Proceedings of Business and Economic Studies, 2025, Volume 8, Issue 2
http://ojs.bbwpublisher.com/index.php/PBES
Online ISSN: 2209-265X
Print ISSN: 2209-2641

Research on Strategies of Energy Internet to Help Smart City Sustainable Development

Cui Wang*, Rong Zheng, Xin Zhou, Letian Rong

Qingdao City University, Qingdao 266106, Shandong, China

**Author to whom correspondence should be addressed.*

Abstract: Driven by the wave of informatization and intelligence, the smart city has become a new trend of global urban development. The intelligent transformation of energy systems is of great importance to a smart city. The Internet helps the sustainable development of smart cities by optimizing resource allocation, improving utilization efficiency, and promoting market competition. This study analyzes the current situation and problems of energy Internet supporting smart cities and finds that policy environment, technology maturity, market demand, and industrial chain integration have a significant positive impact on its development. Based on this, relevant strategies are proposed to provide theoretical and practical guidance for the integrated development of smart cities and the energy Internet.

Keywords: Energy internet; Smart city; Sustainable development

Online publication: April 28, 2025

1. Introduction

With the acceleration of urbanization and the continuous progress of science and technology, the construction of smart cities has become an important way to improve the comprehensive competitiveness of cities and the quality of life of residents [1]. China has made remarkable achievements in the construction of smart cities, but it also faces many challenges. As an emerging energy system, the energy Internet provides new ideas and methods for the sustainable development of smart cities by optimizing resource allocation and improving utilization efficiency. This paper takes Qingdao as an example to deeply study how the energy Internet can help the development of smart cities [2].

2. Current situation of smart city development

2.1. Foundation of smart city construction

In recent years, China has made remarkable achievements in the construction of smart cities. Taking Qingdao as an example, from 2020 to 2024, huge investments will be made in the fields of smart power grid, smart charging pile, data center, and optical fiber network. Landmark projects such as Haier New Energy Comprehensive Park

and Blue Valley Smart Energy Management Platform will be completed and put into operation, promoting the intelligent and green transformation of the energy system [3]. At the same time, the cross-border integration of intelligent transportation, smart community, industrial manufacturing, and energy Internet has injected new vitality into the construction of smart cities. However, there are also some challenges in the construction of smart cities, such as insufficient talent reserves, cross-departmental collaboration, and information integration problems [4,5].

2.2. Research hypothesis and analysis

This study aims to optimize resource allocation, improve energy utilization efficiency, promote market competition, and promote the sustainable development of smart cities through the energy Internet. Four hypotheses are proposed to explore the impact of policy environment, technology maturity, market demand, and industrial chain integration on the development of smart cities. Hypothesis H1: The policy environment has a significant positive impact on the development of smart cities; Hypothesis H2: Technology maturity has a significant positive impact on smart city development; Hypothesis H3: Market demand has a significant positive impact on the development of smart cities; Hypothesis H4: industrial chain integration has a significant positive impact on the development of smart cities.

The correlation analysis results in **Table 1** show that policy environment, technology maturity, market demand, industrial chain integration and smart city development level are all significant, and the correlation values are 0.420, 0.453, 0.492 and 0.504, respectively, and all are greater than 0, indicating that these four factors are positively correlated with smart city development level.

Table 1. Analysis of correlation results

	Mean value	Standard deviation	Policy environment	Technology readiness	Market demand	Industrial chain integration	Smart city development level
Policy environment	3.818	0.804	1				
Technology readiness	3.847	0.737	0.420**	1			
Market demand	3.806	0.794	0.453**	0.412**	1		
Industrial chain integration	3.798	0.841	0.492**	0.459**	0.519**	1	
Smart city development level	3.782	0.934	0.504**	0.446**	0.498**	0.634**	1

*$P < 0.05$, **$P < 0.01$

The results of regression analysis in **Table 2** show that the standardization coefficients of policy environment and technology maturity are 0.183 and 0.118, respectively, and both are significant at the 0.05 level, indicating that policy guidance and technical support are key elements to promote the development of smart cities. The standardization coefficient of market demand is 0.153, which is also significant at 0.05 level, revealing the promoting effect of market demand on the development of smart cities. The standardization coefficient of industrial chain integration is as high as 0.410 and is significant at the 0.01 level, emphasizing the core position of upstream and downstream cooperation in the industrial chain in promoting the overall development of smart cities.

