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Green Productivity and Energy Efficiency Optimization in the Transformation of Intelligent Manufacturing: Challenges, Opportunities and Strategies

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Abstract: Against the backdrop of escalating climate change and resource scarcity, fostering high-quality productivity and reducing pollution/carbon emissions have become national strategic priorities. China's Ministry of Industry and Information Technology (MIIT) announced in 2021 its commitment to advancing new digital infrastructure, aiming to complete the construction of green, intelligent, and secure digital systems by 2025. This study employed mixed-methods research, combining sampling surveys with 1,092 valid questionnaires and on-site interviews. It conducts a multidimensional analysis to study how new digital infrastructure can facilitate the co-development of green productivity in smart manufacturing enterprises. Model validation was achieved through field investigations and data analytics to predict/optimize green productivity and energy efficiency. Using enterprise-level pollutant/carbon emission data, the research analyzed mediation effects with green finance and green technology development as mediating variables. Case studies of smart manufacturing firms revealed that green finance and technological advancements significantly enhance pollution/carbon reduction synergies enabled by new infrastructure.

Keywords: Green Productivity; Intelligent Manufacturing Enterprises; Energy Efficiency Optimization; New infrastructure.

1. Introduction

In September 2023, during his inspection tour in Heilongjiang Province, General Secretary Xi Jinping first proposed the concept of "new quality productivity", emphasizing that developing new quality productivity is an inherent requirement and a key focus for promoting high-quality development. "New quality productivity" refers to productivity of new types, new structures, high technological levels, high quality, high efficiency, and sustainability. It serves as an important material and technological foundation for high-quality development and Chinese-style modernization. It plays an irreplaceable fundamental role and is an urgent requirement for promoting high-quality development and Chinese-style modernization. It is also a fundamental task in the new era and new stage of development.

A detailed study on the energy efficiency index of 30 provincial administrative regions in China was conducted from 2010 to 2018. The research finds that the energy efficiency level in our country generally shows a distribution pattern of "higher in the east and south, followed by the central region, and lower in the west and northeast". The energy efficiency index of the eastern coastal areas and the southern coastal areas is generally higher than that of other areas and is in the first echelon. The northern coastal areas and the middle reaches of the Yangtze River are in the second tier. The southwest region and the middle reaches of the Yellow River are located in the third tier. Except for a few provinces, the energy efficiency levels in the northwest and northeast regions are relatively low and rank in the fourth tier.

Since the manufacturing revolution, the excessive use of fossil energy has led to excessive CO2 emissions, accelerating the process of global warming and threatening global ecological security and sustainable development. The issue of global warming has become a huge challenge that all mankind is facing together at present. As the "main battlefield" of energy conservation and emission reduction, intelligent manufacturing enterprises are confronted with a series of problems such as unbalanced industrial structure and energy structure, and relatively low resource utilization efficiency. By transforming to green development, strengthening technological innovation and industrial cultivation in clean production, and enhancing the industrialization of equipment, it is necessary to comprehensively improve the clean production level in all fields. It is of great significance to promote the synergy of pollution reduction and carbon emission reduction. At the same time, we should balance development and emission reduction, take into account both the short term and the long term, and coordinate the overall situation with key points. We should develop green productive forces in a powerful and orderly manner to achieve the synergy of pollution reduction and carbon emission reduction. Promoting clean production and guiding the transformation and upgrading of intelligent manufacturing towards new energy can fundamentally improve the quality of the ecological environment, contribute to the goals of carbon peaking and carbon neutrality, and promote a win-win situation for economic development and environmental protection.

2. Design of the Investigation Plan for the Collaborative Understanding of Pollution and Carbon Emission Reduction of New Infrastructure

2.1. Survey Background and Significance

The Third Plenary Session of the 20th Central Committee of the Communist Party of China proposed to "improve the systems and mechanisms for developing new quality productive forces in accordance with local conditions, promote revolutionary technological breakthroughs,

innovative allocation of production factors, and in-depth transformation and upgrading of industries", and explicitly required "to lead the optimization and upgrading of traditional industries with the improvement of national standards, and support enterprises in transforming and upgrading traditional industries with digital and intelligent technologies and green technologies".

