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College students' career planning for the development of low-carbon renewable energy economy

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Abstract: This study examines the impact of low-carbon renewable energy economic development on college students' career planning. Findings reveal rapid industry growth but a significant talent shortage, with only 15% of students considering careers in this sector due to limited awareness. The paper proposes enhancing industry promotion, improving relevant knowledge and skills, expanding internships and employment channels, and calls for governmental and societal support to foster sustainable industry growth and talent cultivation.

Keywords: low carbon economy; employment; renewable energy; market research; career planning; survey research.

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Biographical notes: Yunwei Dong obtained his Bachelor's in Economics from Zhengzhou University in 2007 and Master's in Management from Rajamangala University of Technology Tawan-Ok, Thailand in 2022. Presently, he serves as a Lecturer at Zhoukou Vocational and Technical College. His areas of interest are international economics and trade, human resource management, ideological and political education for college students, and career planning for college students.

1 Introduction

The emergence of the low-carbon economy stems from a profound background, primarily centred around the following aspects: First, the rapid change of climate and the serious threat to the living environment of human beings are the direct and fundamental reasons for human beings to seek self-help and develop low-carbon economy (Shanzhan, 2019; Liao, 2022). 'There has been a long-standing debate about whether climate change is real or not, but now all known regions and environments in the world are facing increasingly dangerous weather conditions.

Traditional crude oil production is expected to peak in the next 10 to 20 years, and then gradually decrease. By 2050, crude oil production will be reduced to one third or less of the current level, and the dependence of the world economy on natural gas will

gradually increase (Patel, 2020). Every country in the world is scrambling to develop low-carbon economy. Besides coping with the economic crisis and promoting the transformation of development mode, occupying the commanding heights of the new round of green industrial revolution and mastering the leading power of formulating the 'rules' of low-carbon economy are also the strategic motives of implementing the 'green new deal'. As US President Barack Obama said, whoever masters clean and renewable energy will dominate the 21st century; whoever wins the first place in the field of new energy will become the best in the post-oil economy era (Edgerton et al., 2020). Britain, Germany, France, Japan and other countries are naturally unwilling to lag behind. They have launched their own green new policies, and used their competitive advantages in low-carbon technologies to build a new 'competitive stage' and formulate rules of the game to increase their chips for seeking international competitiveness and global dominance (Wallace, 2018; Hadi, 2020). For instance, nations that are highly developed, such as the USA, prioritise new energy sources as the linchpin of their low-carbon economic growth. They anticipate that nations that heavily rely on conventional industrial models will emulate this approach, thereby gaining a competitive edge in technology and marketplaces. Additionally, some other developed countries impose restrictions on the development of other nations citing reasons such as energy conservation, emission reduction, and ecological preservation. Green tariffs and green trade barriers represented by carbon taxes have emerged; Germany and others have also turned environmentalism into a new universal value and international discourse power in the important world political topic of climate change, and competed for the voice in international green politics.

Against this background, this study aims to investigate college students' career planning in relation to the low-carbon renewable energy sector. Specifically, we seek to understand:

- The level of awareness and interest among college students regarding careers in this sector
- Factors influencing their career decisions
- The alignment between their career planning and industry demands.

Our research employs a mixed-methods approach, combining quantitative survey data with qualitative insights to provide a comprehensive understanding of this important issue.

2 Research methodology

2.1 Research design and data collection

This study employed a mixed-methods approach, combining quantitative surveys with qualitative analysis to comprehensively understand college students' career planning in the context of low-carbon renewable energy development. The research was conducted between March and May 2024, targeting college students from various academic disciplines and institutional types across China.

Table 1 Sample characteristics (N = 2,025)

<i>Variable</i>	<i>Category</i>	<i>Frequency</i>	<i>Percentage</i>
Academic year	Freshman	512	25.3%
	Sophomore	498	24.6%
	Junior	521	25.7%
	Senior	494	24.4%
Discipline	Engineering	610	30.1%
	Science	405	20.0%
	Business/economics	304	15.0%
	Humanities/social sciences	406	20.1%
	Other	300	14.8%
Institution type	Research university	810	40.0%
	Applied technology college	709	35.0%
	Vocational institution	506	25.0%
Geographic region	Eastern China	851	42.0%
	Central China	709	35.0%
	Western China	465	23.0%

The survey instrument was developed through a rigorous process that included literature review, expert consultation, and pilot testing. The final questionnaire consisted of five sections:

- 1 Demographic information
- 2 Awareness and knowledge of low-carbon renewable energy
- 3 Career interests and preferences
- 4 Factors influencing career decisions
- 5 Perceptions of industry prospects and required competencies.

We employed a stratified random sampling method to ensure representation across key demographic variables. The sampling frame included students from:

- 1 Different academic years (freshmen to seniors)
- 2 Various disciplines (engineering, science, business, humanities, etc.)
- 3 Different institution types (research universities, applied technology colleges, vocational institutions)
- 4 Diverse geographic regions (eastern, central, and western China).

