

Research on the Transformation and Development of Natural Gas Resource-Based Cities Under the Dual Carbon Background: A Case Study of Dazhou City, Sichuan Province

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ABSTRACT

With global climate change and the proposal of the "Dual Carbon Goals," promoting a low-carbon economy and green transformation has become a critical agenda for nations worldwide. As one of China's significant natural gas resource bases, Dazhou City in Sichuan Province boasts abundant natural gas reserves, particularly the Puguang Gas Field, whose substantial energy potential has driven rapid local economic growth. However, the over-reliance on resource extraction has led to the "resource curse," severely constraining the diversification and sustainable development of Dazhou's economic structure. Against the backdrop of the "Dual Carbon" policy, balancing natural gas resource exploitation with green, low-carbon transformation has become an urgent challenge for local governments. This study analyzes the current economic development status of Dazhou City and the challenges faced by resource-based cities, exploring pathways for green transformation under the guidance of the "Dual Carbon" goals. First, the research employs a literature review method to revisit the "resource curse" theory, examining issues such as ecological pressure and economic structural imbalances in resource-based cities. Second, drawing on successful domestic and international case studies, it proposes strategies for Dazhou to overcome the resource curse, including industrial diversification, green technology innovation, and low-carbon policy support. Finally, the study summarizes the difficulties and bottlenecks encountered during Dazhou's green and low-carbon transformation and provides corresponding policy recommendations.

KEYWORDS

Resource curse; Natural gas; Dual carbon; Dazhou city

1 Introduction

As global climate change intensifies, reducing carbon emissions and achieving a green, low-carbon transition have become global imperatives. In September 2020, China announced its "Dual Carbon" goals at the 75th United Nations General Assembly, pledging to peak carbon dioxide emissions by 2030 and achieve carbon neutrality by 2060. This commitment underscores China's heightened responsibility in global climate governance and sets a clear direction for domestic energy restructuring and economic transformation.

China is currently the world's largest energy consumer, with coal accounting for 56.8% of its energy consumption in 2020. It is also the largest carbon emitter, contributing approximately one-third of global carbon emissions in the same year. In recent years, the country has vigorously promoted clean energy, accelerating the exploration and development of natural gas. By 2020, China's natural gas production reached 192.5 billion cubic meters, with consumption hitting 328 billion cubic meters. Under the "Dual Carbon" framework, natural gas, as a cleaner fossil fuel, is poised to play a pivotal role in the energy transition, serving as a bridge from high-carbon to renewable energy sources.

For cities dominated by resource extraction, ensuring energy supply and stable economic growth while advancing low-carbon transformation has become a pressing task. Located in eastern Sichuan Province at the intersection of the "Belt and Road" and the Yangtze River Economic Belt, Dazhou City is one of China's key natural gas production hubs. The Puguang Gas Field, one of the world's largest shale gas fields, is situated within its jurisdiction. In recent years, Dazhou's economy has become heavily reliant on the energy sector, particularly natural gas extraction and utilization. While resource-driven growth has delivered short-term economic benefits, it has also resulted in a monolithic industrial structure and a lack of diversification^[1].

Guided by the "Dual Carbon" goals, green and low-carbon industries, technologies, and urban management have emerged as core pathways for the sustainable transformation of resource-based cities. For Dazhou, the critical challenge lies in ensuring energy security while actively promoting green industries and technologies to gradually reduce dependence on natural gas. By exploring green and low-carbon development strategies, Dazhou has the potential to achieve high-quality economic growth and serve as a valuable model for other resource-based cities in China.

2 Theoretical foundations

2.1 The resource curse hypothesis

The "resource curse" has long been a focal point in development economics. It refers to the phenomenon where

countries or regions rich in natural resources (e.g., minerals, energy) often experience sluggish economic growth, social inequality, and environmental degradation ^[2]. Since the 1990s, scholars have observed that resource-abundant nations or regions tend to grow more slowly than their resource-scarce counterparts, giving rise to the concept of the resource curse ^[3].

Research indicates that the transmission mechanisms of the resource curse include the "Dutch Disease" effect, crowding-out effects, and institutional weakening effects. The "Dutch Disease" describes how a sudden boom in natural resources (e.g., oil, gas, minerals) can lead to the decline of other economic sectors (e.g., manufacturing, agriculture) ^[4-5]. Crowding-out effects manifest when governments prioritize resource industries, diverting investments away from education, research, and innovation ^[6]. Institutional weakening effects arise from flawed governance systems, inadequate regulations, and other institutional factors, leading to unsustainable resource exploitation, inefficiency, corruption, inequality, environmental degradation, and even regional conflicts ^[7-8].

