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The Reform and Practice of the Teaching Model for the Course "Introduction to Environmental Protection" under the Background of Carbon Neutrality

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Abstract: Carbon peaking and carbon neutrality are commitments made by China as a responsible major country to actively respond to climate change. "Introduction to Environmental Protection" is a course based on the dual carbon vision, which is designed to meet the demand of electrical engineering and automation majors and industry development trends. By understanding the degree to which students master the dual carbon policy and analyzing the problems existing in the existing curriculum, we have conducted multidimensional exploration and practice of teaching reform for the course Introduction to Environmental Protection. By adopting the "case+ discussion" teaching mode and the Flipped classroom to strengthen practical teaching, it is beneficial to integrate theory with practice, improve students' sense of responsibility and family feelings, guide students to integrate personal development into the great cause of realizing the Chinese Dream, thus forming a carbon peak and carbon neutral strategy that can guide electrical engineering practice in the future employment.

Keywords: Carbon Neutrality; Introduction to Environmental Protection; Teaching Reform

1. Introduction

At the 75th United Nations General Assembly, China made a significant pledge to achieve carbon peaking by 2030 and carbon neutrality by 2060, referred to as the "dual-carbon" goals. These objectives represent a long-term strategic initiative, with talent development serving as a fundamental pillar for their successful realization [1,2]. The announcement of the dual-carbon targets has had a profound impact on higher education institutions in China, prompting a range of policy responses. In 2021, the plan in terms of "Notice on the Implementation of the Carbon Neutrality Technology Innovation Action Plan for Higher Education Institutions" highlights the urgent need for interdisciplinary integration across relevant academic fields [3, 4]. In 2022, this initiative was further reinforced by releasing "Work Plan for Strengthening the Construction of Talent Cultivation Systems for Carbon Peaking and Carbon Neutrality in Higher Education". This was followed by the 20th session of the International Financial Forum (IFF), which focused on the theme "Carbon Neutrality Education: Future Trends and Challenges." Experts at the forum emphasized that higher education, in the context of achieving carbon neutrality, must enhance students' climate literacy, strengthen academic discipline construction-particularly in interdisciplinary fields related to the dual-carbon goals-and drive systemic reforms through industry – university - research collaboration based on societal needs.

In response to these national strategies, the course "Introduction to Environmental Protection" has been developed to align with the needs of the electrical engineering and automation discipline, while also addresses broader industry trends under the dual-carbon vision. The course content includes essential topics such as sustainable development theory, resource and environmental protection, circular economy, clean production, and environmental pollution control technologies. This course plays a pivotal role in shaping students' understanding of environmental protection and sustainable development, while also guiding them in applying these concepts in engineering

practice.

As outlined in the action plan for achieving the "30-60" strategic targets, the energy and power industry is a key sector in the realization of the dual-carbon goals. As a primary source of talent development in the power sector, the electrical engineering and automation discipline requires a robust and forward-thinking curriculum. Incorporating dual-carbon-related content into the "Introduction to Environmental Protection" course is critical for reforming and innovating the talent cultivation model in this field, particularly in the context of the new era's challenges. This approach provides fresh perspectives on the sustainable development of future electrical engineering professionals.

To this end, the course's pedagogy should include a comprehensive interpretation of carbon neutrality policies, while identifying key knowledge points that directly align with the electrical engineering profession. A blended teaching model that combines case studies with classroom discussions-facilitated through flipped classroom techniques-will be crucial for organizing and delivering the course content effectively. This teaching strategy aims to foster environmental awareness among electrical engineering students and cultivate a dual-carbon mindset that can guide their future engineering practices.

2. Introduction to the Course "Introduction to Environmental Protection"

2.1 Course Structure and Textbook

The course "Introduction to Environmental Protection" is a mandatory subject for students majoring in Electrical Engineering and Automation at the School of Electrical Engineering, Heilongjiang University of Science and Technology. It is taught in the second semester of the second academic year and consists of a total of 16 class hours. The course is delivered by a team of experienced educators and researchers, particularly those with expertise in energy conservation, carbon reduction, emission control, and the development of functional materials. This solid foundation underpins the course's academic rigor. The primary textbook for the course is "Introduction to Environmental Protection" (2nd Edition), published by the Chemical Industry Press. This textbook is part of the national "13th Five-Year Plan" for general higher education textbooks, ensuring that it meets the academic and practical needs of the course.