Table 2. Results of regression analysis (n = 133)

	Nonnormalized coefficient		Coefficient of standardization	t	P	Collinearity diagnosis	
	B	Standard error	Beta			VIF	Tolerance
Constant	-0.023	0.382	-	-0.061	0.951	-	-
Policy environment	0.213	0.090	0.183	2.366	0.019*	1.479	0.676
Technology maturity	0.150	0.095	0.118	1.571	0.021*	1.394	0.717
Market demand	0.180	0.092	0.153	1.956	0.032*	1.518	0.659
Industrial chain integration	0.455	0.091	0.410	5.027	0.000**	1.639	0.610
R^2			0.481				
Adjust R^2			0.465				
F			F (4,128) = 29.656, P = 0.000				
D-W value			1.930				

Note: Dependent variable = smart city development level, *P < 0.05, **P < 0.01

3. Simulation analysis of energy Internet to support smart city development

3.1. Simulation model construction

To further study the supporting role of the energy Internet on the development of smart cities, aiming at the specific impact of "Jiaozhou Bay Second Tunnel Green Energy Supporting Project," the simulation model is built around four key factors: policy environment, technology maturity, market demand, and industrial chain integration. Respectively through the policy effect coefficient (PEC), technology maturity index (TMI), market demand index (MDI), and industry chain integration index (CII) to quantify.

3.2. Simulation results

The simulation results (**Table 3)** showed that with the improvement of technology maturity and market demand, the degree of industrial chain integration has increased year by year, formed a synergy effect, and promoted the improvement of the overall smart city development level (SDL). In the fifth year, the policy effect coefficient (PEC) increased to 0.85, indicating that a policy optimization measure implemented at this time promoted the further improvement of technology maturity, market demand, industrial chain integration, and smart city development level.

Table 3. Simulation results

Time step (year-end)	Policy effect coefficient (PEC)	Technology readiness Index (TMI)	Market demand Index (MDI)	Industrial chain integration index (CII)	Smart city development level (SDL)
Initial (0 years)	0.8	6.5	7.0	6.0	55
1 year	0.8	6.8	7.2	6.2	57
2 years	0.8	7.0	7.4	6.4	59
3 years	0.8	7.2	7.6	6.6	61
4 years	0.8	7.5	7.8	6.8	63
5 years	0.85 (policy optimization)	7.8	8.0	7.0	65

4. Energy Internet to support smart city development strategy

4.1. Created the top-level design of the energy Internet of "interaction + interconnection + interoperability + mutual trust"

First, at the level of environmental policy, we should pay attention to the "interaction and mutual trust mechanism," use big data and AI technology to adjust supply and demand, encourage distributed energy to participate in market trading, introduce carbon trading policies, and promote the application of low-carbon technologies. Secondly, at the technical level, it is necessary to pay attention to the integration of the energy Internet, build an open access system, ensure flexible access and scheduling of energy, promote data interaction between energy Internet and other systems in smart cities, and establish a unified energy big data platform [6]. Moreover, at the market-driven level, it is necessary to create an economic incentive mechanism for interaction, interconnection, interworking, and mutual trust. With interaction as the core, demand-side response should be introduced; Build a two-way interactive platform with interconnection as the link; Leveraging connectivity as a bridge to integrate markets and technologies; and, based on mutual trust, we should coordinate market and regulation [7].

