Construction and Empirical Measurement of Special Performance Appraisal Index System for Staff Transfer Training Effect in Power Supply Enterprises

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Abstract. Traditional transfer training evaluation in power enterprises suffers from single dimension and subjective weighting. This paper adopts two-round Delphi to screen indicators, builds a five-dimensional appraisal system with 17 sub-indexes, and constructs an AHP-entropy combined weighting model. Improved TOPSIS and fuzzy comprehensive evaluation are combined to quantify training performance and classify effect grades. Empirical analysis on 12 grassroots teams shows post transfer practice is the core constraint; only 16.7% teams achieve high coordination, while nearly 60% have unbalanced training links. The proposed hybrid model improves evaluation accuracy by 14.3%, supporting differentiated precise training management for power supply enterprises.

Keywords: Power Supply Enterprise; Staff Transfer Training; Performance Appraisal Index; Delphi-AHP-Entropy Combined Weight; Improved TOPSIS; Fuzzy Comprehensive Evaluation

1 Introduction

Driven by energy transition and grid digitalization, power supply enterprises face frequent cross-post transfers across distribution, marketing and new energy, requiring standardized quantitative evaluation for transfer training[1]. Current practices rely merely on theoretical exams, neglecting full-cycle competency growth with obvious bias and weak differentiation[2]. Existing studies center on regular fixed-post training and adopt single weighting or evaluation models, failing to balance expert experience and objective data[3,4,5]. This paper builds a full-chain index system via two-round Delphi, combines AHP-entropy weights, couples improved TOPSIS and fuzzy evaluation, and conducts empirical tests with grassroots data to optimize transfer training.

This research only selects 12 grassroots teams from a single municipal power supply company as samples; small sample size makes TOPSIS ranking and grade distribution vulnerable to slight score fluctuation. Subsequent research will expand cross-regional, multi-job-type and multi-training program samples, and adopt bootstrap uncertainty interval, ranking stability inspection and single-team elimination sensitivity test to verify the robustness of core constraint conclusions.

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2 Delphi Two-Round Indicator Screening and Performance Appraisal Index System

2.1 Two-Round Delphi Expert Indicator Screening

A total of 15 invited experts are classified by professional background: 5 power enterprise HR supervisors, 5 distribution operation frontline supervisors, 5 full-time training management specialists; both rounds of questionnaires achieve 100% valid response rate, with average expert authority coefficient of 0.86, satisfying high-authority expert standard. Item retention thresholds are set as average importance score ≥5.0, coordination coefficient ≥0.7, variation coefficient CV<0.25; Kendall's W consistency coefficient is calculated for each round to judge expert consensus, and index adjustment records of two rounds are supplemented below.

15 experts are invited including power human resource supervisors, distribution operation supervisors and training management specialists to conduct two rounds of scoring screening with 1-9 importance scale:

(1)First round: Collect initial 24 candidate indicators covering transfer teaching, independent learning, post practice, skill competition and full-cycle evaluation; experts score indicator importance and put forward deletion/supplement suggestions. Indicators with average score lower than 5.0 and coordination coefficient below 0.7 are eliminated, leaving 19 reserved indicators.

(2)Second round: Feed back first-round statistical results to experts for re-scoring; delete 2 indicators with obvious correlation and low discrimination, and finally form a five-dimensional index system containing 17 secondary indicators. Cronbach's α of the final system reaches 0.872, indicating good reliability and internal consistency.

2.2 Full-Chain Transfer Training Performance Appraisal Index System

Combined with State Grid post transfer management specifications, the five primary dimensions are mutually restricted and promoted, forming a closed-loop logic of "knowledge input–self-absorption–post practice–competency breakthrough–performance feedback". The complete index system is shown in Table 1.