2.2 Importance and Challenges of the "Introduction to Environmental Protection" Course in Engineering Talent Cultivation

To meet the future career needs of Electrical Engineering and Automation students and align with industry development trends, "Introduction to Environmental Protection" has been integrated into the curriculum. This course is pivotal in fulfilling the professional accreditation requirements for engineering education. Specifically, graduation requirement 7.1 for this major mandates that students "understand the connotation and significance of environmental protection and social sustainable development, study relevant laws and regulations on environmental protection, and understand the development directions of electrical engineering that support environmental and social sustainability." In the context of sustainable development and carbon neutrality, offering environmental protection courses within an engineering curriculum is both essential and necessary. "Introduction to Environmental Protection" is the sole course in this major that addresses environmental protection and meets the associated graduation requirement. However, several challenges in its teaching approach must be addressed, including a lack of alignment with the specific needs of the discipline, outdated content, and a limited range of instructional methods.

2.2.1 Lack of organic integration between course content and the electrical engineering context

Historically, "Introduction to Environmental Protection" was viewed primarily as a foundational course designed to introduce electrical engineering students to environmental issues and basic environmental protection theories. This perspective limited the course content, making it overly focused on popular science and theoretical concepts, often presented through dense text, with minimal opportunities for student interaction or discussion. As a result, students often found the course disengaging.

The application of environmental protection theories within electrical engineering goes

beyond the mere explanation of basic concepts. It involves integrating these theories with real-world applications in the field. For example, it is crucial to explore how the electrical industry can contribute to the achievement of the "dual-carbon" goals through technological upgrades, energy-saving measures, and industrial restructuring. Teaching this integration requires not only a solid understanding of environmental knowledge but also the ability to connect this knowledge with the practical realities of electrical engineering. Therefore, it is essential to update the course's content to reflect the needs of the electrical engineering profession, incorporating real-world case studies that highlight the role of electrical engineering in advancing carbon neutrality. This will help students internalize the concept of carbon neutrality as a guiding principle in their future engineering practices.

2.2.2 Outdated content

While the current textbook for "Introduction to Environmental Protection" provides a well-structured, comprehensive overview of foundational topics-such as sustainable development, circular economy, low-carbon economy, and pollution control technologies for air, water, and soil-it fails to fully reflect the rapid technological advancements in recent years. Notably, the accelerated pursuit of carbon neutrality in the past two years necessitates the inclusion of up-to-date content that reflects the latest policies, technologies, and practices associated with carbon reduction. Higher education institutions have a dual responsibility: to impart technical skills and to shape students' worldviews, life values, and social responsibility. Integrating "Ideological and Political Education" [5,6] into the course offers an opportunity to bridge foundational environmental knowledge with broader societal goals, particularly the national strategy of carbon neutrality. This approach not only aligns with China's climate goals but also provides students with a clear sense of purpose regarding their future roles in contributing to global sustainability. Consequently, the course content should be updated regularly to incorporate the latest carbon neutrality policies and technological advancements, ensuring that students are well-equipped to engage with contemporary challenges in environmental protection.

2.2.3 Lack of innovation in classroom teaching methods

Traditional teaching methods, which center around lectures, textbooks, and structured content delivery, are often insufficient to engage today's students, especially in a course as broad and complex as "Introduction to Environmental Protection". Such methods typically focus on theoretical knowledge, limiting opportunities for students to engage critically with real-world environmental issues or to explore emerging technologies. Given the rapid pace of technological and societal change, especially in the context of environmental protection and carbon neutrality, a more dynamic, student-centered approach to teaching is necessary.

The course must move beyond the passive learning model to foster active student participation. The traditional focus on basic theory and rigid step-by-step instruction can lead to disengagement, with students failing to grasp key concepts or become interested in the subject matter. In the age of information technology, where much of the relevant knowledge is readily accessible online, the role of the teacher should shift to that of a facilitator, guiding students to actively engage with current environmental issues and to apply theoretical concepts to practical scenarios.

To promote deeper learning, the course should adopt innovative teaching methods that emphasize student participation, critical thinking, and problem-solving. A flipped classroom model, for example, could be used to encourage students to engage with the material before class, allowing for more interactive discussions and case study analyses during class time. Additionally, the course should be tailored to the unique characteristics of the electrical engineering profession, equipping students with the tools to apply carbon neutrality principles to engineering design and practice. This approach will not only enhance students' understanding of environmental protection but will also ensure that they are better prepared to address the challenges of a sustainable, low-carbon future.

