Research on Virtual Power Plant Technology Training System under the Background of New Power System

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Abstract. Driven by the goal of " double carbon " China 's new power system is accelerating its construction. As an important means to build a new power system, virtual power plant breaks the boundary between the traditional power generation side and the power consumption side, and realizes the transformation from " source with load " to " source network load storage. " With the advancement of new power system construction, higher requirements are put forward for dispatching technicians, and it is urgent to train high-level and high-level power grid dispatching personnel. At present, various power training centers and universities have not yet formed a complete training system, which is only mentioned in high-end technical skills training and individual lectures, but the course content is not systematic, the teaching object is not clear, the course goal is not targeted, and the professional knowledge and ideological value training are out of touch. This paper analyzes the necessity of the key technology course of virtual power plant for the training of power grid dispatching professionals. Based on the current situation of training and education, this paper puts forward the method of teaching exploration by means of course content design, course ideological and political infiltration, course teaching mode design, etc., in order to achieve good training results.

Key words: Virtual power plant, training system, reform of teaching.

1. Introduction

New energy is vigorously developed under the background of new power system.And because of randomness, scale, unpredictability and uncontrollability,characteristics of new energy, it poses new challenges to the accuracy of load forecasting and traditional dispatching plan of power grid[1][2].The traditional "source to load" scheduling method is no longer suitable. Virtual Power Plant (VPP) has played an important role as a new energy scheduling model to address the challenges of grid supply and demand balance brought about by new energy sources. Virtual power plants are a new generation of intelligent control technology and interactive business model that aggregates and optimizes the clean development of "grid source load storage". On the traditional physical architecture of the power grid, relying on the Internet and modern information and communication technology, various resources such as distributed power sources, energy storage, and loads that have not yet been included in the existing regulation scope of the power grid are aggregated for collaborative optimization of operation control and market transactions, achieving multi energy complementarity on the

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power side, flexible interaction on the load side, and flexible invocation on the energy storage side. Auxiliary services such as peak shaving, frequency regulation, and backup are provided to the power grid. Relying on the Internet and modern information and communication technology,Various resources such as distributed power sources, energy storage, and loads that have not yet been included in the existing regulation scope of the power grid are aggregated for collaborative optimization of operation control and market transactions based on the traditional physical architecture of the power grid.It achieves multi energy complementarity on the power side, flexible interaction on the load side, and flexible invocation on the energy storage side. Auxiliary services such as peak shaving, frequency regulation, and backup are provided to the power grid[3][4].Therefore, the essence of virtual power plants is a new type of scheduling system, which plays a very important role in the power dispatch process. Power grid dispatch bears the heavy responsibility of maintaining power balance and ensuring safe operation. With the advancement of the construction of new power systems, higher requirements have been put forward for dispatch technicians, and there is an urgent need to cultivate high-level and high-level power grid dispatch personnel. Therefore, while conducting regular power grid dispatch training and learning, it is necessary to incorporate knowledge related to virtual power plants. According to research, current universities and power skill training institutions have not organically integrated key technologies of virtual power plants into the training of power grid dispatch positions. Therefore, it is necessary to conduct research on the training system of key technologies of virtual power plants and organically integrate it into the training of power grid dispatch majors

This article proposes a training system that organically integrates virtual power plants and traditional power grid dispatch technologies based on the current power grid dispatch training and education model, which is conducive to promoting the standardization and scale of virtual power plant technology training.

2. Necessity of key technology training system construction of virtual power plant

As a new technology developed in recent years and an innovative product in the new generation of energy,virtual power plant has attracted much attention and trust due to their high efficiency, environmental protection, and sustainability. They have great application potential and market prospects. With the continuous development and application of virtual power plant technology, as well as the continuous operation of virtual power plant demonstration projects, the demand for high-level technical and skilled personnel related to virtual power plants continues to increase. Therefore, training on key technologies of virtual power plants is particularly necessary. According to research, various power training centers and universities have not yet formed a complete training system, which is only mentioned in high-end technical skills training and individual lectures. However, the course content is not systematic, the teaching objects are not clear, and the course objectives are not targeted. Therefore, it is urgent to study a complete virtual power plant key technology training course system.