2.2 Resource-based cities

In 2013, China's State Council defined resource-based cities in the *National Sustainable Development Plan for Resource-Based Cities (2013-2020) as "cities where the extraction and processing of local minerals, forests, and other natural resources dominate the economy." These cities are classified into four types: growing, mature, declining, and regenerating. Dazhou City is categorized as a mature resource-based city, alongside cities like Daqing and Dongying.

3 Literature review

The "resource curse" has been extensively studied in development economics, with scholars examining its formation mechanisms, impact pathways, and mitigation strategies. Sachs and Warner (1995) introduced the concept, noting that resource-rich countries generally grow more slowly than resource-poor ones ^[2]. Corden and Neary (1982) developed the "Dutch Disease" model to explain economic structural imbalances ^[4]. Ross (1999) and Collier & Hoeffler (2005) explored how resource revenues fuel corruption, rent-seeking, and social conflict ^[9-10]. Mehlum et al. (2006) highlighted how nations like Norway and Botswana avoided the curse through robust institutional design ^[11]. Recent studies have expanded into environmental issues (Badeeb et al., 2017) ^[12], and low-carbon transition challenges ^[13] (2021), emphasizing the role of institutions, economic diversification, and digital technologies in mitigation.

Recent domestic research on the "resource curse" can be broadly categorized into two main streams. One line of inquiry investigates whether the resource curse actually exists in specific regions. For example, Hao Xiaowei et al. (2022), using a spatial regression discontinuity design, find that the resource curse not only exists at the county level in China but also exerts a significant "crowding-out effect" on educational investment ^[14]. The second stream focuses on whether green strategies under the dual carbon goals—such as green economy development, green performance evaluations, and environmental regulations—can mitigate or prevent the occurrence of the resource curse. For instance, Ren Shenggang et al. (2024) used city-level panel data to demonstrate that green assessment policies reduce resource dependence and promote cleaner industries ^[15]. Xu Xuan et al. (2024) analyzed how green finance alleviates the curse by fostering technological innovation and industrial upgrading ^[16]. Zhenjing Gu et al. (2025) found that carbon emission reductions significantly boost non-resource economic growth ^[17]. Additionally, Lin Boqiang (2019) and Guo Jiatang & Luo Pinliang (2020) provided empirical support for resource-based city transitions by examining the impact of natural gas abundance on emissions and the role of digital technologies in reducing carbon intensity ^[18-19].

While studies on natural gas and national development under the "Dual Carbon" framework are abundant, research on tailored strategies for gas-rich cities—especially at the prefectural level—remains limited. This paper addresses this gap by focusing on Dazhou City as a case study, exploring how natural gas resource-based cities can overcome the resource curse and achieve green transformation under the "Dual Carbon" goals.

4 Analysis of the resource curse in Dazhou

Dazhou City, located in southwestern China, is a prominent resource-based city in Sichuan Province, renowned for its natural gas reserves. With a prospective natural gas reserve of 3.86 trillion cubic meters (13% of China's total) and an annual sulfur output accounting for 40% of the national total, Dazhou serves as a critical hub for the "West-East Gas Pipeline" project. While resource development has spurred infrastructure and economic activity, it has also entrenched the city in a resource-dependent growth model.

As a typical resource-based city, Dazhou faces challenges such as high resource dependence, a monolithic industrial structure, and sluggish industrial transformation. Despite its resource wealth, economic benefits often flow outward, leaving local per capita income below provincial averages. The dominance of state-owned enterprises in resource extraction has weakened local control over industrial chains, hindering the development of high-value-added industries. Under the "Dual Carbon" goals, Dazhou must urgently transition from resource dependency to green, diversified

development. Overcoming the resource curse while balancing ecological protection and economic growth has become its core challenge.

4.1 Economic volatility and resource dependence

Since the development of the Puguang Gas Field in 2006, Dazhou's secondary sector—particularly energy-related industries—experienced rapid growth. However, this growth has been highly susceptible to fluctuations in natural gas prices. From 2009 to 2014, the secondary sector drove GDP expansion, but after 2014, declining global oil and gas prices led to a sharp contraction. Data from the Dazhou Bureau of Statistics show that from 2014 to 2016, the revenue of large-scale natural gas and chemical industries fell by 17.8% annually, while profits plummeted by 62.3%. The gas extraction sector alone swung from a profit of 6.7 billion yuan to a loss of 318 million yuan, dragging down overall GDP. This volatility underscores the fragility of resource-dependent economies and their vulnerability to external shocks.