4.2. Formulate industrial policies conducive to technology diffusion

It is recommended that smart cities formulate special energy Internet development policies, including accelerating the construction of information infrastructure such as 5G, big data and the Internet of Things, promoting cross-sector and cross-industry data sharing and innovative applications through data open platforms and standardization, and achieving green and low-carbon development through intelligent transportation and energy management technologies, with a focus on supporting the development of new energy and smart grid technologies. Provide tax breaks, financial subsidies, and other incentives and improve the relevant legal construction, give play to the linkage effect of smart energy demonstration projects, and set up demonstration projects in key areas to drive development in other fields [8,9].

4.3. Increased investment in scientific research and building an energy Internet research platform

Establishing an interdisciplinary mechanism to promote renewable energy, encourage the installation of solar energy equipment, and establish a green electricity trading mechanism. Accelerate smart transportation, promote electric vehicles, formulate green building standards, and build urban management platforms using big data and the Internet of Things. Participation in the construction of smart cities and green energy will be encouraged through policy incentives. We will strengthen industry-university-research cooperation, establish joint research and development institutions, focus on key technologies, and promote technological innovation and application [10]. We will enhance the transformation of scientific research results, support enterprises in validating technologies, promote the implementation of innovative projects, and help smart cities develop rapidly in the field of energy technology.

4.4. Stimulating market demand and promoting technology commercialization

Using big data and artificial intelligence to improve the efficiency of urban management, and enhance the public's understanding of smart management through open data and citizen interaction to stimulate the demand for related technologies; To promote the application of energy saving and renewable energy technologies through cooperation with enterprises to achieve optimal allocation of power resources; Build a series of demonstration projects to promote the application of energy-saving technologies in construction, transportation and other fields, and enhance market awareness of smart energy management through data sharing; Demonstrate the application of energy-efficient technologies, and promote the market demand for energy-efficient technologies by raising public awareness of green buildings and smart energy through publicity and education activities [11].

4.5. Promoting the integration technology of regional energy Internet and wide area Internet at the technical level

Promoting the seamless connection of renewable energy such as wind energy and solar energy with the power grid, and use smart grid technology to achieve dynamic management and distribution of new energy to ensure stable access and supply of energy; The integration of regional Internet and energy saving services to improve energy efficiency services, can be integrated through the intelligent dispatch platform, regional Internet and energy saving services to promote energy efficiency management of buildings and parks; Specific practices through data collection and intelligent analysis, real-time monitoring of energy consumption, and combined with artificial intelligence technology to optimize energy conservation strategies, so as to reduce energy consumption, help achieve the "double carbon" goal; Focus on the development of unified technical standards and protocols, through standardization to improve the interoperability between different energy systems, to ensure the stability and compatibility of technology applications [12,13].

4.6. Ensuring information security and data security, it is recommended to reserve professionals with new quality productivity at the management level

Establishing a comprehensive information security management system and formulate data privacy protection policies; Encourage enterprises to cooperate with colleges and universities to carry out internship and practical projects, so that students can practice their practical ability in real projects and cultivate their innovative thinking and problem-solving ability; Regularly collect and update talent information, and formulate talent introduction policies to attract talents with cutting-edge technological backgrounds and new quality and productivity-oriented talents, to ensure competitiveness in a rapidly developing technological environment [14].

4.7. Promoting industrial integration and cross-border cooperation

First, deepen the integration of energy and the industrial Internet. Research shows that industrial chain integration is crucial to the development of smart cities. It is necessary to strengthen industrial chain coordination, ensure system compatibility and mutual operation, establish a standardized technical environment, and promote the rapid application of technical standards. For example, a green manufacturing evaluation system should be formulated to encourage enterprises to save energy and reduce emissions, and energy consumption emissions should be monitored through industrial Internet platforms to provide data support for government regulation [15]. Secondly, expand the cross-border application of the energy Internet. We will establish a cross-industry technical standard system, focusing on smart transportation, construction, and medical care. In transportation, an energy management system will be built to monitor and dispatch energy. In the building sector, an energy efficiency management platform will be built to promote energy-saving renovation and green buildings. In the medical sector, developing customized energy solutions to achieve efficient utilization and cost savings.