3. Teaching Reform and Practice in the Course "Introduction to Environmental Protection"

3.1 Awareness of Teaching Prospects and Course Design

To align the "Introduction to Environmental Protection" course with the evolving national priorities of carbon neutrality, a thorough analysis of core concepts such as "carbon peaking" and "carbon neutrality" was conducted. This analysis was complemented by a survey aimed at assessing students' understanding of various aspects of the dual-carbon goals. The survey focused on students' knowledge of the dual-carbon concepts, their awareness of current social issues related to carbon neutrality, their low-carbon consumption behaviors, and their engagement in environmental protection practices. The results of this survey were used to inform the adaptation of the course content, ensuring it is aligned with the national carbon neutrality agenda and responsive to students' awareness levels. The findings will serve as a foundation for refining the course structure and content within the context of carbon neutrality.

3.1.1 Survey participants and methodology

The survey, titled "Dual-Carbon Education Survey for the 'Introduction to Environmental Protection' Course (Student Version)", was distributed to the 2021 cohort of Electrical Engineering and Automation students at Heilongjiang University of Science and Technology. The survey was designed to align with the course's research objectives and was conducted using the "Wenjuanxing" online survey platform, which facilitated distribution through a student communication group.

3.1.2 Survey design

The survey questionnaire was structured around three primary dimensions and seven secondary dimensions, exploring the following areas:

1. Students' current understanding of the dual-carbon goals (carbon peaking and carbon neutrality).
2. Students' awareness and attitudes towards the integration of carbon-neutral education within the "Introduction to Environmental Protection" course.
3. Students' perspectives on incorporating carbon-neutral education into the future development of electrical engineering.

The questionnaire primarily consisted of multiple-choice questions, with some questions allowing multiple answers depending on the context. The specific dimensions addressed in the survey are summarized in Table 1.

Table 1. Content Structure of the "Introduction to Environmental Protection" Teaching Survey

Primary dimension	Secondary Dimension
Students' current understanding of carbon peaking and carbon neutrality	Understanding of Dual-Carbon Related Concepts and Their Connotations
	Pathways for Implementing Carbon Neutrality Goals
	Sources for Acquiring Knowledge on Dual-Carbon Issues
Students' awareness and attitudes toward the teaching of 'Introduction to Environmental Protection'	Current Understanding of the "Introduction to Environmental Protection" Course
	Satisfaction with the Current Course Structure
Students' attitudes toward teaching 'Introduction to Environmental Protection' in the context of carbon neutrality	Students' Expectations for the 'Introduction to Environmental Protection' Course
	Suggestions for Teaching the 'Introduction to Environmental Protection' Course in the Context of Carbon Neutrality

3.1.3 Designing the teaching content of "Introduction to Environmental Protection" based on the carbon neutrality framework

Following the survey analysis, the course content was designed to closely align with the national carbon neutrality framework. The survey results indicated varying levels of understanding among students regarding the dual-carbon goals, underscoring the urgency of adapting teaching activities to foster greater awareness and engagement.

To enhance the course's relevance, the content was expanded to incorporate global environmental events, pressing environmental issues, and recent pollution incidents in China, alongside relevant pollution control theories. These social issues provided a timely context for the course and helped broaden students' perspectives on the global and national significance of environmental protection. Moreover, the course content emphasized key national policies, such as the concept that "Green mountains and clear water are as valuable as mountains of gold and silver," the strategic imperative of "Building an Ecological

Civilization," and the "30-60 Targets" (carbon peaking by 2030 and carbon neutrality by 2060). By integrating these policies into the curriculum, the course sought to instill a sense of environmental responsibility in students, while fostering a deeper sense of national pride and commitment to ecological sustainability.

The overarching goal of these teaching reforms is not only to improve students' technical knowledge in environmental protection but also to cultivate a sense of social responsibility and environmental stewardship that will guide their future careers as electrical engineers.