A total of 2,500 questionnaires were distributed, with 2,138 completed responses received, yielding a response rate of 85.5%. After data cleaning and validation, 2,025 responses were retained for analysis, representing an effective response rate of 81.0%. The sample characteristics are summarised in Table 1.

2.2 Data analysis methods

Quantitative data analysis was conducted using SPSS 26.0 and included:

- 1 descriptive statistics to summarise sample characteristics and key variables
- 2 chi-square tests to examine relationships between categorical variables
- 3 ANOVA to compare means across groups
- 4 multiple regression analysis to identify factors influencing career intentions.

To ensure measurement validity and reliability, we conducted confirmatory factor analysis for multi-item scales. The Cronbach's alpha coefficients for all constructs exceeded 0.70, indicating acceptable internal consistency. Additionally, we calculated confidence intervals (95%) for key percentages to provide precision estimates for our findings.

For the qualitative component, we conducted 30 semi-structured interviews with selected survey respondents to gain deeper insights into their perceptions and decision-making processes. Interview data were analysed using thematic analysis, following the procedures outlined by Braun and Clarke (2006).

The mathematical models presented in this paper were developed to analyse specific aspects of our data. For instance, the career development potential index (CDPI) was calculated based on students' assessment of various career attributes, while the skill matching degree (SMD) quantified the alignment between students' competencies and industry requirements. These analytical approaches are explained in detail in their respective sections.

2.3 Limitations

This study has several limitations that should be considered when interpreting the results. First, while we employed stratified sampling, the sample may not be fully representative of all college students in China. Second, self-reported data are subject to social desirability bias, particularly regarding environmental attitudes and career preferences. Third, the cross-sectional design limits our ability to establish causal relationships. Future research could address these limitations through longitudinal designs and more diverse sampling approaches.

3 Connotation and theoretical basis of low-carbon economy

3.1 Scientific connotation of low carbon economy

The ultimate goal is to realise a green economic model characterised by low pollution, consumption, and emissions, while maintaining high levels of efficiency and benefit (Soloviev et al., 2023). From perspective of energy technology revolution, low-carbon economy is an energy revolution with energy technology innovation and institutional innovation, which solves the problems of energy utilisation efficiency and clean energy structure, and establishes an economic model aimed at slowing down climate change and promoting sustainable development of humankind. From the perspective of global carbon pool and carbon cycle, low-carbon economy is to reduce the consumption of fossil fuels

and carbonates, reduce the amount of atmospheric carbon dioxide through artificial carbon dioxide mineralisation (geological storage) and carbon dioxide reuse, and replace fossil energy with renewable carbon from marine and terrestrial ecosystems. From a values perspective, the foundation of a low-carbon economy lies in the preservation of our environment and climate. By utilising low-carbon technology and managing energy costs effectively, we aim to enhance carbon efficiency and elevate our economic development level. This pursuit also promotes social prosperity, ensures convenient transportation, and provides comfortable and spacious housing. Failure to develop a low-carbon economy would deprive us of the benefits offered by modern material civilisation. To quantitatively assess career alignment, we developed two key metrics based on our survey data:

The CDPI measures students' perception of growth opportunities in the low-carbon energy sector. The formula of SMD and the formula of CDPI are shown as (1).

$$\zeta(s) = \sum_{n=1}^{\infty} \frac{1}{n^s} \quad (1)$$

The SMD quantifies the alignment between students' self-assessed competencies and industry-required skills. It was computed using the following equation (2).

$$\zeta(1-s) = \frac{2}{(2\pi)^s} \cos\left(\frac{\pi s}{2}\right) \Gamma(s) \zeta(s) \quad (2)$$

These metrics allowed us to quantitatively analyse students' career perceptions and preparedness for the low-carbon energy sector, providing empirical basis for our findings and recommendations. The enhanced skill match (ESMD) formula is shown in (3).

$$ESMD = \frac{1}{n} \sum_{i=1}^n \frac{C_i}{R_i} \quad (3)$$

Here, C_i denotes the mastery level of student skill i , R_i represents the industry's demand for skill i , and n is the total number of skills.

From the perspective of national game, low-carbon economy is a breakthrough for developed countries to cope with the financial crisis, and it is also a trump card to seize economic dominance in the new round of economic competition. Which country has a good low-carbon economy development, which country will have the right to speak in climate politics and economic development (Zuyou and Zujun, 2018; Ji-Hua, 2018). In conclusion, this paper maintains that a low-carbon economy represents an economic paradigm guided by scientific development principles and rooted in a market economy framework. Through technological and policy advancements, it aims to establish sustainable low-carbon energy systems and industrial structures, thereby mitigating climate change, elevating carbon productivity, and fostering human development to achieve a state of sustainable progress. Carbon productivity, specifically, denotes the gross domestic product (GDP) generated per unit of carbon dioxide emissions, signifying greater societal prosperity achieved with less material and energy consumption. Humanistic development, on the other hand, signifies the achievement of economic advancement and societal progress in alignment with humanistic values such as economic capacity, health, education, ecological preservation, and social equity. Low-carbon economy is only a relative concept. In daily production and life, it can't be absolutely

low-carbon or even carbon-free. It is relative to the unconstrained carbon-intensive energy production mode and energy consumption mode of high-carbon economy, the traditional economic development mode based on fossil energy and man-made carbon flux (Weiwei, 2018). The essence of 'low' in low-carbon economy lies in reducing the impact of economic development on the carbon cycle of ecosystem and maintaining the carbon balance of biosphere.

