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Research on the Assessment of Residents' Ecological Well-being in Green and Low-carbon Energy Transition: A Social Survey Based in Hefei

Minghao Liu
School of Sociology and Political Science, Anhui University, HeFei 230601, Anhui, China

Abstract: With the increasing severity of global climate change, green and low-carbon transition has become a shared objective for national energy development worldwide. Against this backdrop, assessing residents' ecological well-being during the energy transition process holds significant importance for promoting sustainable development and building a harmonious society. Based on a social survey of residents' ecological well-being in Hefei's green and low-carbon energy transition, this study develops primary and secondary indicators to evaluate residents' ecological well-being. Through logistic regression analysis, the research examines residents' ecological well-being across environmental, social, and economic dimensions. The findings reveal that the influencing factors on residents' ecological well-being demonstrate significant systematic characteristics, suggesting that green and low-carbon energy transition should achieve balanced and synergistic progress among environmental, social, and economic aspects.

Keywords: energy transition; green and low-carbon; ecological well-being; social survey

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1. Introduction

In 2022, the National Development and Reform Commission (NDRC) and the National Energy Administration (NEA) issued the Opinions on Improving the Institutional Mechanisms and Policy Measures for Green and Low-Carbon Energy Transition. These measures aim to address climate change, enhance environmental quality, and boost energy efficiency. By establishing a dual-control system for energy consumption and non-fossil energy targets, the policy strengthens regulatory guidance and support for the energy sector, facilitates economic transformation, and fosters a win-win scenario for economic growth and environmental protection. Ultimately, policy objectives center on improving national welfare, which for most residents equates to well-being. In essence, happiness constitutes the primary life goal for individuals[1].

Well-being is an abstract concept encompassing subjective perceptions and emotional states. It is influenced by multiple factors—quality of life, economic status, social relationships, health, job satisfaction, cultural context—with variations across individuals. Contemporary research focuses on five fundamental questions: the definition of happiness, its origins, formation mechanisms, assessment methodologies, and enhancement strategies. Scholarly interpretations diverge significantly. Shin and Johnson, grounded in hedonic traditions, equate well-being with life satisfaction—an individual's holistic self-evaluation based on personal criteria[2]. Ross and Kishchuck conceptualize it as affective self-assessment, expressed through statements like "I feel good" or "I feel bad"[3]. Eudaimonic perspectives, emphasizing self-actualization, have gained prominence. Ryff defines well-being as the experience of fulfillment through realizing one's potential[4]. Xing Zhanjun synthesizes these views, framing well-being as a positive psychological state arising from the interplay between objective conditions and personal values, integrating satisfaction, pleasure, and purpose. He further identifies ten dimensions: contentment, mental health, growth, social confidence, purpose, self-acceptance, interpersonal adaptation, physical health, emotional balance, and family harmony.

Green and low-carbon energy transition is pivotal for achieving carbon peak/neutrality goals and modernizing energy systems. While prioritizing ecological sustainability, this transition lacks direct linkages to core subjective well-being elements—personal life, mental health, and self-development—rendering generalized assessments impractical. Ecological well-being evaluation offers an alternative. It measures public satisfaction and happiness regarding environmental conditions, encompassing perceptions of ecosystems and human-nature interactions. This approach reflects the interdependence between ecological conservation and societal health, incorporating environmental quality assessments alongside subjective experiences. Evaluating residents' ecological well-being during energy transition thus holds practical significance. This study designs an assessment framework and applies it to Hefei's energy transition initiatives.