Meanwhile, the report of the 20th National Congress of the Communist Party of China also emphasizes "promoting the high-end, intelligent and green development of the manufacturing industry". These policies provide a clear direction and guidance for the research on green productivity and energy efficiency optimization in the transformation of intelligent manufacturing. An infrastructure system that applies the digital economy to the entire industrial chain of "new infrastructure", driven by technological innovation, guided by new development concepts, and based on information networks, and is oriented towards the needs of high-quality development, providing services such as intelligent upgrading, digital transformation, and integrated innovation.

2.2. Survey Purpose

This study focuses on the multiple functions of new infrastructure in promoting the development of green productivity and carbon emission reduction, and conducts an in-depth evaluation of its effectiveness in reducing pollutant emissions and improving energy efficiency. In addition, the perceptions and attitudes of different stakeholders from the government, industry and research fields on the synergistic effect of infrastructure construction and pollution reduction and carbon reduction are also examined.

By building an evidence-based precise strategy framework for energy conservation and emission reduction of new energy enterprises, the research is committed to promoting the rapid application of cutting-edge technologies in the field of infrastructure, enhancing the concept of green development of enterprises, and providing a scientific basis for the formulation of sustainable policies supported by data. The ultimate goal is to integrate technological innovation, production activities and management system to help enterprises properly handle the relationship between environmental protection and economic expansion in the context of continuous evolution of new infrastructure, and achieve a development vision that attaches equal importance to economic benefits and ecological balance.

2.3. Survey Object and Scope

The objects of this survey are mainly targeted at the staff of intelligent manufacturing enterprises, the staff of government and enterprises and the general public.

2.4. Survey Method

(1) Questionnaire survey. Questionnaires were designed and distributed to intelligent manufacturing enterprises and relevant government departments to collect data and information on the cognition of pollution reduction and emission reduction cooperation and efficiency improvement and related impacts of new infrastructure empowerment. Collect and analyze the data of energy consumption, pollutant emission and green productivity development of intelligent manufacturing enterprises, understand the views of government and enterprise staff on new infrastructure and other related policies, evaluate their enabling effect on energy efficiency optimization, and summarize and sort out the obtained data.

(2) Interview and survey. Experts, scholars and industry consultants in relevant fields were invited to conduct interviews to obtain their views and suggestions on the impact of new infrastructure enabling intelligent manufacturing enterprises to reduce pollution and emissions. Cooperate with relevant industry associations to obtain the general situation and experience in the industry, and understand the promotion and effect of new infrastructure in the whole industry.

(3) Field investigation. On-site visits were made to intelligent manufacturing companies with more advanced technologies and new energy enterprises with more advanced new infrastructure technologies to understand their specific operation modes and cooperation and efficiency improvement results of pollution reduction and emission reduction. The survey results are compared with other similar enterprises or industries to analyze the difference in the impact of new infrastructure in different situations.

2.5. Questionnaire Design

This questionnaire adopts a structured design and consists of four core modules: basic information collection of respondents, cognitive assessment of core concepts, differentiated question module and open suggestion collection. Firstly, basic information such as gender, age and education level is used to lay the foundation for subsequent data analysis. The questionnaire sets up a career diversion mechanism, and sets differentiated questions for respondents with different professional backgrounds: focusing on the perspective of industry practice for practitioners of relevant enterprises, the questionnaire examines the effect of policy implementation, pain points and optimization suggestions; For government civil servants, we focus on the dimension of policy coordination, and explore the space of government-enterprise cooperation mechanism optimization and institutional innovation under the background of new infrastructure.

The questionnaire focuses on four aspects: cognition, policy, influence and participation. In the cognitive dimension, it evaluates the depth of respondents' cognition on enabling new infrastructure to reduce pollution and carbon emissions. Policy analysis of different groups to the current policy system attention and evaluation; It will also analyze the actual effect of the application of new infrastructure technology on green transformation and collect the optimization path and innovation scheme of government-enterprise collaborative governance.

Through the data of this questionnaire, we can summarize and analyze the methods of intelligent manufacturing enterprises for pollution reduction and carbon reduction, and the respondents' suggestions for the government in enabling new infrastructure to reduce pollution and carbon reduction, providing reference for policy making. Finally, according to the opinions and suggestions of the respondents, the development trend of new infrastructure enabling green productivity and energy efficiency optimization is predicted.

