9h AIEE Energy Symposium

The Impact of New Energy Base Construction in China's Desert, Gobi, and Decertified (Shagehuang) Areas on Soil Organic Carbon

Presenter: DONG Hanmin, Central China Normal University

November 21, 2025

Table of Contents

Research Background and Significance

Practical Background

- **Global Climate Governance: Post-COP29, carbon neutrality and ecological resilience have become core agendas, with negative emission pathways gaining increasing attention.**
- **National Strategy: Under China's "dual carbon" goals, new energy base construction in Shagehuang areas has emerged as a key layout for energy transition.**
- **Ecological Challenges: Shagehuang areas are characterized by poor soil quality, low SOC storage, and fragile ecosystems, where engineering construction may cause soil disturbance.**

Research Background and Significance

Research Significance

- **Theoretical Significance: Fills the research gap between new energy infrastructure and soil carbon cycles in arid regions, expanding the application scenarios of nature-based solutions (NbS).**
- **Practical Significance: Provides empirical support for the coordinated "ecology-energy" development of new energy bases in Shagehuang areas, facilitating the optimization of climate policies.**

Theoretical Framework and Research Hypotheses

Core Theoretical Basis

- **Ecological Functions of Soil Organic Carbon (SOC): As the largest terrestrial carbon pool, SOC affects soil fertility, erosion resistance, and climate regulation.**
- **Ecological Effects of New Energy Infrastructure: Acts on SOC through pathways such as land use change, vegetation restoration, and hydrological regulation.**

Theoretical Framework and Research Hypotheses

Mechanisms and Research Hypotheses

- **Mechanism 1: Vegetation Cover Change (vegetation restoration under photovoltaic panels/vegetation destruction due to engineering land occupation) → Affects organic carbon input.**
- **Mechanism 2: Microclimate Regulation (shading and moisture preservation by photovoltaic panels/wind disturbance from wind power) → Alters soil temperature, humidity, and microbial activity.**
- **Mechanism 3: Soil Disturbance (construction activities/ecological restoration projects) → Influences SOC stability and accumulation efficiency.**
- **Research Hypothesis: The impact of new energy base construction in Shagehuang areas on SOC exhibits dual effects, with the final net effect determined by construction modes and ecological restoration measures.**

Research Design

Sample Selection

- **Panel data of 30+ counties/cities in Shagehuang concentrated areas (e.g., Inner Mongolia, Gansu, Qinghai) from 2010 to 2023.**
- **Treatment group: Regions with new energy base construction (photovoltaic/wind power) approved by the state.**
- **Control group: Regions with similar natural and socio-economic conditions but no new energy base construction.**
- **Data processing: Address missing values using the non-linear predictive mean matching method; log-transform continuous variables to mitigate heteroskedasticity.**

Research Design

Variable Definition

Variable Type	Variable Name	Definition & Measurement
Dependent Variable	Soil Organic Carbon (SOC)	Surface soil organic carbon concentration (g/m^2)
Independent Variable	New Energy Base Construction (NEB)	Dummy variable: 1 if the region launches new energy base construction in year t, 0 otherwise
Control Variables	Economic Development (GDP)	Per capita GDP (logarithmized)
	Population Density (POP)	Population per unit area (logarithmized)
	Water Resources (WAT)	Total regional water resources (logarithmized)
	Industrial Structure (IND)	Proportion of secondary industry (%)

Research Design

Empirical Model

- Adopts the multi-period Difference-in-Differences (DID) method to identify causal effects, leveraging the staggered construction of new energy bases as a quasi-natural experiment:

$$SOC_{i,t+1} = \alpha + \theta * NEB_{i,t} + \beta * X_{i,t} + f_i + f_t + \varepsilon_{i,t}$$

- Notes: i = region, t = year; $X_{i,t}$ = control variable vector; f_i = region-fixed effects; f_t = year-fixed effects; $\varepsilon_{i,t}$ = random error term; θ = core coefficient reflecting the net effect of new energy base construction on SOC.