3. Thoughts of raining system construction

3.1.Clarify the teaching object and curriculum objectives

Traditional power plants are physical power plants, such as thermal power plants, hydropower plants, etc., while virtual power plants have no power generation equipment. Power transmission equipment, etc., but play a similar role and traditional power plants. The relatively dispersed power supply (power generation end), power grid (transmission), load (demand and power end), energy storage (energy storage end) and other elements are integrated and regulated to form an intelligent black box, which is equivalent to a controllable power supply. It can be used as a “positive power plant” to supply power to the system, or as a ' negative power plant ' to absorb the power of the system, playing a flexible role in peak shaving and valley filling. It simulates the operation mode of a physical power plant and plays the role of a power plant.Therefore, although the virtual power plant is a virtual power plant, its essential problem is to cover the scheduling problem of new energy and other loads[5]. Therefore, the teaching objects of the virtual power plant are the power grid dispatching specialty and the power plant and power system specialty.

The specialty of power grid dispatching and power plant and power system is oriented to the posts of national skill standard power dispatcher and power grid dispatching automation operation duty officer[6]. In terms of the setting of curriculum objectives, it is necessary to increase the integration of new technologies such as virtual power plant on the basis of the original teaching content, promote the integration of ideological and political education in the curriculum, and optimize the original simple combination of theory and practice, so as to realize the combination of knowledge imparting, ideological and political education and practice, cultivate students’ safety first, lean rescue consciousness of excellence , establish the spirit of loving labor and loving work, and have the vocational skills of power dispatcher and power grid dispatching automation operation duty officer. Our school (Shandong Electric Power College) is a school-enterprise cooperation school, set up the power plant and power system and power grid dispatching professional, the following to the school training teaching as an example to elaborate.

3.2.Develop personalized training programs

At present, the traditional training teaching mode often adopts a set of training programs, without personalized design for students and students at different levels, which will affect the quality of teaching. To implement the"differentiated" teaching concept, according to different teaching objects, personalized training programs should be developed to meet the learning needs of different levels of students [7]. In the formulation of training programs, we should investigate the training objects, clarify the basic level, professional knowledge and learning methods of the training objects, expand and extend the course content to different degrees, and optimize the course teaching methods and course design based on the research results to meet the academic requirements. For students with good basic level and strong learning ability, their learning needs can be met by deepening pre-class guidance and after-class extension. For students with poor foundation, the basic requirement is to master the knowledge in class well, so as to reduce the difficulty of pre-class guidance and after-class extension.

3.3.Innovate curriculum form

The traditional teaching form is an organic combination of theory and practical operation. However, for the majors of power grid dispatch and power plant and power system, the actual operation content is limited by practical training systems and does not involve new technologies in virtual power plants. The content of virtual power plants is only taught through theoretical teaching methods, and students cannot intuitively learn and feel. The learning effect needs to be improved, therefore, it is necessary to innovate the teaching form of the course. This can be achieved through enriching course resources, optimizing teaching modes, developing simulation training systems, and deepening school enterprise cooperation[8].

a) Enriching curriculum resources: At present, the main curriculum resources of traditional teaching include single resources such as simulation software, courseware and homework guidance in the training room. The students' learning methods are single and the learning content is boring, which cannot adapt to the current students' learning cognitive rules in the Internet era. Therefore, it is necessary to develop diversified resources, such as short videos, video animations, interactive videos, etc., based on the existing teaching platform (Shandong Electric App), on the basis of docking job requirements standards. Join topics of interest, questions and answers, interesting interactions, etc., integrate into the current latest news, topics, etc., and publish before and after class to attract students ' interest and improve the motivation of learning.

b) Optimize the teaching mode: Virtual power plant technology is developed on the basis of power grid control. Therefore, it is necessary to organically integrate virtual power plant technology into the course learning of electronic control and regulation specialty. In terms of teaching mode, it is necessary to change the traditional lecture-listening-practice teaching mode based on the working background of the production site, and compile a total of 10 course situations for power grid regulation and operation, including regulation and control system cognition, equipment monitoring and signal analysis, monitoring and remote control, basic operation of power grid, remote adjustment operation, transformer outage operation, bus outage operation, line outage operation, power grid anomaly and accident handling, dispatching automation and network security. The new technology of virtual power plant is organically integrated into the teaching situation, and the students carry out task learning according to the situation, so as to realize the organic integration of new technology under the premise of the close connection between the job content and the course content.