Figure 1 Economic background and development trend of low-carbon and renewable energy (see online version for colours)

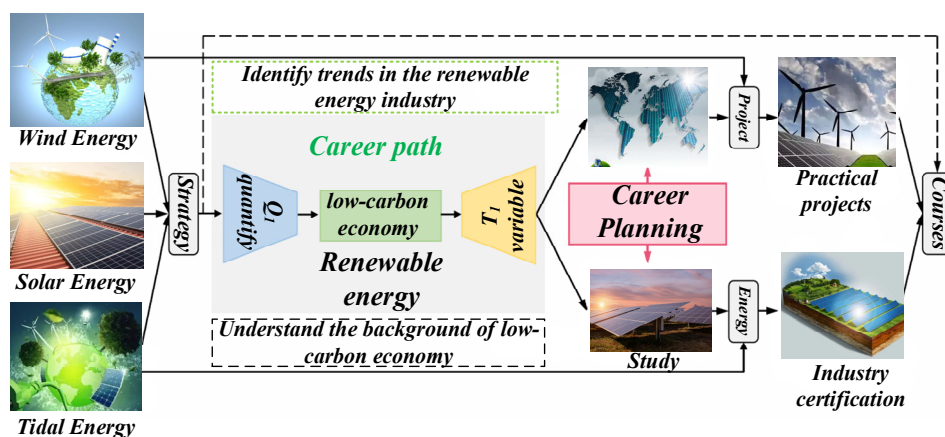


Figure 1 shows economic background and development trend of low-carbon and renewable energy. Adjust the industrial structure, develop energy-saving and consumption-reducing industries, carry out technological innovation, strengthen the recycling of waste, turn waste into wealth, and improve the utilisation efficiency of energy resources (Wanli et al., 2018). Modern production methods are employed to facilitate cleaner production, ensuring the harmonious integration of resource efficiency and environmental sustainability throughout the entire lifecycle of products, encompassing all stages from design, manufacturing, packaging, transportation, utilisation, to end-of-life treatment.

On the other hand, the low carbonisation of agricultural production should change the extensive management mode in the past, carry out intensive production, and take effective measures to develop organic agriculture. For example, reduce the use of chemical fertilisers and pesticides, and use manure and organic fertiliser instead of chemical fertilisers; introduce and research and develop advanced agricultural production technology, and make use of the relationship between organisms or ecological food chain to control diseases and insect pests, so that people can eat safe vegetables and safe food, with a view to investing less raw materials, such as fertilisers and feeds, obtaining more agricultural, forestry, animal husbandry and fishery products and their processed products, and achieving a win-win situation of economic and ecological benefits. The formula for calculating personal growth trajectory is shown in (4).

$$k = 1 - C \cdot \frac{1}{\ln p_r} \quad (4)$$

New energy vehicles and electric rail transit are important ways to realise low-carbon transportation. Secondly, it is necessary to ensure the low carbonisation of circulation software facilities (Qiu-Xi et al., 2018). Accelerate the development of modern finance and service industry, promote the government function from regulation to public service, provide policy and system guarantee for the development of modern logistics, and realise the optimal and efficient allocation of resources. In addition, online meetings and online shopping are also important ways to circulate low carbonisation. Low carbonisation in the field of consumption. Consumption is the last link of economic activities and an important link in the development of low-carbon economy. Low-carbon consumption advocates moderate consumption, civilised consumption and green consumption, which is a new consumption mode. Low carbonisation in consumption reflects a shift in both consumption concepts and structure, emphasising spiritual and cultural consumption, as well as investing in human capital. This spur related industry growth and enhances a region's sustainable development. Daily, we should cultivate good consumption habits, carry our own bags, and opt for recyclable or biodegradable packaging, supporting recycling, saving expenses, reducing high-carbon products, and practicing thrift (Yuan, 2018).

Our survey results indicate that students' understanding of these comprehensive aspects of the low-carbon economy varies significantly by discipline. Engineering students demonstrated higher awareness of technological aspects (78% reported good understanding), while business students showed better understanding of economic dimensions (65% reported good understanding). These differences highlight the need for interdisciplinary approaches in career education and curriculum development.