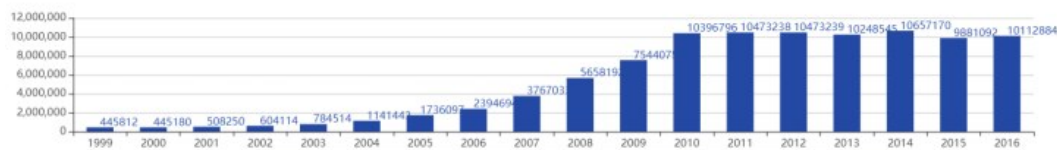


Figure 1 Total output value of industries above designated size in Dazhou over the years

(from:China City Statistical Yearbook)

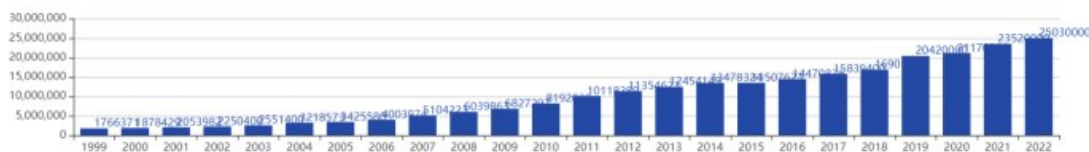


Figure 2 Gross domestic product (GDP) of Dazhou over the years

(from:China City Statistical Yearbook)

4.2 Monolithic industrial structure and lack of high-end industries

Industrial monoculture is a hallmark of the resource curse. Dazhou's economy has long relied on resource extraction and primary energy processing. Although the tertiary sector's share has risen slightly, high-value-added and technology-intensive industries remain underdeveloped. From 2009 to 2016, Dazhou maintained a "secondary-tertiary-primary" industrial structure, with the secondary sector heavily tied to natural gas.

Downstream industrial extensions are notably weak. Despite a foundational chemical industry, advanced sectors like fine chemicals, hydrogen energy, and material recycling have yet to scale. Most natural gas is exported as primary products, with profits accruing to state-owned enterprises rather than local economies. Meanwhile, emerging industries like digital manufacturing lag, leaving the city without a diversified industrial ecosystem to mitigate structural risks.

4.3 Fiscal dependence and misallocated public investment

Resource-based economies often fall into "rentier dependency," and Dazhou is no exception.

First, resource tax revenues are disproportionately low. Despite a statutory natural gas resource tax rate of 5%–10%, major corporations like CNPC and Sinopec pay reduced rates (4.43% and 3%, respectively) due to sulfur content claims. Additionally, joint ventures operating under outdated contracts have deprived Dazhou of over 14 billion yuan in tax revenues. Sulfur, a byproduct of gas extraction, is excluded from taxation despite Dazhou producing nearly half of China's output.

Second, local governments cannot share in corporate income taxes. Central state-owned enterprises like CNPC and Sinopec register subsidiaries outside Dazhou, diverting tax revenues to other jurisdictions. This fiscal leakage exacerbates regional inequities.

Moreover, fiscal expenditures prioritize infrastructure over public services, R&D, and green innovation, perpetuating a "fiscal-industrial lock-in" that stifles local innovation and human capital development—a deep-seated institutional manifestation of the resource curse.

4.4 Lagging innovation and brain drain

Resource-based cities often underinvest in innovation. In Dazhou, technological advancements are concentrated in state-owned enterprises, with local firms contributing less than 15% to core R&D. Public data show that Dazhou's R&D spending as a percentage of GDP lags behind national averages, and metrics like high-tech firm counts and patent

outputs rank low in Sichuan Province.

Compounding this issue, Dazhou struggles to attract and retain talent. Weak urban appeal, limited industrial diversity, and inadequate amenities have led to a "brain drain," reinforcing a vicious cycle of "resource dependency → industrial monoculture → innovation stagnation → talent exodus."

4.5 Ecological pressures and "dual carbon" constraints

Although natural gas is cleaner than coal, its extraction still poses environmental risks. The Puguang Gas Field, situated in an ecologically fragile zone, faces challenges like water pollution, soil degradation, and gas leaks. Hydraulic fracturing for shale gas exacerbates water scarcity concerns.