In addition, it is also necessary to innovate the "pre-exploration-understanding-solid-evaluation-extension" mode of pre-class preview to improve interest, in-class inquiry learning, comprehension improvement, and after-class consolidation and improvement as shown in **Figure 1** . Before class, teachers publish learning tasks on the platform, including current news, videos, topics and other forms, and publish relevant learning materials and contents, and arrange pre-class learning tasks. Students receive learning tasks to punch in, and can search and query or learn PPT or text and other materials published by teachers according to their learning interests and characteristics. Before class, teachers can have a good idea of learning tasks, and dynamically optimize the teaching content and difficulty according to the feedback of students before class. In the course of "exploration", "enlightenment", "consolidation" and "evaluation", the teacher throws out the situational work task, combines the review situation of the students before the class, guides the students to explore the course content through the

teaching method, discussion method, demonstration method and video method, and introduces the actual case of the production site to guide the students to understand the true meaning of the work. After mastering the basic principles, the students were divided into groups to practice repeatedly and understand the improvement. At the end of the course, the simulation assessment is carried out to consolidate and improve, and the teacher evaluates and comments on the whole course. After-class "extension", teachers release after-class tasks on the platform, including basic tasks and post-expansion tasks. Students consolidate and learn classroom content by completing after-class tasks. Questionable content can be posted in the discussion area, and students or teachers can discuss or answer questions. For students who have the ability to learn, they can receive the task of improving, carry out extended learning, and truly teach students in accordance with their aptitude.

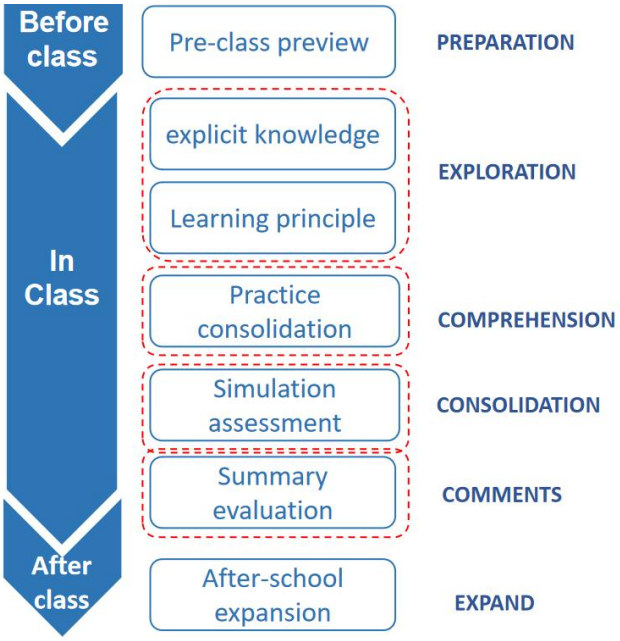

Figure 1. Teaching model

c) Development of training simulation system: Based on the characteristics of current students who enjoy hands-on and are good at exploring and learning in virtual simulation and other game links, optimize the traditional scheduling simulation system by adding new energy grid connection elements such as distributed power generation and electric vehicles, and develop a power grid scheduling simulation training system. The system includes two subsystems: traditional power grid dispatch and virtual power plant system, and tasks are divided according to the course context. Through the simulation training system, students can understand the importance and key technologies of scheduling and virtual power plants from multiple perspectives.

d)Deepen school-enterprise cooperation[9]: Thanks to the mode of school-enterprise cooperation, the advantages of enterprise tutors can be fully utilized in the implementation of

training and teaching. In the teaching link, the enterprise tutor teaching link is added in time, and the course knowledge is studied in depth from the perspective of the production site. For example, in the case of line shutdown and transmission, the enterprise tutor can introduce the course content in combination with the production site situation, and carry out group teaching according to the actual production site. At the same time, students can also be arranged to study in-depth enterprise visits, in-depth understanding of the production site scheduling system workflow.

3.4.Construction Organic integration of ideological and political elements

In 2019, the ideological and political symposium proposed that we should adhere to the unity of explicit education and invisible education, tap the ideological and political education resources contained in other courses and teaching methods, realize the ideological and political education resources contained in the whole process and teaching methods, and realize the all-round education of the whole process. In 2020, the Ministry of Education issued the"Guidelines for the Construction of Ideological and Political Education in Colleges and Universities" to provide a direction for higher vocational colleges to comprehensively promote the construction of ideological and political education[10]. Therefore, it is necessary to integrate ideological and political education into the study of professional courses, implement the fundamental task of cultivating morality and cultivating people, and simultaneously cultivate professional knowledge and ideological values.

The power grid dispatching major is mainly oriented to the power grid dispatching post of the power system. Therefore, the ideological and political direction mainly focuses on the four directions of dedication, safety responsibility, craftsman spirit and enterprise spirit. Through the integration of ideological and political elements, students' cognition of future work is improved, and students' sense of identity with the power industry is enhanced, so as to improve their enthusiasm for learning.

