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Research on the Cultivation Prospect and Optimization Path of Strategic Scientists in Power Central SOEs During the 15th Five-Year Plan Period

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Abstract. Dual-carbon goals and new power system construction drive the upgrading of power industry, and key technologies have been included in national research layouts[1]. Power central SOEs undertake the mission of cultivating strategic scientists, whose complete cultivation cycle lasts 15-25 years[2]. Existing studies mainly focus on other industries and adopt qualitative analysis[3]. This paper clarifies the core research problem, optimizes evaluation indicators and comparable research samples, and supplements complete empirical calculation processes. It analyzes cultivation status and bottlenecks, and puts forward solutions to fill the research gap.

Keywords: strategic scientist; power central SOE; talent cultivation

1 Introduction

Dual-carbon targets and new power system construction accelerate power industry reform, with UHV, new energy storage and power AI listed in national key technology research layouts[1]. As executors of national energy strategies, power central SOEs bear important responsibilities for strategic scientist training[1].

Strategic scientists need a 15-25 year training cycle featuring interdisciplinary coordination and major project management capacity[2]. Existing research mostly focus on universities, aerospace and petrochemical industries with qualitative discussion, lacking quantitative empirical research targeting power enterprises under the 15th Five-Year Plan[3]. This paper clarifies the core research problem, improves the rationality of evaluation indicators, optimizes research samples with strong comparability, supplements complete empirical calculation processes, and explores cultivation status, obstacles and optimization paths to fill research gaps.

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2 Theoretical Framework and Research Methods

2.1 Definition of Strategic Scientists

Different from ordinary R&D engineers focusing on single-field technical improvement within a 5–10 year growth cycle, power industry strategic scientists are top disciplinary pioneers rooted in the power sector. Such scarce talents rely on engineering practice and institutional support, and play a vital role in helping power central SOEs achieve technological self-reliance[1].

Combined with industrial features, this paper establishes a five-dimensional capability framework for power strategic scientists, and explicitly links each capability to core business scenarios of new power systems, UHV, new energy storage, power AI and source-grid-load-storage coordination in the power industry:

- Strategic judgment: Grasp national energy strategies and define long-term technological development routes for new power systems, UHV and new energy.
- Interdisciplinary integration: Integrate resources of electric power, AI, materials and management to promote collaborative innovation.
- Major project leadership: Lead national key R&D and large-scale power engineering projects to solve core technical difficulties.
- Academic inheritance: Cultivate young talents and build echelon teams for sustainable innovation[2].
- Engineering & risk control: Combine theoretical research with on-site practice, and manage risks in exploratory research.

This paper further differentiates strategic scientists from similar high-end talents to define research boundaries:

- Scientific leading talents: Solve field-specific technical problems with short-term performance orientation and insufficient strategic thinking.
- Chief scientists: Deliver single research projects but lack long-term industrial planning vision.
- Engineering experts: Focus on on-site technical operation and optimization, with weak capacity in basic and forward-looking research.
- Tech entrepreneurs: Prioritize market benefits and industrialization over national strategic research.
- Power strategic scientists: Focus on national energy strategies, and integrate strategic planning, basic research, cross-disciplinary innovation and project leadership as all-round top talents.

2.2 Theoretical Cultivation Framework

Referring to the innovation ecosystem theory, high-end talent growth rules and SASAC's talent policies for central SOEs[3-4], combined with the operational characteristics of power central SOEs, this paper constructs a theoretical framework with four major dimensions: task-driven training, resource guarantee, platform support and institutional constraint. The framework covers six core elements: practice of major strategic projects[1], stable basic research funds[4], national-level innovation platforms[3], academic inheritance mechanism[2], early screening of outstanding talents[4], and fault-tolerance system for exploratory research[4]. On this basis, seven measurable evaluation indicators are selected to form a complete evaluation system for the cultivation level of strategic scientists.

2.3 Quantitative Empirical Model and Calculation Formula

Entropy-weighted TOPSIS is adopted to quantify comprehensive cultivation level, and obstacle degree model is used to screen key restrictive factors. All indicators originate from publicly released annual reports, white papers and policy documents of central SOEs and SASAC[1,4], ensuring data authenticity and repeatability of empirical results.

Entropy-weighted TOPSIS Model.

Step 1: Extreme difference standardization of indicators (positive indicators, higher values represent better cultivation foundation)

$$x_{ij}' = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)} \tag{1}$$

where x_{ij} refers to the original data of the j-th indicator of the i-th evaluation object; $\max(x_j)$ and $\min(x_j)$ represent the maximum and minimum values of the j-th indicator; x_{ij}' is the standardized indicator value.

Step 2: Calculation of indicator proportion and information entropy

$$p_{ij} = \frac{x_{ij}'}{\sum_{i=1}^{n} x_{ij}'},\ e_j = -\frac{1}{\ln n} \sum_{i=1}^{n} p_{ij} \ln p_{ij} \tag{2}$$

where p_{ij} is the indicator proportion; e_j is the information entropy of the j-th indicator. Lower entropy value represents stronger indicator discrimination and higher weight.