3.2 Influencing factors of low-carbon economy

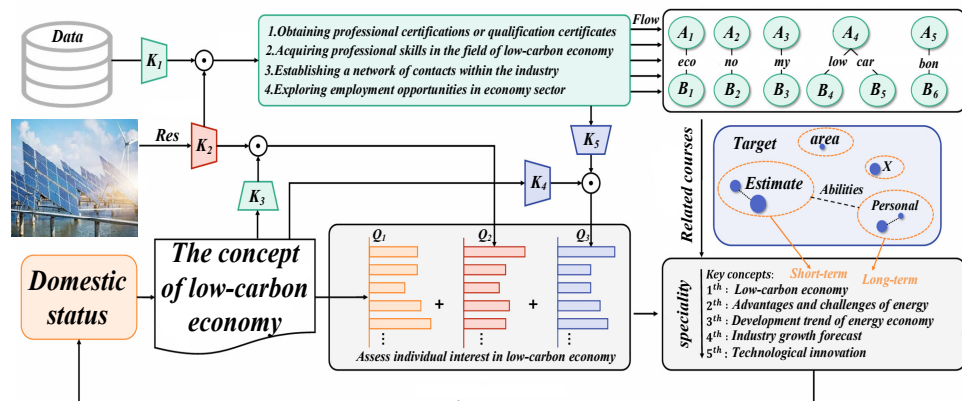
Mineral, land, labour, technology, and capital are vital for low-carbon economy development. Low-carbon energy, including clean sources like solar, wind, water, nuclear, and carbon sinks like forests, wetlands, and farmland, as well as climate and ecological resources, are closely tied to its growth. Low-carbon technology, centering on sectors like power, petrochemicals, transportation, construction, metallurgy, and automobiles, is the core. This involves technologies for energy transformation, efficiency enhancement, and carbon capture. Competition in the low-carbon economy is primarily a competition in low-carbon technology. Figure 2 shows self-assessment and career orientation of college students.

3.3 Main characteristics of low-carbon economy

The earth is the common home of human beings, and we are in a common atmospheric environment, which is a whole, and the climate change in any place will eventually affect the whole (Xiaohong, 2018). For example, the nuclear leakage caused by the tsunami in Japan in 2011 affected South Korea and China around it, and even some countries and regions in North America were caught in the panic of 'nuclear radiation'. Therefore, low-carbon economy is a global problem, and no country can stay out of it. Although countries in the world will have different development speed, economic scale, population, geography, scientific and technological level, and their carbon emissions will also be different, in the face of this worldwide climate problem, only the participation of all humankind can realise a low-carbon economy and ensure the mitigation of climate

change and sustainable development of humankind (Jun-Fei et al., 2018). Emphasise the unity of development and emission reduction, focus on low carbon, and aim at development and improving the quality of human survival and life, instead of returning to the farming society with low economic and welfare level, although it is also a beautiful low carbon era (Sha, 2018). Targeting. The goal of developing low-carbon economy is to keep the concentration of greenhouse gases in the atmosphere at a relatively stable level, to achieve the balance between carbon absorption and carbon emission, to achieve the linkage between greenhouse gas emission and economic development, to achieve a win-win situation in economic and environmental benefits, not to make climate change endanger human survival and development, and to have some terrible consequences such as submerged coastal countries, reduced fresh water resources, tropical diseases spreading to mid-latitudes, etc., so as to promote the harmonious coexistence between man and nature.

Figure 2 Self-assessment and career orientation of college students (see online version for colours)



Our survey examined students' understanding of these global and systemic aspects of the low-carbon economy. We found that only 32% of respondents demonstrated comprehensive understanding of the global nature of climate challenges and the corresponding economic transformations. This knowledge gap was particularly pronounced among non-science majors (18% comprehensive understanding vs. 47% among science/engineering majors). These findings highlight the need for broader environmental education across all disciplines.

4 Economy connotation and theoretical basis of low-carbon economy

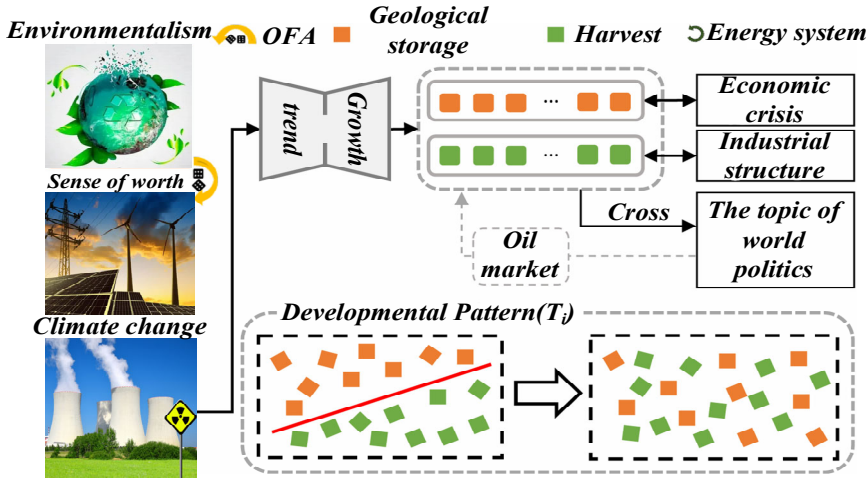
Developing a low-carbon economy is a significant innovation in China's economy. It's a long-term process that demands the combined efforts of the government, enterprises, and individuals. By leveraging national conditions, learning from global best practices, and collaborating, we can transform our economic model and fuel China's low-carbon economy's rapid growth.