3. Survey Implementation and Statistical Description

3.1. Investigation Process

The instructor and team members discuss the topic selection together, and the team leader makes a detailed time

plan and work arrangement. Subsequently, questionnaires were designed through the online platform, distributed and collected. Integrate and analyze data to further adjust the research plan. After the investigation, the team members discussed the research ideas together, clearly divided the research report into parts according to the division of labor, wrote the research report respectively, and finally summarized and polished it.

3.2. Pre-Survey Data Processing and Testing

(1) Pre-investigation. In order to make the questionnaire more convincing, this survey will check whether the questionnaire is scientific before the official start, so this survey will conduct a simulated survey to fill in the questionnaire. For some ambiguous and abstract questions, this survey will change, and adjust the unreasonable order, so as to lay a foundation for the formal questionnaire and increase the accuracy. In the pre-survey, the questionnaire was designed through the questionnaire network, and then the group members were asked to actively forward and fill in the questionnaire on social media platforms such as QQ, wechat and Weibo. From February 25 to March 25, 2025, a total of 175 questionnaires were collected and selected as follow. ① Eliminate the questionnaires with abnormal data and those that do not meet the requirements. ② Eliminate the questionnaires with missing values. ③ The questionnaires with less than 100s answering time are excluded. Finally, 161 valid questionnaires were obtained, and the recovery rate reached 92%, which met the basic requirements. Finally, in the process of data entry, the method of double input is adopted, and the questionnaire is automatically calibrated by Epidata software to ensure the accuracy of the questionnaire and improve the quality of the questionnaire. Finally, the questionnaire was effectively used for data statistics and further analysis.

(2) Formal investigation. In order to ensure the accuracy and reliability of the questionnaire, this survey adopts the Credamo platform to distribute the questionnaire. This survey will focus on the staff of CATL enterprises, nearby government personnel and related personnel, and distribute questionnaires to the data mart. The period from April 1 to April 5, 2025 is the collection period of this questionnaire. As of the last moment, a total of 1210 questionnaires were collected in this survey. The collected questionnaires were screened as follows: ① The repeated questionnaires filled by interviewers were excluded. ② Based on the actual content, the questionnaires irrelevant to the data are eliminated. ③ Eliminate the questionnaires with missing or missing values. ④ The questionnaires with the respondents' answering time less than 100s are excluded.

Excluding the unqualified questionnaires, a total of 1092 valid questionnaires were collected in this survey, with a recovery rate of 90.3%, basically meeting the requirements. Further input, collate and code valid data, and conduct further data analysis.

3.3. Data Quality Analysis

3.3.1. Reliability test

The reliability test mainly focuses on the consistency, stability and reliability of the measurement results, that is, whether the test results reflect the stable and consistent real characteristics of the tested people. The reliability analysis method adopted in this survey is Cronbach's Alpha (α value) reliability coefficient method. The formula is as follows:

$$a = \frac{k}{k-1}\left(1 - \sum_{i=1}^{k} \frac{s_i^2}{s_p^2}\right) \quad (1)$$

Where, k is the number of items in the scale is the variance of the ith item and is the total variance of the scale. This formula involves the ratio of the number of items to the number of items minus one, multiplied by the difference between the total variance of the scale and the variance of each item. As shown in Table 1, the Cronbachs alpha coefficient ranges from 0 to 1, with higher values indicating greater internal consistency.

Table 1. Reliability analysis table of pre-survey

Cronbachs alpha	Number of terms
0.803	15

Because Cronbachs alpha>0.8, the questionnaire structure and questions were reasonably designed.

3.3.2. Validity test

Validity refers to the degree to which a measurement tool or means can measure the things that need to be measured. In order to explore whether the factors fit the data analysis, the KMO test and Barlett's test of sphericity were used in this investigation.

Table 2. KMO test and Barlett's test of sphericity

KMO and Barlett's test		
Kaiser-Meyer-Olkin measures for sampling adequacy		0.687
Barlett's test of sphericity	Approximate chi-square	27.904
	df	6
	Significance	<0.0001

As shown in Table 2, the value of KMO is >0.5, indicating that there is correlation between variables, and in Barlett's sphericity test, the significance is <0.05, indicating that the questionnaire questions have reached the standard and can be used for the next step of modeling.