According to the task of the course, the ideological and political case library with electric power characteristics is developed. According to the requirements of dispatching professional jobs and professional standards, it is necessary to penetrate the whole process of enterprise spirit such as meticulous, serious and responsible for power grid dispatching. At the same time, it is also necessary to add case materials such as craftsman spirit and safety production accidents on the power site to shape students' respect and professional identity for the profession and awe for safety production.

The specific implementation needs to be organically integrated into various working situations according to the collection of deeds of craftsmen, models of the times, and model craftsmen in the power industry. At the same time, it may also collect various safety accident cases at the power production site to form a typical case base of this course,typical ideological and political cases are shown in **Table 1**.

When using the case library, it can be carried out through pre-class push, in-class learning, and after-class extended learning. In addition, on-site learning can also be carried out with the help of the school's model worker artisan exhibition hall, so as to truly integrate the ideological and political elements into the mind.

Table 1. Ideological and political case library schematic

Type	Ideological and Political Case
Love the job dedication Corporate spirit	1) Power dispatching propaganda video- ' stick ' case ; 2) Times model Qian Navy-light warm home, forge ahead on the road to common prosperity. 3) Power Light Road Video 4) Xu Chuanzi - Share power ' carbon bill ' at United Nations Headquarters' .....
Innovative spirit	1) Jiang Guangmin - 50 inventions to protect the lights 2) Zhang Liming-Innovation makes work happier 3) Liu Hongji - special gnawing hard bones 4) Henan Electric Power Innovation Studio-Ingenious dream, skills to serve the country .....
Craftsmanship spirit	1) The case of Zhang Liming, a model of the times 2) The case of Wang Jin, a great craftsman 3) Great country craftsman-Feng Xinyan 4) Power craftsman Pi Zhiyong 's ingenuity to protect the central nervous system of the power grid .....
Safety production case (Security responsibility)	1) Tibet Motuo safety accident-loaded broaching gate 2) Sichuan Meishan safety accident-uncorrectly hanging ground wire 3) India 's massive blackout in 2012 4) 2006 European blackout .....
Labor spirit	1) Household electricity for the benefit of the people 2) Powerful country 's political power preservation 3) Electric Power Skyway Lighting the Frontier 4) The electric iron army dare to fight and win .....

3.5.Optimizing Curriculum Evaluation

The traditional curriculum evaluation method is single. It is evaluated only through theoretical examinations and practical training examinations. It does not evaluate the students' learning attitude and innovation ability, and cannot effectively reflect the students ' learning level. Therefore, it is necessary to explore diversified learning evaluation methods [11]. In the evaluation, the evaluation can be carried out in accordance with the four links of pre-exploration-comprehension-consolidation-extension.The evaluation subject of each link is transformed from a single teacher evaluation to a student self-evaluation, intra-group mutual evaluation, and teacher evaluation. The specific implementation process is as follows:The evaluation is carried out according to 10 teaching situations. The total score of each situation is 100 points, which is divided into 3 evaluation subjects and 10 evaluation indexes. The evaluation subject consists of three parts : teacher evaluation, student evaluation and enterprise teacher evaluation. The evaluation indicators mainly include pre-class preview evaluation, attendance evaluation, classroom test evaluation, classroom discipline evaluation, after-school homework completion, expansion task completion, participation in training activities, mastery

of learning content, training safety norms, and innovative spirit. Among them, teacher evaluation is mainly carried out from six aspects: pre-class preview evaluation, attendance evaluation, classroom test evaluation, classroom discipline evaluation, after-school homework completion, and expansion task completion. The self-evaluation and mutual evaluation of the students' group mainly include two aspects:the participation of practical training activities and the mastery of learning content; the evaluation content of enterprise tutors is mainly carried out from two aspects : training safety norms and innovative spirit. The specific evaluation rules are compiled by the teacher according to each task, and the practical operation part evaluated by the enterprise tutor needs to be strictly refined into the evaluation standard according to the practical operation instruction.

Each evaluation index is 100 points system, and finally according to the proportion of conversion summary, get the total score of the learning task. Combined with the final skill evaluation results, the students ' scores can be obtained by weighted average according to the proportion of 60 % and 40 %. The proportion of each evaluation index is shown in the following **Table 2**.

Table 2 Diversified evaluation methods

Evaluation subject	Index			Proportion	
Teacher evaluation 40%	pre-class preparation			10%	
	checking on work attendance			20%	
	classroom test			20%	
	classroom discipline			20%	
	homework			20%	
	development tasks			10%	
	Total			100%	
Student evaluation 30%	group evaluation	Participation in practical training activities	50%		60%
		Mastery of learning content	50%		
	self-assessment	Participation	50%		40%
		Mastery of learning content	50%		
	Total			100%	
Enterprise mentor evaluation 30%	Safety specification degree			80%	
	innovation			20%	
	Total			100%	

4. Conclusion

This paper analyzes the necessity of virtual power plant course learning, and based on the existing training teaching mode, from the aspects of training scheme, course mode and course evaluation, this paper puts forward the research method of training system of integrating new technology of virtual power plant into power grid dispatching specialty. The scheme will be gradually applied in the college, in order to achieve good training effect.