5. Conclusion

In the era of information technology and intelligence, the integrated development of energy Internet and smart city is of great significance. This paper reveals the key role of policy environment, technology maturity, market demand, and industrial chain integration in the development of smart cities through the analysis of the current situation of smart cities, hypothesis verification, and simulation. From creating top-level design to formulating industrial policies, from strengthening scientific research input to stimulating market demand, from technology integration to management guarantee, and then to promoting industrial integration. These strategies aim to guide the coordinated development of smart cities and the energy Internet. In the future, with the gradual implementation and improvement of various

strategies, it is expected to accelerate the application of the energy Internet in smart cities, build a more intelligent, green, and efficient urban ecosystem, and enhance the sustainable development capacity of cities.

Funding

Research and Innovation Team Building Project of Qingdao City University (QCU23TDKJ01)

Disclosure statement

The authors declare no conflict of interest.

References

[1] Ding Y, Wang H, Liu M, 2021, Overview of IoT based Smart City Energy Management Technologies. Proceedings of the CSEE, 41(10): 2625–2637.

[2] Zhao Y, Liu Y, Zhang X, et al., 2023, Intelligent energy Management System for Renewable Energy based on Internet of Things. IEEE Transactions on Industrial Information, 19(2): 1234–1245.

[3] Zhang L, Xu W, Jiang C, 2021, Research on Supply-demand Side Collaborative Optimization Control Method of Smart City Power System based on Big Data. Transactions of China Electrotechnical Society, 36(3): 1053–1062.

[4] Wang H, Li M, Zhang Q, et al., 2023, Integrating Renewable Energy into the Grid Using Smart Grid Technologies: A Case Study of Aliso Canyon. Renewable Energy, 150: 789–798.

[5] Liu X, Zhang Y, Wang L, et al., 2023, Smart Grid Integration of Renewable Energy Sources: A Comprehensive Review and Future Trends. Renewable and Sustainable Energy Review, 78: 123–134.

[6] Gao B, Li Z, Wang B, et al., 2022, Research on Smart City Construction based on Ubiquitous Electric Power Internet of Things Technology. Science and Technology Innovation and Application, 12(34): 20–23.

[7] Wang J, 2021, Stimulating New Kinetic Energy of Data Elements to Drive the Transformation and Development of Energy and Electric Power. Software and Integrated Circuits, (05): 30–31.

[8] Dong A, Ni S, Cao M, 2019, Building Energy Internet to Help Smart City Development. People's Mind, (07): 64.

[9] Qu R, Wan Z, Wen J, et al., 2019, Research on the Impact of Energy Construction on Smart City Development. Straits Technology and Industry, 33(12): 87–89.

[10] Zhang S, Miao A, 2016, Energy Internet Supports Smart City Development. Power of China, 49(03): 12–17 + 23.

[11] Zou X, Wang C, 2022, Construction Idea of Smart City Energy System. Electrotechnical Engineering, (14): 52–55 + 166.

[12] Tang Y, Xia Q, Zhang P, et al., 2022, Value Creation, Format Innovation and Development Strategy of Energy Internet. Global Energy Internet, 5(02): 105–115.

[13] Xiong W, 2022, Ten Years of Energy Internet. Legal Person, (01): 47–50.

[14] Yu X, Luo X, 2021, China's "Internet Plus" Smart Energy: Multiple Connotations and Development Promotion. Fujian Forum (Humanities and Social Sciences Edition), (11): 91–101.

[15] Wang D, 2021, Research on Countermeasures of Ubiquitous Electric Power Internet of Things to Promote Smart City Construction, dissertation, Qingdao University.