller areas, significantly reducing the number of citizens affected by power outages.

However, the design and placement of existing LVDCs pose various challenges, particularly in city centers where historical heritage is preserved and pedestrian traffic is dense (Figure 1). The installation of these cabinets on sidewalks or in front of buildings presents safety risks and negatively impacts the city's aesthetic appearance. In areas with high pedestrian traffic, the presence of these cabinets on sidewalks restricts pedestrian flow and hinders mobility. This situation reduces the quality of life for both residents and visitors, leading to public dissatisfaction.

In densely populated and historical urban areas, the lack of available space for installing LVDCs on sidewalks has become a significant issue for local authorities and electricity distribution companies. In this context, innovative solutions are required to eliminate the current disadvantages of LVDCs and facilitate urban life.

Figure 1. Distribution Cabinets Obstructing Pedestrian Traffic on Sidewalks

2. Design Criteria and Production Process

The cabinet design has been optimized to occupy minimal space. When field personnel need to intervene, the cabinet will be elevated to the same dimensions as above-ground distribution cabinets through a retractable mechanism. Once the intervention is completed, the cabinet will retract back to ground level, aligning flush with the sidewalk. This feature has been developed to facilitate ease of intervention for field personnel.

A metal support frame is incorporated to ensure the stability of the LVDC in both vertical and horizontal positions. This frame, designed to bear the cabinet's weight, is made of 3 mm thick pre-galvanized sheet metal, coated with anti-corrosion primer, and painted in RAL 7035 color. The metal support frame is housed within a concrete enclosure and securely fastened to the side walls and base using appropriately sized bolts or steel anchors. Additionally, the frame includes a dedicated section where the hydraulic arms used to lift the cabinet are attached.

The underground LVDC is designed in compliance with the IEC 61439 standard. The inner panel has an IP54 protection rating, while the external enclosure meets the IPX6 protection level.

As shown in Figure 2, the designed underground distribution cabinet consists of seven main components.

1. Low voltage distribution panel
2. Metal support frame
3. Cable connection section
4. Concrete enclosure
5. Concrete enclosure metal top frame
6. Above-ground outer protective cover

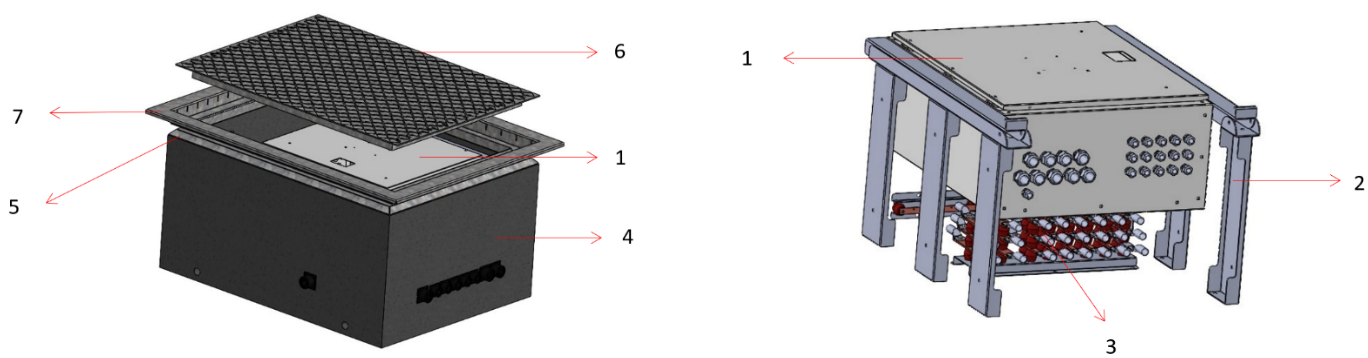

Figure 2. Underground LVDC Integrated Design

The LVDC is assembled within a monoblock concrete enclosure with a fully enclosed structure on all four sides and the base. It includes a metal transport frame, copper busbar connection block, and connection cables. This concrete enclosure has dimensions of 1150 x 1500 x 750 mm (width x length x height) and is manufactured using C35-grade ready-mix concrete, reinforced with iron and wire mesh for internal reinforcement. The base is designed with a 2-3% slope towards the center to facilitate water drainage, and a central drainage siphon hole is provided. To facilitate transportation, four lifting holes are incorporated into the bottom of the concrete enclosure, allowing for the placement of carrier pipe profiles. The total weight of the concrete enclosure is approximately 1 ton. The positioning of the underground LVDC is shown in detail in Figures 3, 4, and 5.

Figure 3. Vertical-Side Position

Figure 4. Horizontal Position

Figure 5. Vertical Position

3. Installation and Assembly

The underground LVDC was successfully installed in January 2025 within the service area of Boğaziçi Elektrik Dağıtım Anonim Şirketi. As shown in Figure 6, the installation was carried out by surrounding the enclosure with gravel stones, ensuring that the external protective cover is flush with the ground level.