2. Policy Selection: Green and Low-Carbon Energy Transition

To assess residents' ecological well-being in this transition, a scientific evaluation index system must be established. Key indicators should encompass: Residents' awareness and willingness to adopt clean energy; Recognition and satisfaction toward energy transition policies; Perception and evaluation of ecological environment improvements. Through data collection and analysis, policymakers can gauge public attitudes and expectations, providing critical references for policy formulation and implementation. For the empirical assessment in Hefei, this paper compiles relevant municipal policies, quantifies and operationalizes policy dimensions into measurable indicators, and conducts scientific evaluation to inform decision-making. Relevant Policies for Green and Low-Carbon Energy Transition in Hefei：

a.Implementation Plan for the Battle Against Agricultural and Rural Pollution in Hefei (2022-2025).

b.Hefei 14th Five-Year Plan for High-Quality Energy Development.

c.Implementation Rules for Rectification and Verification of Ecological Environment Issues in Hefei's "Green Shield" Nature Reserves.

d.Hefei 14th Five-Year Plan for Ecological Environmental Protection.

e.Action Plan for Creating Green Schools in Hefei High-Tech Zone (2023).

f.Key Points of Emergency Management Work in Hefei (2023).

g.Notice on Further Strengthening the Management of New Energy Projects in Hefei (Draft for Comments).

h.Implementation Rules for Income Distribution Management of Photovoltaic Poverty Alleviation Power Stations in Hefei.

i.Action Plan for "Better Services for the People" in Hefei (2023).

j.Implementation Measures for Income Distribution Management of Photovoltaic Poverty Alleviation Power Stations in Changfeng County.

k.Several Policies for Further Promoting the Application of New Energy Vehicles and Intelligent Connected Vehicles in Hefei.

l.Several Policies for Further Promoting the High-Quality Development of the Photovoltaic Industry in Hefei.

m.Key Points of Tourism Resource Development Work (2023).

n.Hefei Regulations on Optimizing the Business Environment.

o.Several Policies for Promoting Economic Development in Hefei

3. Indicator Design and Research Framework

3.1. Indicator Design: Ecological Well-being Assessment Indicators

In energy transition research, ecological well-being assessment demands indicator redesign. Deconstructing green and low-carbon energy transition reveals it as both a critical pathway for environmental, economic, and social sustainability and a vital contributor to global sustainable development goals. Sustainability theory advocates shifting from "economic and social objective-centered" development toward an "environment-centered" approach, achieving balanced integration across all three dimensions. Consequently, ecological well-being assessment should incorporate environmental, social, and economic well-being as primary indicators, each subdivided into secondary indicators[5].

Environmental quality fundamentally determines human survival and development. Traditional industrial growth neglected ecological protection, causing severe environmental degradation. Pollution critically compromises terrestrial, aquatic, and marine ecosystems. Heightened environmental awareness has driven regulatory enhancements and public education on conservation via mass media. To mitigate air pollution from carbon emissions, governments promote efficient renewable energy development while assessing environmental risks of energy projects—implementing preemptive disaster management and exit mechanisms. Ecological restoration maximizes environmental quality maintenance. Corresponding secondary indicators include: S1 Pollution reduction effectiveness, S2 Renewable energy adoption rate, S3 Environmental regulatory intensity, S4 Ecological restoration and conservation, S5 Environmental education and awareness, S6 Environmental risk management.

Society functions as a complex network centered on human interactions. Protecting shared socio-ecological environments requires collective effort. Energy policies involve all citizens; inclusive decision-making ensures positive societal and environmental outcomes. Despite China's abundant resources, uneven distribution creates energy poverty. Governments must engage experts to assess energy service accessibility, coverage, and affordability for low-income groups, while examining inequitable resource allocation and disproportionate environmental burdens. Resolving these issues enhances social well-being. Secondary indicators comprise: S7 Public participation in energy decision-making and environmental actions, S8 Energy poverty alleviation progress, S9 Ecological equity and social justice, S10 Community engagement and benefit-sharing.

Sustainability encourages synergistic economic-environmental advancement rather than growth limitation. Energy transition necessitates shifting from high-input, high-consumption, high-pollution models toward clean energy adoption for emission reduction, technological innovation for efficiency gains, green energy development for economic transformation, and low-carbon lifestyles promoting circular economy and green consumption—collectively improving quality of life. Secondary indicators include: S11 Green innovation and technological advancement, S12 Eco-compensation mechanism maturity, S13 Eco-tourism development, S14 Green investment and employment, S15 Eco-economic growth.