Step 3: Calculation of objective indicator weight

$$w_j = \frac{1 - e_j}{\sum_{j=1}^{m} (1 - e_j)} \tag{3}$$

where w_j is the objective weight of the j-th indicator, with the total weight sum of 1.

Step 4: Calculation of positive and negative ideal solutions, Euclidean distance and comprehensive proximity

$$D_i^+ = \sqrt{\sum_{j=1}^{m} w_j (x_j^* - x_{ij}')^2},\ D_i^- = \sqrt{\sum_{j=1}^{m} w_j (x_j^0 - x_{ij}')^2} \tag{4}$$

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{5}$$

where D_i^+ and D_i^- represent the distance of positive and negative ideal solutions respectively; C_i is the comprehensive cultivation proximity ranging from 0 to 1, and a higher value indicates a better cultivation level.

Obstacle Degree Model.

$$O_j = \frac{\sum_{i=1}^{n} I_{ij}}{\sum_{j=1}^{m} \sum_{i=1}^{n} I_{ij}} \times 100\% \tag{6}$$

where I_{ij} is the single indicator obstacle index; O_j is the overall obstacle degree of the indicator, which is used to rank core restrictive factors, and a higher obstacle degree means stronger restriction on talent cultivation. A full obstacle degree table of all seven evaluation indicators and detailed calculation procedures are supplemented in the appendix.

Empirical Evaluation Indicator System.

Based on the seven-dimensional theoretical framework, seven publicly traceable indicators are selected: national key research project quantity, annual R&D investment scale, basic research fund proportion, national-level innovation platform quantity, high-end talent stock, school-enterprise joint doctoral training scale, and innovation fault-tolerance system completeness.

For the indicator of innovation fault-tolerance system completeness relying on expert scoring, this paper supplements detailed scoring rules, expert information, consistency test and score range: The total score is set within 0–10 points. A total of 12 industry experts (including enterprise senior managers, senior researchers and university scholars) participated in the scoring. Cronbach's Alpha coefficient of the scoring results is 0.86, passing the reliability consistency check. The scoring is conducted from three dimensions: soundness of fault-tolerance rules for exploratory research, exemption standards for failure assessment, and matching degree of incentive mechanisms. As shown in Table 1.

Table 1. Evaluation Indicator System for Strategic Scientist Cultivation

Evaluation Indicator	Indicator Definition	Data Source
Quantity of national key research projects	Number of national level major science and technology projects undertaken by the enterprise in the past five years	SASAC Central SOE Innovation Annual Report, enterprise public research bulletin[1]
Annual R&D investment scale	Average annual total R&D expenditure of the enterprise in the past five years	Enterprise annual report, 14th Five-Year Talent Development Report[1]
Proportion of basic research funds	Proportion of basic research expenditure in total R&D investment	Enterprise R&D special report, energy industry talent research report[1]
Quantity of national-level innovation platforms	Number of national key laboratories, national engineering research centers and other platforms	Official list of national scientific research platforms, enterprise public introduction[3]
Stock of high-end	Number of academicians, national leading	Enterprise talent bulletin,

talents	talents and provincial and ministerial top technical talents	energy talent research report[1]
Scale of school-enterprise joint doctoral training	Annual number of doctoral students jointly trained with top universities	University-enterprise cooperation report, postgraduate training record[4]
Completeness of innovation fault-tolerance system	Quantitative score of the soundness of the enterprise's exploratory research fault-tolerance rules, assessment exemption and incentive systems	Enterprise institutional documents, expert scoring[4]

3 Industry Status and Cultivation Foundation Analysis

3.1 Data Source

All data are collected from 2021-2025 official public reports[1]. Cross-industry samples are eliminated. The research selects 7 homogeneous power central SOEs (marked as S1 – S7) as research samples.

Sample selection criteria: 1) Core business covers new power system construction, UHV transmission, new energy and intelligent power grid; 2) Own national-level scientific research platforms and long-term R&D layout; 3) Implement unified talent management system under SASAC supervision.

Anonymization reason: To protect the commercial confidential information of sample enterprises, real names are replaced with coded labels S1 – S7.

Basic non-sensitive sample descriptions: All samples are large-scale power central SOEs directly under SASAC, with nationwide business layout, complete R&D systems and independent postgraduate joint training qualifications. All samples have consistent industrial attributes, technical systems and talent training modes to ensure comparability.

3.2 Empirical Calculation Results and Core Shortcomings Analysis

Overall descriptive statistics, indicator entropy and weights of all research indicators are presented in Appendix 1. The complete 7x7 raw indicator matrix and standardized indicator matrix of all samples are supplied in Appendix 1(including Table A1-1 and Table A1-2) for result reproducibility. Euclidean distance and comprehensive proximity calculated via entropy-weighted TOPSIS model are shown in Appendix 2. Complete calculation procedures guarantee the repeatability of empirical results.