3.2 Multidimensional Case-Based and Discussion Teaching Model

In the "Introduction to Environmental Protection" course, cases illustrating how electrical engineering can contribute to achieving "carbon neutrality" through technological innovation and conceptual transformation are integrated into the curriculum. These cases allow students to experience the seamless connection between "carbon neutrality" and the electrical engineering profession. This approach not only helps students master foundational theoretical knowledge but also cultivates a deep-rooted environmental consciousness, which will guide their future careers in electrical engineering. The selection of cases is critical, as it must balance students' understanding of theoretical concepts with the latest developments in the electrical engineering field under the dual-carbon framework, while also addressing the actual societal demands for the skills they will acquire.

The course adopts a case-based teaching method within the "carbon neutrality" context, referred to as the FTP model: Fundamental Case Analysis (F), Thinking Case Analysis (T), and Practical Case Analysis (P).

3.2.1 The first level: fundamental case analysis (F)

The primary goal of fundamental case analysis is to deepen students' understanding of key concepts covered in a specific chapter or series of chapters. It enables students to apply theoretical knowledge to real-world scenarios. For example, when discussing "blue algae blooms" in the "Introduction to Environmental Protection" course, real-world cases such as the Taihu Lake blue algae bloom incident and the Chaohu Lake bloom outbreak are introduced. Students might be prompted with questions like: "Why do algae blooms primarily occur in May and June each year?" This leads to an exploration of the key factors influencing blue algae growth, such as temperature and nitrogen-phosphorus concentration. Students may also be asked: "Why does the surface of the water turn green during a bloom?" [7,8] This question opens the discussion on the physiological characteristics of blue algae. By progressively breaking down the case, students are guided to analyze it through theoretical frameworks, helping them understand the mechanisms behind algae blooms and the strategies for mitigating them.

3.2.2 The second level: thinking case analysis (T)

Thinking case analysis encourages active student engagement by presenting cases for group discussion. Students are tasked with analyzing these cases based on the knowledge they have acquired. For example, in the chapter on sustainable development, the 2021-2022 Schneider Electric Sustainability Report and the 2021-2025 Schneider Electric Sustainability Impact Index (SSI) Plan can be introduced. Students are divided into groups, with each member assuming the role of an employee at Schneider Electric, and the group leader acting as the head of a department. The teacher provides highlights from Schneider Electric's 2022 sustainability achievements, and students, through group discussion, are tasked with designing a plan to help the company achieve its sustainability goals and contribute to carbon neutrality.

After the discussion, the teacher provides feedback. This teaching design encourages students to transition from passive receivers of knowledge to active participants in the learning process. The open nature of the discussions and the creation of actionable plans increase student engagement and foster critical thinking. This approach not only facilitates the quick acquisition of key knowledge but also cultivates essential teamwork and problem-solving skills, the detailed case design in sustainable development chapter is shown in Figure 1.

3.2.3 The third level: practical case analysis (P)

Practical case analysis is implemented in the final stage of the course, after students have developed a solid understanding of the core principles of environmental protection.

Students are tasked with a project in which they assume the role of employees within a school that functions as an enterprise. They conduct detailed research on various campus areas, such as classrooms, cafeterias, and dormitories, identifying existing environmental issues. They then propose practical, feasible solutions to help the school achieve its carbon neutrality goals. Additionally, students are encouraged to participate in the annual Environment Day on June 5th, engaging in environmental protection campaigns and activities that contribute to realizing the "carbon neutrality" vision. This hands-on involvement ensures that environmental protection becomes more than just an academic subject; it becomes a deeply ingrained awareness and practice for the students.

Through this structured, case-based teaching model, students gain not only theoretical knowledge but also the practical skills and environmental consciousness necessary for implementing sustainable solutions in their future careers.