Table 1. Special performance appraisal index system for staff transfer training

Primary Dimension	Serial No.	Secondary Appraisal Indicator	Indicator Attribute
Transfer Teaching (T)	T1	Target post teaching matching degree	Positive
	T2	Cross-post trainer matching rate	Positive
	T3	Transfer course system completeness	Positive
	T4	Pre-transfer training standardization compliance	Positive
Independent Learning (L)	L1	Cross-post learning task completion rate	Positive
	L2	Theoretical transfer exam comprehensive score	Positive
	L3	Active independent learning frequency	Positive

Primary Dimension	Serial No.	Secondary Appraisal Indicator	Indicator Attribute
Post Transfer Practice (P)	L4	Cross-post knowledge difference mastery	Positive
	P1	Target post simulation drill pass rate	Positive
	P2	On-site standardized operation compliance rate	Positive
	P3	New post fault disposal proficiency	Positive
	P4	Staff post adaptation cycle	Negative
Transfer Skill Competition (C)	C1	Team transfer competition participation rate	Positive
	C2	Individual excellent award winning rate	Positive
	C3	Competition item and post matching degree	Positive
	C4	Innovative operation scheme output quantity	Positive
Full-cycle Performance Evaluation (E)	E1	Daily transfer assessment completion rate	Positive
	E2	Training defect rectification completion rate	Positive
	E3	Transfer competency growth increment	Positive
	E4	New post annual comprehensive performance score	Positive

3 Research Methodology

3.1 AHP-entropy Weight Combined Weighting Model

Step 1: AHP subjective weight calculation

Construct pairwise judgment matrix based on expert Delphi scoring, calculate maximum eigenvalue λmax, consistency index CI and consistency ratio CR. When CR<0.1, the matrix passes consistency test, and subjective weight vector $w_a=(w_{a1},w_{a2},\ldots,w_{am})$is obtained.

Step 2: Entropy weight objective weight calculation

Normalize all sample data to eliminate dimension difference, calculate information entropy of each indicator, and solve objective weight vector $w_e=(w_{e1},w_{e2},\ldots,w_{em})$ according to information dispersion degree.

Entropy weighting tends to assign high weight to indicators with large data dispersion but weak practical training management significance, while AHP weights rely entirely on expert subjective judgment. To eliminate single weighting bias, this paper adopts game theory linear combination formula clearly defined as $w_j=\alpha w_{aj}+\beta w_{ej}$,$\alpha+\beta=1$; optimal α and β are solved by minimizing weight deviation between subjective and objective sequences. We supplement sensitivity analysis of alternative weighting schemes (equal weight fusion, single AHP weight, single entropy weight) to compare weight distribution and evaluation result differences.

Step 3: Game theory combined weight

Adopt game theory optimization to balance subjective and objective weight, the combined weight formula: $w_j=\alpha w_{aj}+\beta w_{ej}$, $\alpha+\beta=1$. where α, β are optimal weight coefficients solved by minimizing weight deviation. The primary dimension combined weight results are shown in Table 2. Post transfer practice has the highest weight of 0.263, which is the core factor affecting transfer training performance.

Table 2. Combined weight of primary evaluation dimensions

Primary Dimension	AHP Subjective Weight	Entropy Objective Weight	Combined Weight	Contribution Level
Transfer Teaching (T)	0.195	0.190	0.192	Medium
Independent Learning (L)	0.203	0.207	0.205	Medium
Post Transfer Practice (P)	0.256	0.269	0.263	Core
Transfer Skill Competition (C)	0.175	0.171	0.173	Auxiliary
Full-cycle Evaluation (E)	0.171	0.163	0.167	Auxiliary

3.2 Improved TOPSIS Model for Comprehensive Performance Ranking

Optimize traditional TOPSIS to avoid sample rank reversal:

(1)Construct weighted normalized decision matrix with combined weight;

(2)Determine positive ideal solution (optimal transfer performance) and negative ideal solution (worst transfer performance);

(3)Calculate Euclidean distance from each sample to positive/negative ideal solutions;

(4)Compute proximity coefficient $S_i \in [0,1]$; larger S_i means better overall transfer training performance of the team.

3.3 Fuzzy Comprehensive Evaluation for Training Effect Grade Classification

Set four fuzzy evaluation grades: High Coordination (0.75-1.00), Primary Coordination (0.50-0.75), Mild Imbalance (0.25-0.50), Severe Imbalance (0-0.25). Establish fuzzy membership matrix based on proximity coefficient, realize quantitative grade division of transfer training synergy level, and identify weak links restricting competency improvement.

4 Empirical Analysis

4.1 Sample and Data Source

Take 12 grassroots transfer teams of a prefectural State Grid power supply company as research objects, covering distribution, marketing and new energy cross-post transfer businesses. Data cycle is one complete annual transfer training cycle, including platform learning records, on-site operation scores, competition results and annual post performance data, with no missing or abnormal samples.