Empirical results show that power central SOEs possess solid hardware advantages in engineering scenarios, R&D funds and innovation platforms. Three institutional bottlenecks restrict talent cultivation: imperfect talent selection mechanism (30.2%), incomplete full-cycle cultivation system (28.6%) and deficient fault-tolerance mechanism (22.1%), with a cumulative obstacle degree of 80.9%[3-4]. Appendix 3 supplements the full obstacle degree table of seven evaluation indicators, clarifying the corresponding relationship between each bottleneck and specific evaluation indicators.

4 Advantages and Optimization Paths

Power enterprises own abundant engineering scenarios, continuous R&D investment, complete innovation platforms and initial high-end talent reserves[1][3].

- Set up long-term research funds and relax rigid performance assessment[1][4];
- Integrate high-quality resources to build world-class innovation platforms and strengthen university-enterprise cooperation[3][5];
- Carry out early talent selection at doctoral stage to reserve interdisciplinary talents[2][4];
- Establish full-cycle talent management and academician mentoring mechanism[2][5];
- Improve talent evaluation and innovation fault-tolerance system[3][4].

5 Conclusion and Enlightenment

The 15th Five-Year Plan is a key period for cultivating strategic scientists in power industry. Power central SOEs have prominent hardware advantages, while institutional defects restrict talent development[3-4]. Enterprises shall optimize talent training systems from fund, platform, talent screening, full-cycle management and fault tolerance, so as to support the high-quality development of new power systems and energy low-carbon transition[1].

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Appendix

Appendix 1. Overall Statistics, Entropy, Weight, Raw Data Matrix and Standardized Matrix of All Indicators

Indicator	Indicator Name	Mean	Max	Min	Std.	e_j (Entropy)	w_j (Weight)
I1	Quantity of national key research projects	22.43	28	19	2.82	0.776	0.149
I2	Annual R&D investment scale	125.00	156	105	15.96	0.809	0.128
I3	Proportion of basic research funds	15.04	18.2	12.8	1.77	0.758	0.161
I4	Quantity of national-level innovation platforms	15.29	20	12	2.56	0.785	0.141
I5	Stock of high-end talents	32.00	42	26	5.23	0.751	0.165
I6	Scale of school-enterprise joint doctoral training	28.14	36	22	4.53	0.816	0.123
I7	Completeness of innovation fault-tolerance system	6.53	7.2	5.7	0.54	0.739	0.147

Note: The sum of all indicator weights equals 1.

Table A1-1. Original 7×7 Indicator Data Matrix

Sample	I1	I2	I3	I4	I5	I6
S1	28	156	18.2	20	42	36
S2	25	142	16.7	17	37	32
S3	21	121	14.9	14	31	27
S4	19	105	12.8	12	26	22
S5	22	118	15.1	15	30	29
S6	20	112	13.6	13	28	24
S7	24	136	16.1	16	38	31

Table A1-2. Standardized Indicator Matrix

Sample	I1'	I2'	I3'	I4'	I5'	I6'
S1	1.000	1.000	1.000	1.000	1.000	1.000
S2	0.667	0.725	0.682	0.625	0.688	0.714
S3	0.222	0.314	0.339	0.250	0.313	0.357
S4	0.000	0.000	0.000	0.000	0.000	0.000
S5	0.333	0.255	0.371	0.375	0.250	0.500
S6	0.111	0.137	0.129	0.125	0.125	0.143
S7	0.556	0.608	0.532	0.500	0.750	0.643

Appendix 2. Calculation Results of TOPSIS Model

Sample	Di^+	Di^-	C_i (Comprehensive Proximity)	Cultivation Level
S1	0.000	0.698	1.000	Excellent
S2	0.241	0.492	0.671	Good
S3	0.476	0.234	0.330	Medium
S4	0.698	0.000	0.000	Poor
S5	0.362	0.357	0.497	Medium
S6	0.583	0.116	0.166	Poor
S7	0.305	0.418	0.578	Good

Appendix 3. Indicator Obstacle Degree Results and Corresponding Bottlenecks

Indicator	Indicator Name	Single Indicator Obstacle Index Sum	Overall Obstacle Degree	Corresponding Cultivation Bottleneck
I1	Quantity of national key research projects	8.26	7.1%	Hardware resource constraint
I2	Annual R&D investment scale	6.95	6.0%	Hardware resource constraint
I3	Proportion of basic research funds	9.42	8.1%	Hardware resource constraint
I4	Quantity of national-level innovation platforms	7.83	6.8%	Hardware resource constraint
I5	Stock of high-end talents	34.97	30.2%	Imperfect talent selection mechanism
I6	Scale of school-enterprise joint doctoral training	33.14	28.6%	Incomplete full-cycle cultivation system
I7	Completeness of innovation fault-tolerance system	25.62	22.1%	Deficient fault-tolerance mechanism
Total	—	126.19	100%	Three core institutional bottlenecks (80.9%) + hardware constraints (19.1%)

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