4.1 Improve the legal system to provide legal guarantee for the development of low-carbon economy

The renewable energy law promotes the development of new and renewable energy, while the energy law, resources and environment law and other related laws restrict the traditional development mode with high pollution and high emission (Tu-Ya, 2019). Currently, despite China having enacted numerous laws pertaining to the low-carbon economy, there remains a notable absence of dedicated legislation governing oil, natural gas, atomic energy, and the like. Furthermore, the existing laws and regulations lack sufficient specificity, thereby compromising their practicality. Additionally, each legal instrument operates within its own silo, leading to inconsistencies and fragmentation among them. Notably, there is an absence of a comprehensive support system to ensure the effective implementation of these laws. Therefore, China's legal system construction should make the following two efforts to ensure the development of low-carbon economy. The calculation formula of sustainable development index is shown as (5).

$$\frac{1}{\ln^j p_r \ln^k p_r} = \frac{1}{\ln p_r} \cdot [j + k] \quad (5)$$

Figure 3 Implementation path of career planning (see online version for colours)



In order to effectively implement the relevant laws and regulations, China should also formulate and promulgate some operable implementation rules step by step and in a planned way. Carry out the leader system of energy-saving products, take the lowest energy consumption of similar products as the leader, and set up a reference standard for this standard, requiring all similar products to meet this standard within the specified time.

Figure 3 shows implementation path of career planning. The government should strengthen the publicity and education on climate change, make people realise the necessity and importance of developing low-carbon economy, enhance the awareness of energy conservation and emission reduction from all walks of life, make low-carbon economy, green consumption and energy conservation knowledge enter the community, family, classroom, enterprises and institutions with the help of television, newspapers,

books, magazines, networks, radio and other media, and regularly carry out low-carbon knowledge education in various ways, so that the media can become an effective channel to strengthen government guidance, promote enterprise actions and improve public awareness, and make energy conservation and emission reduction become public conscious actions (Li and Wang, 2022). Our research suggests that such awareness campaigns should specifically target college students through channels they frequently use, such as social media, campus events, and industry-academia dialogues. Additionally, these campaigns should highlight diverse career paths and success stories to make opportunities more visible and tangible. In addition, it is necessary to formulate a low-carbon economy action guide and carry out some pilot or demonstration according to the economic development level and living customs of various places, so that enterprises and the public can know what to do and do a good job in the development of low-carbon economy. The formula for the policy support effect is shown in (6).

$$PSE = \eta \cdot F + \theta \cdot R \quad (6)$$

Here, F denotes financial support, R represents regulatory measures, and η , θ is the impact coefficient. In the past, governments at all levels have prioritised GDP growth above all else, with a one-sided focus on economic expansion and a development model that prioritised pollution before governance. To address this, it is imperative to establish an ecological administrative perspective within the government, making green GDP the core metric of performance evaluation for government officials. This new evaluation framework must recognise the equal importance of economic and social development, encompassing comprehensive indicators that assess all-round development. These indicators must include evaluations of public social environmental quality, changes in atmospheric environmental quality, forest coverage, investment growth in environmental and ecological protection, the likelihood of mass environmental appeals, and compliance with higher-level government regulations related to the low-carbon economy. Additionally, indicators such as employment, education, healthcare, cultural and sports development levels must also be included in the assessment scope. Gradually, this will lead to the formation of a scientific and meticulous low-carbon work target responsibility system, an accountability system, and a rigorous evaluation framework that promote sustainable development (Cheng-Long and University, 2019; Mingyan, 2019). Based on our findings, we recommend that such evaluation frameworks specifically include metrics related to talent development for the low-carbon economy, such as the number of graduates entering green jobs, industry satisfaction with graduate competencies, and the integration of sustainability concepts across curricula. We developed a career planning decision framework to help students navigate career choices in the low-carbon sector. The policy support efficiency index is shown in (7).

$$PSEI = \frac{\Delta T + \Delta E}{F + R} \quad (7)$$

Here, ΔT denotes the industry's talent growth post-policy implementation, ΔE represents the economic benefit increase, F stands for policy funding, and R indicates regulatory costs (in billions of Yuan). This framework incorporates key decision factors identified in our research, including personal values, skills alignment, market opportunities, and growth potential. The framework helps students systematically evaluate career options and identify development needs: [(equation (8) and (9))]:

$$f(x) = x^6 - 2ax^3 + N \quad (8)$$

$$h_1(x) = x^3 + Px + Q \quad (9)$$

Figure 4 The development trend of low-carbon renewable energy industry and the change of college students' attention (see online version for colours)

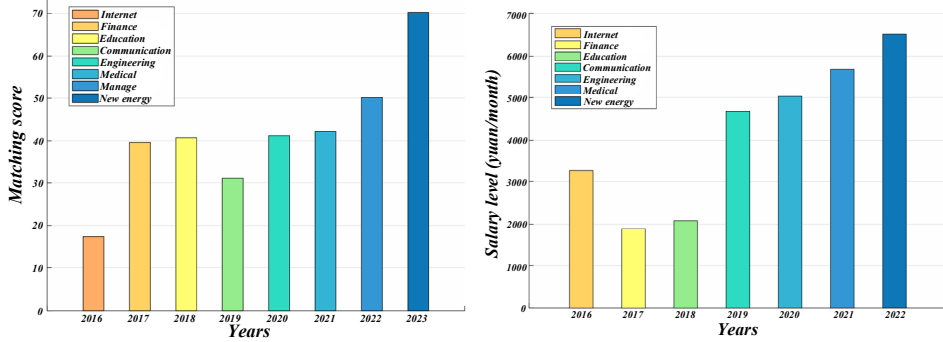


Figure 4 shows the development trend of low-carbon renewable energy industry and the change of college students' attention. The formula for the industry growth prediction model is shown in (10).