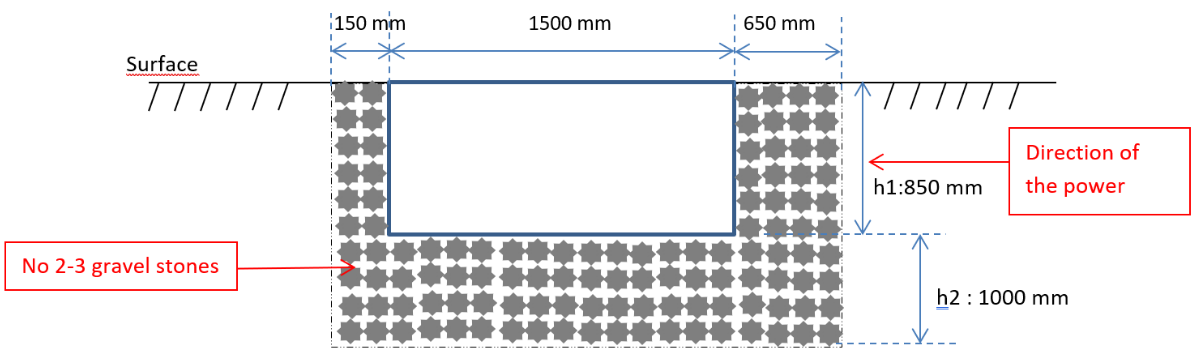

Figure 6. Installation Guide

During the installation process, the excavation area was prepared to ensure the proper positioning of the concrete enclosure. First, two copper rods were placed in the excavation area for protective grounding. Then, gravel stones of size 2-3 were spread up to a depth of 85 cm from the ground level to facilitate rainwater drainage. The concrete enclosure was carefully positioned in the installation area using a crane, and the incoming and outgoing power cables, along with grounding cables, were routed through the cable glands on the concrete enclosure and connected to the copper busbar system. Additionally, connections were completed to the grounding busbar inside the concrete enclosure and the grounding bolt on the upper metal cover frame. The resistance of the protective grounding was measured using a Megger device, ensuring that the values were within the reference limits ($\leq 5\ \Omega$).

In the next phase of the installation, the four sides of the concrete enclosure were filled with 2-3 size gravel stones up to ground level, using approximately 5 m^3 of material. A protective cover was placed over the cable and copper busbar connection section, followed by the installation of the external protective covers using hand grips. The locking screws located at the cover corners were secured with an Allen key, and the area between the pavement level and the cover frame was plastered with cement mortar to achieve an aesthetic and robust finish.

In the final stage, the operational position of the underground LVDC was tested, verifying the functionality of the system with the panel cover both open and closed (Figure 7).

Figure 7. Underground LVDC Field Installation

4. Discussion

Conventional secondary distribution cabinets (SDKs) used in current urban grids often cause significant visual pollution, especially in historically or architecturally sensitive areas. Moreover, they limit pedestrian mobility and hinder the efficient use of public spaces [2]. Additionally, being exposed to external environmental conditions increases the safety risks and long-term maintenance needs of these structures [3]. The underground SDK solution minimizes these issues and offers a more integrated and sustainable approach to urban energy distribution.

In city centers where space is limited, challenges related to the placement of SDKs directly impact the renovation processes of underground networks [4]. Therefore, underground cabinets with compact structures, high safety standards, and easy accessibility offer significant advantages in terms of operational efficiency and long-term infrastructure investment.

From a technical perspective, the transition to underground systems contributes to the reduction of technical losses, improvement of voltage quality, and decrease in maintenance costs [5]. These improvements are also expected to have positive effects on energy supply security and key performance indicators such as SAIDI and SAIFI [6].

Figure 8. Current Status

5. Conclusion

This study highlights the multidimensional benefits of the underground SDK solution, developed as an alternative to conventional applications that pose visual, physical, and technical problems in urban energy distribution infrastructure. This approach contributes to modern urban development by improving aesthetics, safety, energy efficiency, and infrastructure renewal processes [2][3].

The underground SDK project addresses not only short-term aesthetic concerns but also long-term sustainability goals. In addition to minimizing spatial occupation and maintenance difficulties, it offers strategic benefits such as reducing technical losses and increasing customer satisfaction, thus representing a critical step toward the modernization of energy infrastructure [5][6].

5. Acknowledgment

This research is funded under the project titled “Underground Field Distribution Box” with project number 01/23/10-07, within the scope of the “2023 R&D Project Call” organized by the Energy Market Regulatory Authority of the Republic of Turkey.

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