Secondary indicators employ a respondent scoring approach. Each indicator (S1~S15) is scored on a 100-point scale by respondents based on their actual circumstances (each score denoted as am，where m = respondent ID, m ∈ Z，1≤m≤mmax), The aggregate score for each secondary indicator (denoted Sn*,n ∈ Z,1≤n≤15),equals the arithmetic mean of all respondent ratings for that indicator (Formula ①).The aggregate score for primary indicators (denoted Xi*,i ∈ Z,1≤i≤3),equals the arithmetic mean of their constituent secondary indicators' aggregate scores (Formula ②).

① $S_n^*=\sum a_m/m_{max}$

② $X_i^*=\sum S_n^*/g$ (g=6,if i=1,g=4,if i=2,g=5,if i=3)

3.2. Research Framework: Social Survey and Logistic Regression Analysis

This study aims to assess residents' ecological well-being during the green and low-carbon energy transition and examine its influencing factors. To achieve this objective, we adopt an integrated research framework combining social surveys and logistic regression modeling.

Initially, structured questionnaires collect residents' ratings on ecological well-being indicators related to energy transition, encompassing all constructed metrics across environmental, social, and economic dimensions to evaluate multidimensional well-being status.

Subsequently, logistic regression analysis identifies determinants of ecological well-being by incorporating all ecological well-being indicators as independent variables and a dichotomous measure of ecological well-being presence as the dependent variable. This model estimates statistically significant influencing factors and elucidates their underlying mechanisms and pathways.

This research framework aims to elucidate residents' ecological well-being status during the green and low-carbon energy transition, thereby providing scientific evidence for policy formulation and implementation. Simultaneously, by identifying factors influencing ecological well-being, it offers targeted recommendations and interventions to enhance residents' ecological well-being. This approach holds significant implications for advancing energy transition initiatives and improving residents' quality of life.

4. Empirical Analysis

This study examines the impact of green and low-carbon energy transition on residents' ecological well-being through analysis of 282 valid questionnaires. Fifteen indicators (S1-S15) were dichotomized based on respondents' self-reported ecological well-being status (Whether=1 indicating sufficient ecological well-being, Whether=0 indicating insufficient ecological well-being). For respondents reporting Whether=1, the top eight highest-scoring indicators were coded as "1" and others as "0"; for those reporting Whether=0, the bottom eight lowest-scoring indicators were coded as "2" with others remaining as "0". Logistic regression analysis was subsequently performed using SPSS software.

As the independent variables (S1-S15) were categorical, chi-square tests were first conducted to examine their associations with the dependent variable (Whether=1/0). Cross-tabulation analysis revealed statistically significant differences (Pearson Chi-Square=0 for all variables, see **Figure 2**), confirming the appropriateness of retaining all variables in subsequent analyses. Multicollinearity diagnostics showed tolerance values exceeding 0.875 and variance inflation factor (VIF) values ranging between 1-3 (see **Figure 3**), indicating no substantial multicollinearity concerns among the independent variables.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	150.167[a]	2	.000
Likelihood Ratio	207.990	2	.000
Linear-by-Linear Association	19.476	1	.000
N of Valid Cases	282		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 33.04.

Figure 2. Chi-square test output for independent variable S1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.784	.055		32.383	.000		
	S1	-.074	.022	-.120	-3.349	.001	.875	1.143
	S2	-.135	.021	-.222	-6.317	.000	.912	1.097
	S3	-.151	.021	-.253	-7.242	.000	.922	1.085
	S4	-.135	.022	-.216	-6.285	.000	.948	1.054
	S5	-.119	.022	-.192	-5.523	.000	.934	1.071
	S6	-.139	.021	-.225	-6.574	.000	.956	1.047
	S7	-.107	.021	-.172	-4.988	.000	.946	1.057
	S8	-.128	.022	-.205	-5.803	.000	.899	1.113
	S9	-.092	.021	-.150	-4.366	.000	.947	1.056
	S10	-.084	.022	-.127	-3.741	.000	.970	1.031
	S11	-.081	.022	-.133	-3.724	.000	.875	1.143
	S12	-.109	.021	-.181	-5.101	.000	.893	1.120
	S13	-.090	.022	-.143	-4.171	.000	.957	1.045
	S14	-.126	.021	-.206	-5.896	.000	.922	1.085
	S15	-.081	.022	-.130	-3.768	.000	.948	1.055

a. Dependent Variable: Whether

Figure 3. Coefficient$^{\alpha}$ table output

Binary logistic regression analysis was then performed. The Omnibus Tests of Model Coefficients (**Figure 4**) demonstrated satisfactory model fit (all significance values <0.05), with the likelihood ratio test confirming the statistical significance of the model.