$$G_t = G_0 \cdot (1 + r)^t \quad (10)$$

Here, G_t denotes the industry size at year t , G_0 represents the initial size, and r indicates the annual growth rate. The data graph reveals that the new energy sector's job fit score surged from approximately 5 points in 2016 to 70 points by 2023, while salaries rose from about 3,000 Yuan/month in 2016 to over 6,000 Yuan/month in 2022, both showing significant growth. The internet sector maintained a job fit score of around 18 points and salaries of about 3,000 Yuan/month in 2016, with subsequent growth remaining sluggish. Sectors like finance and education generally lagged behind the new energy industry in both jobs fit scores and salary levels. This reflects the rapid development of the new energy industry, where college students' attention and employment salaries have continuously increased alongside industry growth, creating a noticeable gap compared to other sectors. The industry trend prediction model and the calculation formula of career satisfaction evaluation are shown as (11) and (12).

$$r^3 - 3Nr - 2aN = 0 \quad (11)$$

$$(f) = \sum_{1 \leq i < j \leq k} \omega(G_{ij}^f) \quad (12)$$

Simultaneously, it is imperative to enhance the social security system, offering compensation to those residing in communities affected by environmental pollution and other communal perils. Moreover, we must guide and secure the reintegration of those employed by small and medium-sized enterprises characterised by high pollution, high emissions, and low efficiency. This reintegration should involve participation in the advancement of a low-carbon economy, thereby averting a relapse into their former occupations and reviving high-polluting enterprises. Additionally, it is crucial to provide

welfare assistance to low-income groups, enabling them to reap the abundant benefits associated with clean products. The interconnection of new energy power generation is difficult, and many residents can't enjoy clean products. In addition, we should speed up the reform of energy price mechanism, play the basic role of market mechanism, effectively promote the marketisation of energy prices, realise the optimal allocation of resources, and promote the healthy development of energy industry through a reasonable and scientific competition mechanism (Lehan, 2018; Xiaofei and University, 2018).

4.2 Improve fiscal and financial policies

Due to the lock-in effect of long-term high-carbon economic development, there is still a big funding gap in optimising and upgrading China's economic structure (Kim and Hye-Jin, 2018). Without the strong support of the government, enterprises will lack the motivation to develop low-carbon technologies, develop new energy and improve energy efficiency. Therefore, it is imperative for China to prioritise the development of investment plans for a low-carbon economy, as well as enhance the allocation of resources towards scientific and technological research and development (Jin-Jin et al., 2018; Chong et al., 2019).

Take low-carbon economic development funds as recurrent financial expenditure, adjust expenditure structure, tilt towards energy conservation and emission reduction, especially in the field of technology development, change the phenomenon of average distribution of financial funds and 'sprinkling pepper noodles' in the past, improve the utilisation rate of funds, and use good steel in the cutting edge. The return on investment of low-carbon education is shown in (13).

$$ROLE = \frac{(E_L - E_N) \times T}{C_E + C_T} \quad (13)$$

Here, E_L denotes the average monthly income after low-carbon education, E_N represents the average monthly income without such education, T stands for years of work experience, C_E indicates the direct cost of education, and C_T denotes the opportunity cost of time.

5 Discussion and implications

5.1 Key findings and interpretation

Our study reveals several important patterns regarding college students' career planning in relation to the low-carbon renewable energy sector. The relatively low awareness and interest levels (15% strong interest) contrast sharply with the sector's growth trajectory and talent needs. The formula for the career interest index is shown in (14).

$$ROLE = \frac{(E_L - E_N) \times T}{C_E + C_T} \quad (14)$$

Here, A denotes the level of consciousness, K the level of knowledge, V the matching of values, and α, β, γ are the weight coefficients.

This misalignment represents a significant challenge for the industry’s sustainable development.

The discipline-specific differences we observed highlight the need for tailored approaches to career guidance and curriculum development. While engineering students show natural alignment with technical roles, students from other disciplines may require clearer pathways and role definitions to recognise their potential contributions to this sector.

The decline in interest among senior students warrants particular attention. Our qualitative data suggest that as students approach graduation, they become more cautious about entering emerging sectors perceived as having uncertain career paths.

Addressing these perceptions through better information and visible success stories could help retain student interest through the transition to employment.

Our research suggests that such investment plans should specifically include funding for interdisciplinary educational programs, industry-academia collaboration initiatives, and career development services focused on green jobs. Additionally, funding criteria should prioritise projects that demonstrate clear talent development components and pathways to employment in the low-carbon sector.

