A Study on the Benefits and Impacts of a 110/220 V Three-Phase Four-Wire Low-Voltage Power Supply Configuration

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1. Research Background

To provide value-added and user-centric electricity services while reducing power losses, it is important to consider Taipower’s current three-phase three-wire 220 V supply system. Under this system, customers who need to operate single-phase 110 V electrical appliances must install additional low-voltage autotransformers, resulting in additional power losses and reduced overall system efficiency.

The introduction of a new low-voltage three-phase four-wire power supply system will bring multiple benefits, not only enhancing the quality of power services but also demonstrating the company's proactive fulfillment of its social responsibility. Firstly, in terms of cost savings, customers who can directly obtain the required 110 V low-voltage supply will be able to avoid the expenses associated with installing or replacing low-voltage transformers, thereby reducing the overall cost of power conversion. Secondly, the energy-saving and carbon-reduction benefits are also significant. Eliminating the need for additional voltage-conversion transformers can reduce equipment energy consumption and associated carbon emissions, thereby improving energy efficiency.

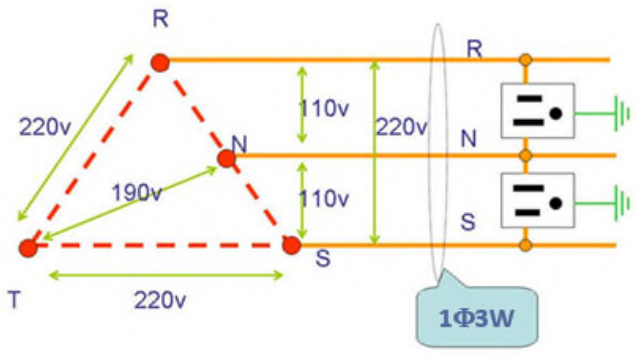
2. Research Content and Results

According to Article 46 of Taipower's current Business Regulations, low-voltage power supply covers single-phase two-wire (110 V, 220 V), single-phase three-wire (110/220 V), three-phase three-wire (220V, 380V), and three-phase four-wire (220/380 V) power supply modes. Under the current framework, customers applying for a three-phase three-wire 220 V supply who also need to operate 110 V equipment must install their own transformers to obtain the required voltage. This not only increases the user's setup and maintenance costs but also reduces the convenience of power supply.

Furthermore, current regulations generally require each customer with a contracted capacity below 100 kW to use only one supply configuration. To address the difficulty of a single power supply mode being compatible with multiple voltage levels of equipment, this plan explores the feasibility of adding a "three-phase four-wire 220/110 V" power supply architecture. While maintaining the principle of single-mode power supply, it is proposed to allow customers with three-phase three-wire 220 V power supply to flexibly add single-phase three-wire 110/220 V auxiliary power supply paths, thereby optimizing power distribution efficiency and meeting diverse load demands.

In the common three-phase four-wire lighting and power co-supply transformer wiring system of Taipower's power distribution system, as shown in Figure 1, in order to simultaneously supply three-phase power (such as motors) and single-phase lighting loads, the center tap of one winding is grounded and serves as the neutral point. This configuration results in a voltage of 110 V to ground for two-phase conductors, while the voltage to ground for the third phase conductor (referring to the one with the higher voltage to ground) will rise to approximately 190

V (110×√3). This phase is referred to as the high-leg phase in engineering practice.



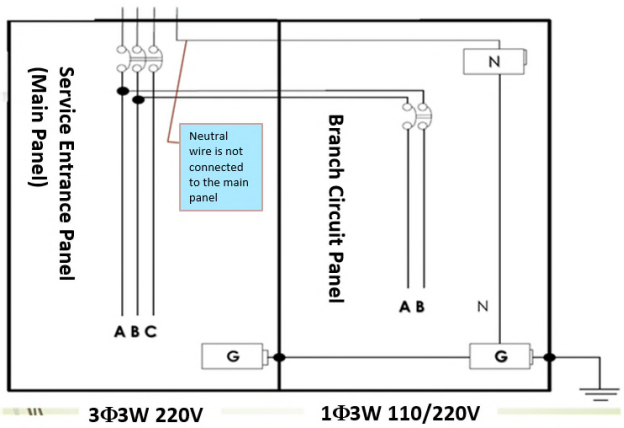
Source: This study

Figure 1. Three-phase three-wire 220V and single-phase three-wire 110/220V wiring

To ensure maintenance and inspection personnel can easily identify this special conductor, Article 33 of the "Rules for User Electrical Equipment Installation" clearly stipulates that this phase conductor must be identified by a different colored sheath. If the conductor sheath color does not match on site, it must be marked at all accessible locations such as joints, junction boxes, and distribution panels using different colored tape, tags, or other permanent means. This visual "color warning" is a crucial safety measure in the secondary wiring of distribution transformers in power distribution systems.

The core purpose of this regulation is to prevent incorrect load connections. If electrical technicians mistakenly connect single-phase 110 V equipment between the distinctly color-marked high-leg conductor and the neutral conductor, the equipment will be subjected to an overvoltage of up to 190V, which could potentially cause instantaneous burnout of electrical appliances, insulation failure, or even a fire. Therefore, the regulation requires that the high-leg phase be typically positioned centrally within the distribution panel to distinguish it from ordinary single-phase circuits. By strictly implementing color-coded identification signs and symmetrical configuration within the distribution panel, maintenance efficiency can be effectively improved and cost losses caused by human error can be reduced, thereby achieving the project's goal of enhancing power supply flexibility and service quality.

In addition to strengthening the user's identification and early warning mechanism for 190V lines, through pre-marking and hazard identification signs for reminders and explanations, it is also necessary to plan for separate configurations of user three-phase switch boxes and single-phase switch boxes, as shown in Figure 2, to separate single-phase three-wire 110/220 V and three-phase three-wire 220 V power supplies. However, the disadvantage is that customers need to install branch switch boxes in addition to the main switch box, which will increase customers' equipment costs and space requirements.



Source: This study

Figure 2. New low-voltage power supply switch box panel configuration

3. Conclusion

While the new three-phase four-wire 220/110 V low-voltage power supply mode can improve power

supply flexibility and meet the needs of customers who simultaneously use three-phase 220V power equipment and single-phase 110/220 V loads, the risk of misconnection due to the 190V voltage to ground on the higher-phase side still needs to be considered. Therefore, when promoting this power supply mode in the future, safety measures such as different color identification markings, hazard warnings, and separate three-phase and single-phase switch boxes should be strengthened to reduce the risk of equipment burnout, insulation failure, and fire. In addition, since existing customers may need to install a neutral line in the service conduit if they switch to the new power supply mode, the limited conduit capacity and installation space may make installation more difficult and risky. Therefore, it is recommended that this power supply mode be mainly promoted to new customers, and that stakeholder meetings be used to improve customer communication and awareness to balance power supply flexibility, user safety, and construction feasibility.