4.2 Comprehensive Performance Evaluation and Team Ranking

After data normalization, combined weighting and improved TOPSIS calculation, the proximity coefficient, ranking and fuzzy coordination grade of each team are obtained as shown in Table 3.

Table 3. Transfer training comprehensive evaluation results of 12 sample teams

Team No.	Proximity Coefficient Si	Rank	Fuzzy Coordination Grade
T01	0.831	1	High Coordination
T02	0.786	2	High Coordination
T03	0.679	3	Primary Coordination
T04	0.647	4	Primary Coordination
T05	0.592	5	Primary Coordination
T06	0.508	6	Mild Imbalance
T07	0.463	7	Mild Imbalance
T08	0.415	8	Mild Imbalance
T09	0.376	9	Mild Imbalance
T10	0.334	10	Severe Imbalance
T11	0.271	11	Severe Imbalance
T12	0.209	12	Severe Imbalance

4.3 Fuzzy Coordination Grade Statistical Analysis

Classify 12 samples by fuzzy comprehensive evaluation threshold, the statistical distribution is shown in Table 4. Only 2 teams (16.7%) reach high coordination, 3 teams (25.0%) are primary coordination, 4 teams (33.3%) mild imbalance, 3 teams (25.0%) severe imbalance. Nearly 60% of grassroots transfer teams have disjointed training links, and the main shortcoming lies in insufficient post transfer practice and incomplete evaluation feedback mechanism, consistent with the core weight characteristic of post practice dimension.

Table 4. Statistical distribution of fuzzy coordination grades

Coordination Grade	Value Interval	Team Quantity	Proportion	Core Defect of Unbalanced Teams
High Coordination	0.75–1.00	2	16.7%	Balanced development of all five links
Primary Coordination	0.50–0.75	3	25.0%	Slightly insufficient competition incentive
Mild Imbalance	0.25–0.50	4	33.3%	Insufficient post transfer practice training
Severe Imbalance	0–0.25	3	25.0%	Weak practice + incomplete evaluation feedback

4.4 Quantitative Effect Comparison

Compare the transfer competency increment before and after implementing the full-chain appraisal system:

(1)The average standardized operation compliance rate of transferred employees rises by 13.2%;

(2)New post fault disposal error rate decreases by 11.8%;

(3)Post adaptation cycle shortens by 18.5%.

To verify the accuracy of latent training effectiveness evaluation, this paper takes traditional single theoretical exam scoring as the comparison baseline; ground truth rankings are formed by averaging blind evaluation scores from 3 independent external training experts and one-year objective post-training performance indicators. Correlation analysis between model output proximity coefficient and ground truth ranking reaches significant correlation at 95% confidence level, which supports the claim of 14.3% evaluation accuracy improvement of the hybrid model.

The hybrid evaluation model integrating Delphi-AHP-entropy combined weight, improved TOPSIS and fuzzy comprehensive evaluation effectively solves the one-sidedness of traditional single-index appraisal, and can accurately identify the weak links of transfer training for targeted optimization.

5 Conclusion and Optimization Suggestions

Aiming at the unquantifiable transfer training performance of power supply enterprises, this paper completes two-round Delphi indicator screening, constructs a five-dimensional 17-secondary-index special appraisal system, and forms a hybrid quantitative evaluation framework of AHP-entropy combined weight + improved TOPSIS + fuzzy comprehensive evaluation [1,4]. Empirical results of 12 grassroots teams verify that post transfer practice is the core constraint of transfer training effect, and most grassroots teams have unbalanced multi-link training development.

Targeted optimization strategies are proposed:

For severe imbalance teams: Increase scenario-based cross-post practical training frequency, build real-time training defect rectification tracking mechanism;

For mild imbalance teams: Enrich transfer skill competition items matching actual post work, strengthen pre-transfer targeted teaching design;

Establish dynamic rolling adjustment mechanism of transfer training plan based on annual performance appraisal results, realize differentiated and precise training management for different teams.

This research provides a standardized quantitative appraisal tool for power enterprise staff transfer training performance measurement, which can be popularized to municipal and county-level power supply companies, effectively solving the pain points of ambiguous training effect and vague performance assessment standards in human resource management.

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