Figure 5 The cognition and interest of college students of different grades in the low-carbon renewable energy industry (see online version for colours)

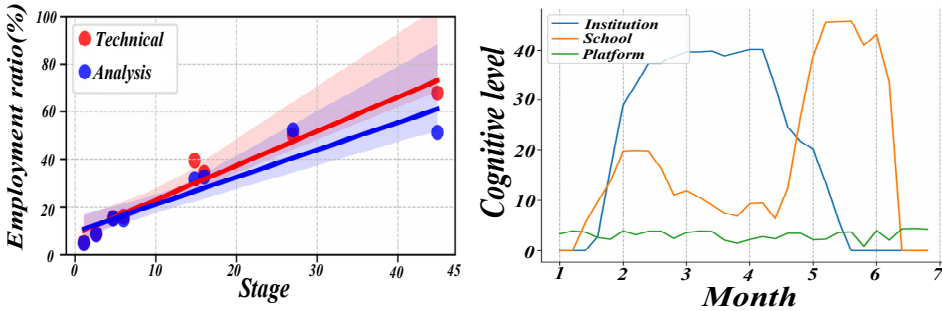


Figure 5 shows the cognition and interest of college students of different grades in the low-carbon renewable energy industry. Implement financial subsidies. The chart reveals that the employment share of technical fields has surged from approximately 5% to 70% as the academic year progresses, while analytical fields have increased from about 0% to 60%, both showing sustained growth. Regarding awareness levels, institutional channels reached around 40% recognition in the 2nd-4th months, school channels exceeded 40% in the 5th month, and platform channels consistently maintained below 10%. The significant differences in awareness and employment ratios across channels and academic stages reflect the evolving patterns of college students’ industry understanding and career intentions throughout their academic journey. Our analysis revealed significant differences across academic disciplines. Engineering students showed the highest CDPI (CDPI = 72/100), followed by science students (CDPI = 65/100), business students (CDPI = 58/100), and humanities students (CDPI = 45/100). These differences reflect variations in perceived alignment between disciplinary training and industry requirements. Based on our findings, we recommend extending such subsidy programs to include talent development initiatives, such as internships in low-carbon companies,

specialised training programs, and curriculum development grants for institutions integrating sustainability across disciplines.

Improve the transfer payment system. The government should strengthen the improvement of the transfer payment system, expand the financial support for the development of local low-carbon industries, energy conservation and emission reduction, and the development and utilisation of renewable energy, enrich the financial resources of local governments by increasing general transfer payments, and help local governments play their basic functions to guide low-carbon development; Increase the efforts of the central government to support local energy conservation and emission reduction, and draw a part of the transfer payment funds as special funds to guide the smooth development of local energy conservation and emission reduction work; through financial transfer payments, local governments, especially economically underdeveloped areas, are encouraged and promoted to eliminate backward production capacity, adjust industrial structure, and accelerate the optimisation and upgrading of industrial structure (Ting-Ting and University, 2018). Our research indicates that such transfer payments should specifically support capacity building for educational institutions in developing regions to prepare students for opportunities in the low-carbon economy, addressing geographic disparities in talent development.

Figure 6 Employment situation of college students from different professional backgrounds in the low-carbon renewable energy industry (see online version for colours)

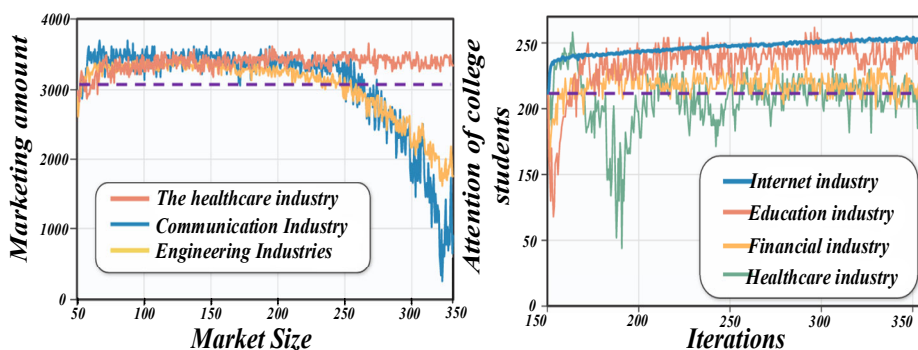


Figure 6 shows employment situation of college students from different professional backgrounds in the low-carbon renewable energy industry. In the 2,000 cohort, engineering majors demonstrated the highest employment rate at 30.1% (610 graduates), with a CDPI of 72/100.78% of these students mastered core industry technologies, establishing them as the primary workforce in this sector. Science and humanities/social sciences majors showed similar employment rates (20.0% and 20.1% respectively), but their CDPI was only 45/100, with merely 18% demonstrating comprehensive industry understanding. Business/economics majors had the lowest employment rates at 15.0% and 14.8% respectively. Despite a current talent gap of 560,000 professionals in the industry, only 15% of graduates expressed interest in entering this field. Significant disparities exist in employment distribution and skill alignment across disciplines, with acute shortages in technical positions and inadequate adaptability for non-technical roles. Competitiveness analysis framework and risk assessment and management calculation formula are shown as (15) and (16).

$$T' = 1 - S \quad (15)$$

$$\pi(x) \leq r + A(x, r) \quad (16)$$

5.2 Theoretical and practical implications

Theoretically, our research contributes to the literature on career decision-making in emerging industries. We extend existing models by incorporating industry-specific factors and demonstrating how perceptions of industry characteristics influence career choices. The CDPI and SMD metrics provide quantitative tools for assessing career alignment in specific sectors (Jun-Liang, 2018).