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	390.708	30	.000
	Block	390.708	30	.000
	Model	390.708	30	.000

Figure 4. Omnibus tests of model coefficients

The coefficient outputs and significance test results (see **Figure 5**) demonstrate that all independent variables S1-S15 show statistically significant effects (Sig. values <0.05), confirming their substantial influence on residents' well-being. Based on the Whether=1/0 classification, the logistic regression model can be expressed as follows:

If Whether=1,

$Logit(P)=\ln(p/1-p)=-18.814+5.21S_1+5.04S_2+4.74S_3+5.30S_4+4.64S_5+5.30S_6+4.94S_7+4.51S_8+4.95S_9+5.32S_{10}+4.22S_{11}+5.12S_{12}+5.38S_{13}+4.45S_{14}+5.38S_{15}$.

If Whether=2,

$Logit(P)=\ln(p/1-p)=-18.814-0.19S_1-0.39S_2-0.42S_3-0.41S_4-0.37S_5-0.43S_6-0.29S_7-0.42S_8-0.27S_9-0.32S_{10}-0.20S_{11}-0.27S_{12}-0.27S_{13}-0.35S_{14}-0.29S_{15}$.

The regression results indicate that S1 demonstrates a positive effect coefficient of 1.08, suggesting that a one-unit increase in S1 score elevates the probability of residents experiencing ecological well-being by 8%. Similarly, one-unit increases in other indicators yield the following probability enhancements: S2 by 5%, S3 by 14%, S4 by 10%, S5 by 4%, S6 by 10%, S7 by 4%, S8 by 2%, S9 by 4%, S10 by 5%, S11 by 7%, S12 by 7%, S13 by 17%, S14 by 9%, and S15 by 2%.

Conversely, S1 shows a negative effect coefficient of 0.08, indicating that a one-unit decrease in S1 score increases the probability of diminished ecological well-being by 8%. Parallel negative impacts are observed for other indicators: S2 by 7%, S3 by 7%, S4 by 7%, S5 by 7%, S6 by 7%, S7 by 8%, S8 by 7%, S9 by 8%, S10 by 7%, S11 by 8%, S12 by 8%, S13 by 8%, S14 by 7%, and S15 by 8%.