References

[1] Yang Z, et al.(2022) Review on optimal planning of new power systems with distributed generations and electric vehicles. Energy Reports 9:501-509. DOI:10.1016/J.EGYR.2022.11.168.

[2] Nikolaidis P,and Poullikkas A.(2022).Optimal carbon-electricity trade-offs through the virtual power plant concept.Discover Energy.2 (1):2-7. DOI:10.1007/S43937-022-00012-Y.

[3] She W,Hu Y,Yang X,Gao S,Liu W.(2017)Virtual Power Plant Operation and Scheduling Model Based on Energy Blockchain Network [J]. Proceedings of the CSEE,37(13):3719-3736, DOI:10.13334/j.0258-8013.pcsee.170364.(In Chinese)

[4] Wang X, Gao H, Zhang H.(2022).Application scenario analysis and construction enlightenment of flexible resource aggregation technology for new power system[J]. Power Demand Side Managemen t,24(01):73-80. https://kns.cnki.net/kcms2/article/abstract?v=3uoqIhG8C44YLTlOAiTRKibYlV5Vjs7iJTKGjg9uTdeTsOI_ra5_XXzcv-exSaeTtIeDYm7iP9NFkPiwjDgYQkyOPZnEv17I&uniplatform=NZKPT (In Chinese)

[5] Chung K,Park M,Hur D.(2015). A Proposal of Institutional Prerequisites to the Participation of Vi rtual Power Plant in Electricity Market under the Smart Grid Paradigm[J]. The transactions of The Ko rean Institute of Electrical Engineers[J],64(3),375-383.https://kns.cnki.net/kcms2/article/abstract?v=LeQIq0pPraN7z56UFBXYmp5cqSpFXzXCbwlunHM0LCzasPdEcpnSjw-fPaoiermnAdHWGWYD9Dt0vZVXaW2h-FVwQehNTGw7VAdKD6FwUmGJAVoVZ_Ei73HOV7h94mBe&uniplatform=NZKPT.

[6] Yu K. (2021)Research on the training system of power grid dispatching staff in X power supply c ompany[D],university of electronic science and technology of china.DOI:10.27005/d.cnki.gdzku.2021.003876.(In Chinese)

[7] Wang C, Deng W, Wan X.(2017).Research on the practice of curriculum reform under the mode o f " integration of production and education " -Taking the course of " power system relay protection " a s an example[J].22(02):48-50.https://kns.cnki.net/kcms2/article/abstract?v=uRYdc5fs95bcXsP_tGGPVw7uTF_O2XHznMMijCHTXIJYuNaiRlN0T8_Bq_YpasZhSrLzRl6KSKPVSeuLS7FkzBOb8YLqY1nghuvs1mYjPe3XkHdbkIiQ2gIS8IQKgy42ZpvEo1_CU38=&uniplatform=NZKPT&flag=copy(In Chinese)

[8] Zhu S(2022)."Research on Mechanism Construction and Innovation of Vocational Colleges Based on School Enterprise Cooperation." Advances in Vocational and Technical Education 4.6. DOI:10.23977/AVTE.2022.040608.

[9] Vats A(2017). Exploration on Teaching Reform of Civil Engineering Construction Organization C ourse Based on BIM Technology[J]. Indian Journal of Public Health Research & Development,3(5). https://kns.cnki.net/kcms2/article/abstract?v=LeQIq0pPraN7z56UFBXYmp5cqSpFXzXCf9scP3lTrc7LypkQbX4Wv1YpAlm4-DQN8sGE9XnGXVeU-YS2HP0iKEOyJi2iW9e5k2Vq2oopS95YGBx0t1XGO9K1Fg-fAa89&uniplatform=NZKPT.

[10] Zhang x, LiY, Niu L ."The Exploring of Curriculum Ideology and Politics in the Teaching of Operational Research." Adult and Higher Education 4.13(2022). doi:10.23977/ADUHE.2022.041306.

[11] Yong Li. An Analysis of Deepening the Reform of Vocational Education Evaluation in the New Era[J]Education and Vocation, 2023(11):57-60.DOI:10.13615/j.cnki.1004-3985.2023.11.005(In Chinese).