While Dazhou has initiated ecological restoration projects, progress remains uneven. With carbon accounting systems underdeveloped and carbon asset management nascent, local governments face dual pressures in meeting "Dual Carbon" targets.

5 Opportunities, challenges, and transition strategies for dazhou under the dual carbon goals

The launch of the "Dual Carbon" strategy has raised new development requirements for cities traditionally driven by resource exploitation. As the region with the highest concentration of natural gas resources in Sichuan Province, Dazhou has long relied on energy extraction and primary processing as its main growth path. However, under the guidance of carbon peaking and carbon neutrality goals, the conventional high-carbon, resource-dependent development model has become unsustainable.

The challenges Dazhou faces are multifaceted, including mounting carbon emission pressures, the urgent need to optimize its energy structure, weak support for green industries, and a mismatch between its fiscal capacity and innovation mechanisms.

At the same time, Dazhou is presented with significant strategic opportunities. As a relatively clean transitional energy source, natural gas still has development potential in the ongoing energy transition. Moreover, numerous national and provincial policy documents support resource-based cities in exploring low-carbon transformation pathways, providing Dazhou with a favorable policy window for energy upgrading, industrial diversification, and institutional innovation.

If Dazhou can leverage the urgency brought by the dual carbon targets and activate its green development potential, it could achieve a strategic leap from a resource-dependent to a green-driven city. Based on the current policy context and development trends, this paper proposes a "green energy – industrial upgrading – institutional support" trinity transition pathway for Dazhou, aiming to provide a practical model and theoretical reference for green development in resource-based cities.

5.1 Clean energy transition: leveraging natural gas to build a diversified low-carbon energy system

In the context of the dual carbon goals, the clean transition of the energy structure forms the core foundation for transforming resource-based cities. Dazhou should fully leverage the "bridging" role of its natural gas resources and promote the evolution of its energy system toward a cleaner and more diversified structure.

First, it should deepen the synergy between natural gas and renewable energies such as hydrogen, solar, and wind power, forming an integrated system of "natural gas + renewable energy + digital energy" to enhance system resilience and carbon reduction capacity. Relying on the Puguang gas field, Dazhou could extend the value chain into natural gas-based fine chemicals and hydrogen energy technologies, thereby building a clean energy integration demonstration zone in northeastern Sichuan.

The Implementation Plan for High-Quality Energy Development (2022–2025) in Dazhou has explicitly supported the complementary development of natural gas and renewables, with the potential to achieve real-time optimization of energy supply and demand through technologies such as smart grids and green heating networks.

Additionally, the city should advance clean end-use transitions in natural gas consumption by promoting projects such as "coal-to-gas" and "coal-to-electricity" conversions to enhance green energy usage in both urban and rural areas. It should also explore carbon-rights bundling mechanisms in natural gas development to integrate energy exploitation with carbon asset management.

5.2 Green industrial transition: building a diversified industrial structure to enhance resilience and value-added capabilities

Optimizing and upgrading the industrial structure is essential for resource-based cities to reduce their dependence on resources and enhance endogenous economic growth. Dazhou should adopt a green industrial orientation, promoting low-carbon transformation of traditional industries, high-end development of emerging industries, and diversification of the overall industrial system. First, the city should push for the low-carbon transformation of traditional industries such as

natural gas chemicals by implementing energy-saving retrofits, clean energy substitution, and waste recycling, thereby improving overall energy efficiency and green performance. For instance, Fuling District in Chongqing has guided the co-development of environmental equipment manufacturing along its shale gas industrial chain, demonstrating the feasibility of green extension in traditional energy sectors. Second, Dazhou should accelerate the development of green emerging industries such as lithium batteries, hydrogen energy, new materials, and digital manufacturing to enhance the technological content and value-added level of its industrial system.

The city has already made progress with projects like the "SVOLT Zero-Carbon Industrial Park" and the Shuguang Advanced Computing Center, which indicate an emerging integration of green manufacturing and the digital economy. Industrial policies should further guide the clustering of green industries. Additionally, mechanisms for green SME incubation should be improved, using fiscal incentives, green financing, and technical support to stimulate local innovation and entrepreneurship, and to foster a diversified industrial ecosystem.