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp (B)
Step 1[a]	S1			.000	2	.000	
	S1(1)	5.21	7265.180	.000	1	.000	1.08
	S1(2)	-.190	6978.661	.000	1	.000	.083
	S2			.000	2	.000	
	S2(1)	5.04	7004.940	.000	1	.000	1.05
	S2(2)	-.392	7152.967	.000	1	.000	.068
	S3			.000	2	.000	
	S3(1)	4.74	6905.221	.000	1	.000	1.14
	S3(2)	-.417	7076.296	.000	1	.000	.066
	S4			.000	2	.000	
	S4(1)	5.30	6658.535	.000	1	.000	1.10
	S4(2)	-.405	6972.522	.000	1	.000	.067
	S5			.000	2	.000	
	S5(1)	4.64	6649.541	.000	1	.000	1.04
	S5(2)	-.373	7078.405	.000	1	.000	.069
	S6			.000	2	.000	
	S6(1)	5.30	6621.068	.000	1	.000	1.10
	S6(2)	-.431	7048.775	.000	1	.000	.065
	S7			.000	2	.000	
	S7(1)	4.94	7256.841	.000	1	.000	1.04
	S7(2)	-.292	6873.865	.000	1	.000	.075
	S8			.000	2	.000	
	S8(1)	4.51	6816.836	.000	1	.000	1.02
	S8(2)	-.422	7335.907	.000	1	.000	.066
	S9			.000	2	.000	
	S9(1)	4.95	6866.338	.000	1	.000	1.04
	S9(2)	-.265	6805.492	.000	1	.000	.077
	S10			.000	2	.000	
	S10(1)	5.32	6827.101	.000	1	.000	1.05
	S10(2)	-.319	7345.664	.000	1	.000	.073
	S11			.000	2	.000	
	S11(1)	4.22	6415.367	.000	1	.000	1.07
	S11(2)	-.198	7111.446	.000	1	.000	.082
	S12			.000	2	.000	
	S12(1)	5.12	6943.605	.000	1	.000	1.07
	S12(2)	-.268	7012.688	.000	1	.000	.076
	S13			.000	2	.000	
	S13(1)	5.38	6974.793	.000	1	.000	1.17
	S13(2)	-.265	6846.668	.000	1	.000	.077
	S14			.000	2	.000	
	S14(1)	4.45	6805.304	.000	1	.000	1.09
	S14(2)	-.350	7016.707	.000	1	.000	.070
	S15			.000	2	.000	
	S15(1)	5.38	6754.476	.000	1	.000	1.02
	S15(2)	-.291	6992.993	.000	1	.000	.075
	Constant	-18.8	16349.331	.000	1	.000	.000

a. Variable(s) entered on step 1: S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14, S15.

Figure 5. Variable coefficients and significance tests

5. Research Conclusions and Policy Recommendations

This study conducted questionnaire surveys among Hefei residents to evaluate the ecological well-being impacts of low-carbon energy transition. Through logistic regression analysis of 15 selected indicators, the research reveals substantial effects of low-carbon energy transition on residents' ecological well-being. The assessment framework incorporates three primary dimensions - environmental well-being, social well-being, and economic well-being - operationalized through 15 secondary indicators: S1 pollution reduction, S2 renewable energy proportion, S3 environmental regulation, S4 ecological restoration, S5 environmental education, S6 environmental risk management, S7 public participation, S8 energy poverty alleviation, S9 ecological equity, S10 community benefits, S11 green innovation, S12 eco-compensation mechanisms, S13 eco-tourism, S14 green investment, and S15 eco-economic growth.

Key findings emerge from the analysis: First, among the 15 indicators, eight (S1, S3, S4, S6, S11, S12, S13, S14) demonstrate particularly significant positive impacts on ecological well-being compared to others. These indicators primarily relate to environmental and economic well-being dimensions, underscoring the crucial roles of environmental quality and economic development in enhancing residents' ecological well-being. The relatively weaker influence of social well-being indicators suggests limited public engagement in energy decision-making and insufficient social dimension integration in energy policies, highlighting the need for improved policy communication and public outreach.

Second, decreases across all 15 indicators show notable negative impacts on ecological well-being. This finding necessitates comprehensive implementation of all indicators while prioritizing enhancement of the eight most influential ones. The results suggest that low-carbon energy transition policies should strategically balance primary and secondary aspects - focusing on environmental and economic policies as core priorities while recognizing their synergistic relationships with social policies. Such an integrated approach would maximize policy effectiveness across different dimensions.

In summary, the green and low-carbon energy transition centered on residents' ecological well-being transcends mere environmental quality improvement, fundamentally representing an exploration of balanced synergies among environmental, social, and economic dimensions. Prioritizing ecological well-being enhancement directly addresses residents' growing aspirations for better living standards and fulfills public expectations. Consequently, energy transition policies must be systematically implemented across environmental, social, and economic domains through coordinated development of energy-environmental, energy-social, and energy-economic policy frameworks. Ultimately, this well-being-oriented energy transition constitutes not merely an inevitable response to global climate challenges and environmental degradation, but also a critical pathway for building social harmony and advancing economic transformation. Only through balanced and synergistic development across all three dimensions can resident well-being be fundamentally elevated and comprehensive green sustainable development achieved.

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Disclosure statement

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