Empirical Results and Analysis

Benchmark Regression Results

- The coefficient of *NEB* is significantly positive, indicating that new energy base construction significantly promotes SOC accumulation in Shagehuang areas.

Robustness Tests

- Parallel Trend Test: Pre-treatment trends of the treatment and control groups are not significantly different, satisfying the DID basic assumption.
- Placebo Test: Randomly assign treatment status 1000 times; the simulated coefficient distribution is concentrated around 0, and the true coefficient is outside the distribution, confirming the robustness of the results.
- Alternative Measurement: Replace SOC with soil organic carbon density (kg/m^3) as the dependent variable; the core coefficient remains significantly positive.

Empirical Results and Analysis

Mechanism Analysis

- **Vegetation Coverage (NDVI): New energy base construction promotes SOC by improving vegetation coverage (e.g., photovoltaic panel shading facilitates vegetation growth).**
- **Soil Moisture (SM): Enhanced soil moisture under photovoltaic panels optimizes SOC storage conditions.**
- **Microbial Activity (MA): Improved microclimate increases microbial activity, accelerating organic carbon decomposition and accumulation.**

Heterogeneity Discussion

Geographic and Climatic Heterogeneity

- **Aridity Index: The promoting effect of new energy bases on SOC is more significant in areas with moderate aridity, while the effect is weak in extremely arid areas.**
- **Topography: Flat areas benefit more from vegetation restoration.**

Construction and Restoration Heterogeneity

- **Restoration Intensity: Regions with high ecological restoration investment have a SOC increase, significantly higher than that of low-investment regions.**
- **Infrastructure Type: Photovoltaic bases have a more significant positive effect on SOC compared to wind power bases, due to better vegetation restoration under photovoltaic panels.**

Heterogeneity Discussion

Socio-Economic Heterogeneity

- **Fiscal Capacity: Regions with strong fiscal capacity show a higher coefficient of 0.459, as sufficient funds support high-standard ecological restoration.**
- **Policy Support: Areas covered by national ecological protection policies have a higher SOC promotion effect than non-covered areas.**

Research Conclusions and Policy Implications

Main Conclusions

- **New energy base construction in Shagehuang areas significantly promotes SOC accumulation, with an average increase of 0.386 units in SOC levels.**
- **Key mechanisms include vegetation coverage improvement, soil moisture regulation, and enhanced microbial activity.**
- **The effect is heterogeneous: more pronounced in moderately arid, flat areas with strong fiscal capacity and high restoration intensity.**

Research Conclusions and Policy Implications

Policy Implications

- **Optimize Construction Modes: Promote the "photovoltaic + vegetation restoration" model, select drought-tolerant native plants for under-panel planting.**
- **Strengthen Ecological Investment: Allocate no less than 5% of new energy project revenue to ecological restoration, focusing on soil improvement and water conservation.**
- **Differentiated Policies: Formulate targeted measures based on aridity, topography, and fiscal capacity; prioritize ecological restoration in extremely arid areas.**
- **Establish Long-term Monitoring: Build a SOC dynamic monitoring network combining remote sensing and field sampling to track ecological effects.**

Research Limitations and Future Prospects

Limitations

- Data constraints: Lack of fine-scale data at the plot level, ignoring micro-scale SOC dynamics.
- Time horizon: Focuses on short-to-medium-term impacts (3-5 years), with long-term ecological feedbacks underexplored.

Future Prospects

- Expand research scope: Incorporate cross-border spillover effects of new energy bases on SOC.
- Deepen mechanism analysis: Explore the interaction between soil microorganisms, vegetation types, and SOC accumulation.
- Integrate economic evaluations: Quantify the economic value of SOC sequestration benefits from new energy bases.

9h AIEE Energy Symposium

Q & A

Thank you for your attention!

Presenter: DONG Hanmin, Central China Normal University

November 21, 2025