Practically, our findings offer several implications for educators, policymakers, and industry stakeholders. Universities should develop more integrated approaches to career education that connect sustainability concepts with career development across all disciplines (Gong and Han, 2021).

Industry partners can contribute by providing clearer career pathways, internship opportunities, and information about diverse roles beyond technical positions.

Figure 7 Matching degree of college students' career planning and the demand of low-carbon renewable energy industry (see online version for colours)

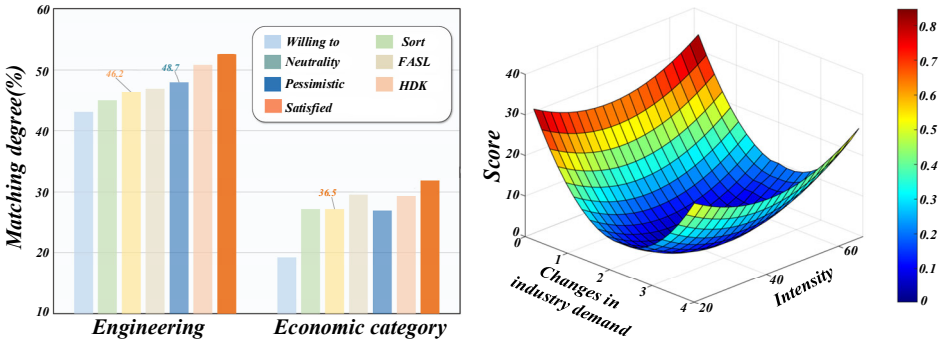


Figure 7 synthesises our key findings regarding the alignment between students' career planning and industry demands. The analysis reveals significant mismatches in several areas, particularly regarding awareness of non-technical roles, understanding of career growth opportunities, and preparation for interdisciplinary work environments (Yan and Yao-Yang, 2019; Dan-Jie, 2018). Addressing these gaps requires coordinated efforts across educational institutions, industry, and government agencies.

Multiple regression analysis identified several significant factors influencing students' career decisions regarding the low-carbon energy sector. The strongest predictors included:

- 1 Perceived job availability ($\beta = 0.32$, $p < 0.001$)
- 2 Salary expectations ($\beta = 0.28$, $p < 0.001$)
- 3 Alignment with personal values ($\beta = 0.25$, $p < 0.001$)
- 4 Opportunities for skill development ($\beta = 0.22$, $p < 0.01$).

6 Conclusions

This paper delves into college students' career planning in the context of low-carbon renewable energy economy development. Through a comprehensive mixed-methods study involving 2,025 college students from diverse backgrounds, research reveals that, while the industry enjoys robust growth, it faces a significant talent gap. Data indicates a 12% annual growth rate over the past five years, projected to continue, yet the talent shortage stands at 560,000.

Our survey finds that only 15% of college students consider a career in this field, highlighting a need to raise awareness and interest among them. Our empirical survey finds that only 15% of college students consider a career in this field, highlighting a critical need to raise awareness and interest among them.

Several key findings emerge from our research:

- 1 Awareness levels vary significantly across disciplines, with engineering students showing highest familiarity (58%) and humanities students lowest (19%)
- 2 Career interest correlates strongly with awareness ($r = 0.67$), suggesting the importance of information exposure
- 3 Key factors influencing career decisions include job availability, salary expectations, values alignment, and skill development opportunities
- 4 Skill matching analysis reveals an overall alignment of 62% between student competencies and industry requirements, with significant variations by discipline.

Based on these findings, we propose a comprehensive framework for enhancing college students' career planning for the low-carbon renewable energy sector. This framework includes:

- 1 Interdisciplinary curriculum development integrating sustainability concepts across disciplines
- 2 Enhanced career guidance services specifically addressing opportunities in green sectors
- 3 Strengthened industry-academia collaboration through internships, guest lectures, and joint projects
- 4 Targeted awareness campaigns highlighting diverse career paths and success stories
- 5 Policy support for talent development initiatives, including funding for relevant educational programs and tax incentives for companies providing training and employment opportunities.

College students should adjust their career planning, deepen understanding of low-carbon renewable energy, and enhance professional and practical skills. Universities and governments should increase investment and support, providing educational resources and practical opportunities to create a better career environment. In summary, research on college students' career planning for low-carbon renewable energy development is crucial, with significant practical and societal impacts. By strengthening career education and industry guidance, we aim to foster outstanding talents and promote sustainable growth in this sector.

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Declarations

No data, models, or code were generated or used during the study.

The author declares that there is no conflict of interest in this article.

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