5.3 Institutional synergy: advancing policy innovation and realigning incentive mechanisms to strengthen governance foundations

The outflow of fiscal revenues has become a major barrier to the sustainable development of resource-based cities. In Dazhou, the public has limited participation and benefit-sharing in resource development, while environmental degradation, talent outmigration, and educational shortcomings have further weakened the city's internal development capacity. Green and low-carbon transformation is not only a matter of technological innovation but also one of institutional restructuring. Dazhou should promote institutional innovation to strengthen policy coordination, resource benefit-sharing, and environmental governance capacity, thereby establishing a sustainable development framework. In terms of resource revenue distribution, Dazhou faces a structural dilemma in which central state-owned enterprises dominate while local governments gain limited benefits. To address this, the city signed an agreement with Sinopec requiring that 15% of any new investment be allocated to local new energy projects, thereby encouraging local processing, value addition, and resource conversion. Dazhou could further draw on international cases, such as Groningen in the Netherlands, which adopted a "carbon budgeting" and local fiscal compensation mechanism after phasing out natural gas. The city should institutionalize and normalize central-local coordination and improve the "central-local cooperation + local retention" mechanism to increase the proportion of natural gas-related taxes and fees retained locally. A green transition fund should be established, dedicated to green infrastructure and ecological restoration. At the same time, Dazhou should explore a coordinated mechanism of "resources + carbon rights + finance" by developing a local carbon trading market and carbon asset management system, thereby enhancing fiscal autonomy and development momentum. In terms of policy incentives, Dazhou has introduced policies such as Measures to Support High-Quality Industrial Development and the Three-Year Action Plan for Private Economic Development, offering fiscal incentives for green manufacturing demonstration enterprises, newly designated industrial firms, and publicly listed companies.

For instance, Daqing has established a corporate carbon ledger system to support emissions monitoring and auditing, and created a green industry fund to direct financial resources toward green SMEs, offering credit facilitation, tax incentives, and green certification support. These measures have effectively stimulated green transformation in local private economies.

Dazhou has implemented targeted policies for private sector support, including a RMB 300 million emergency loan fund and no less than RMB 200 million annually for technological upgrades in private enterprises. The goal is to increase the private sector's contribution to GDP to 65% by 2025. Additionally, newly scaled industrial enterprises are eligible for subsidies ranging from RMB 100,000 to 150,000, and listed companies may receive up to RMB 1.5 million. These policies help attract social capital and boost market vitality during the green transition. The city should continue strengthening its support for the green private economy through mechanisms like refinancing funds, tech subsidies, and green certification rewards to lower barriers and enhance vitality.

For environmental governance, Dazhou should establish a system based on digital monitoring, full-process evaluation, and high-entry thresholds, shifting from static supervision to dynamic governance. It should accelerate the development of digital infrastructure such as carbon data centers and online emission monitoring platforms to improve the precision and real-time nature of environmental governance.

For example, Yulin's Carbon Data Center has integrated energy consumption statistics and carbon accounting systems, offering a smart model for resource-based environmental governance. On this basis, Dazhou could further develop systems like "ecological ledgers" and "carbon footprint management" to enhance the precision, intelligence, and public participation in environmental governance.

6 Conclusion

Under the "dual carbon" strategy, resource-based cities must urgently reduce their reliance on natural resources and

embrace a green, low-carbon development trajectory. Using Dazhou as a case study, this paper systematically analyzes the mechanisms by which the resource curse manifests under the dual carbon context, and explores strategic pathways for green transformation based on the city's natural gas industry characteristics and economic structure.

The findings suggest that Dazhou has made initial progress in optimizing its industrial structure, upgrading energy systems, and institutional innovation. However, it still faces significant challenges, including limited value chain extension, fiscal leakage, weak innovation capacity, and persistent ecological pressure. To address these challenges, this paper proposes a comprehensive strategy encompassing industrial diversification, central-local revenue coordination, strengthened green governance, enhanced public participation, and talent cultivation—aiming to offer both theoretical insight and practical guidance for Dazhou and other resource-based cities seeking to escape the resource curse and achieve sustainable development.

Looking ahead, as the dual carbon goals continue to evolve, resource-based cities must further strengthen green technological innovation and digital transformation, refine carbon asset management and ecological compensation mechanisms, and build a multi-tiered and diversified green industrial system. Only through coordinated development of economic, ecological, and social benefits can resource-based cities truly break free from the constraints of the resource curse and embark on a new stage of green and high-quality growth.

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