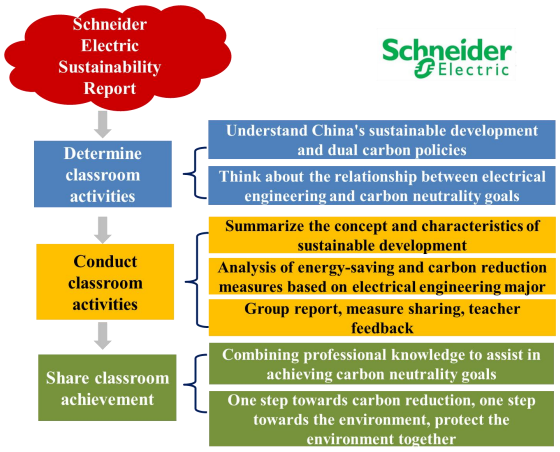

Figure 1. Case Design in Sustainable Development Chapter

3.3 Innovative Assessment Model

To enhance student engagement and learning outcomes, the course incorporates multiple layers of assessment. After case analysis and group presentations, peer assessments and teacher feedback are used to reinforce students' initiative, promote autonomous learning, and develop their teamwork and communication skills. In the final written exam, an open-ended case analysis question related to carbon neutrality within the context of electrical engineering and automation is included. This type of question encourages students to integrate their understanding of carbon neutrality and ecological civilization construction. By critically analyzing these topics, students are prompted to think from multiple perspectives and demonstrate their ability to address complex environmental challenges in the field of electrical engineering. This innovative assessment approach not only evaluates students' understanding of theoretical concepts but also nurtures their capacity for critical thinking, problem-solving, and collaboration—skills essential for their future roles as engineers in a sustainable, low-carbon world.

4. Significance of Teaching Reform in "Introduction to Environmental Protection"

The introduction of China's "30-60" carbon goals has created new opportunities for the development of the Electrical Engineering and Automation discipline. By reforming the course structure, students are not only provided with a solid theoretical foundation, but also given the opportunity to integrate environmental protection principles with the evolving field of electrical engineering through case analysis. This approach offers fresh perspectives on how to sustainably train future electrical engineering professionals in line with national and global environmental objectives.

4.1 Facilitating the Effective Integration of Dual-Carbon Theory and the Electrical Industry

Through a comprehensive analysis of the learning context and curriculum for Electrical Engineering and Automation students, the course design aligns closely with educational objectives, addressing key challenges in the "Introduction to Environmental Protection" course. This includes incorporating elements of ideological and political education alongside multidimensional case studies [9]. This integration helps students understand the dual-carbon strategy from the standpoint of electrical engineering and positions them to contribute to the realization of the carbon neutrality goals. By embedding the dual-carbon framework within the discipline, the course not only strengthens students' theoretical grounding but also enhances their ability to see the connections between environmental protection theory and practical

applications within electrical engineering.

4.2 Keeping Pace with the Times to Support the Implementation of Carbon Neutrality

Electrical engineering and automation are central to realizing the goal of carbon neutrality. In this course, we ensure that the content evolves in response to national strategic priorities by introducing and analyzing case studies that encourage students to consider how electrical engineering can support carbon neutrality. These case studies encourage students to think critically about their discipline's role, whether it concerns energy supply, energy demand, or other related areas. By reflecting on these real-world applications, students can conceptualize solutions that contribute to the achievement of carbon neutrality, directly linking their academic work to the national and global push for sustainable development.

4.3 Establishing the Concept of Ecological Civilization and Cultivating National Pride

The carbon neutrality goal is a solemn commitment made by China as a responsible global power. It represents not only a strategic objective for China's future development but also a vital responsibility for students in the Electrical Engineering and Automation program. In this course, we integrate the principles of "Green mountains and clear water are as valuable as mountains of gold and silver" and "Building an Ecological Civilization" with the core theories of environmental protection. Students are encouraged to link their personal growth with national development goals, maximizing their own value while fostering a deeper sense of national pride and responsibility. By instilling this perspective, the course helps students understand that their future professional contributions to the field are integral to the broader vision of ecological sustainability and national prosperity.

5. Conclusion

This paper explores innovative teaching models and methods for the "Introduction to Environmental Protection" course, grounded in the vision of "carbon neutrality" and tailored to the unique characteristics of the Electrical Engineering and Automation discipline. By aligning with national dual-carbon policies, a survey was conducted to assess students' understanding of the carbon neutrality framework and identify existing challenges in the course. The reform is operationalized through the FTP case study method, which consists of "Fundamental Case Analysis (F)", "Thinking Case Analysis (T)", and "Practical Case Analysis (P)". This method enables students to experience the organic integration of carbon neutrality with electrical engineering, helping them grasp relevant theories while developing their problem-solving skills. The approach fosters critical thinking, encourages the application of theory to practice, and enhances students' ability to analyze and address real-world environmental challenges.

Ultimately, through the reform of the "Introduction to Environmental Protection" course, students are not only equipped with environmental knowledge but also prepared to contribute to the realization of "carbon peaking" and "carbon neutrality" in their future engineering careers. This comprehensive approach ensures that the next generation of electrical engineers is well-prepared to meet the demands of a sustainable, low-carbon world.

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