4. Mediating Effect Analysis of New Digital Infrastructure and Pollution Reduction, Carbon Reduction and Energy Efficiency Optimization

4.1. Variable Selection

4.1.1. Variable setting

(1) Explained variable. Pollutant emissions (POLLUTION): The pollutant emissions involved in this section are the pollutant emissions of enterprise i in year t. The pollutant emissions of enterprises mainly include chemical oxygen demand and ammonia nitrogen emissions in the wastewater of the new energy industry, and sulfur dioxide and nitrogen oxide emissions in the waste gas of the new energy industry. Carbon emission (CO2): Carbon emission accounting is the basic prerequisite for effectively carrying out various carbon emission reduction work and promoting green economic transformation. Carbon accounting can directly quantify the data of carbon emissions, and find out the potential emission reduction links and methods by analyzing the data of carbon emissions in each link, which is crucial to the realization of carbon neutrality goals and the

operation of carbon trading market.

(2) Explanatory variables. Digital infrastructure (DIC): Digital infrastructure is an infrastructure system driven by data innovation, based on communication network and centered on data computing power facilities. It is the main goal of digital economy development during the 14th Five-Year Plan period.

(3) Mediating variable. We divide the level of green development into two intermediary indicators: Development level of green finance (GF): As an important means to promote the transformation of economic structure after China's economic development has entered the "new normal," the value of green finance can reflect the policy intensity of various governments in green finance. We select four indicators: green credit, green investment, green insurance and government support, and use the entropy method to measure the green finance index of all provinces, autonomous regions and municipalities. Green technology Innovation (OIC): Sustained green technology innovation is the driving force for sustained economic growth and the key to high-quality economic development. We select the factor of green innovation efficiency to measure the green technology innovation of enterprises, that is, continuous innovation is taken as an independent variable, and at the same time, we compare the innovation input index (R&D expenses) and innovation output index (patents) before and after the period. The specific formula is as follows:

$$IIP_t = \frac{IIN_t + IIN_{t-1}}{IIN_{t-1} + IIN_{t-2}} \times (IIN_t + IIN_{t-1}) \quad (2)$$

$$OIP_t = \frac{OIN_t + OIN_{t-1}}{OIN_{t-1} + OIN_{t-2}} \times (OIN_t + OIN_{t-1} \quad (3)$$

Where, IIPt and OIPt are the persistence of innovation input and output of the enterprise in year t, respectively; IINt, IINt-i, IINt-2 and OINt, OINt-1, Oint-2 are the R&D expenditure and the number of patent applications of the enterprise in year t, respectively.

(4) Control variables. By collating relevant literature and generalization, we use the following indicators: ① Regional level. We select the level of economic development (EDL), industrial structure (IS), and degree of marketization (MD) as control variables. Among them, the level of economic development is measured by the per capita GDP of each province; IS measured by the ratio of manufacturing value added to regional GDP; MD is obtained by the ratio of government general public budget expenditure to regional GDP. ② Enterprise level. We select financial leverage (LEV), return on total assets (ROA), return on equity (ROE), turnover of total assets (ATO), cash holdings (Cashflow), ownership concentration (TOP1), BOARD size (BOARD), proportion of independent directors (INDEP), and Tobin's Q value (TobinQ). LEV is measured by the year-end asset-liability ratio; ROA is the average residual value of net profit in total assets; ROE is the average residual value of net profit to shareholders' equity; ATO is operating income as a percentage of average total assets; CASH is calculated by dividing the sum of monetary funds and transactional financial assets by total assets; TOP1 adopts the shareholding ratio of the largest shareholder; BOARD takes the natural logarithm of the number of directors; INDEP equals the number of independent directors divided by board size.

4.1.2. Sample selection

The panel data of intelligent manufacturing enterprises from 2011 to 2022 are selected as samples. The original data on green finance, digital infrastructure and enterprises come from the National Bureau of Statistics, Annual Government Work Report, China Statistical Yearbook, China Statistical Yearbook on Science and Technology, China Statistical Annual Report on Ecological Environment, reports released by Internet Society of China and Information Center of the Ministry of Industry and Information Technology, CSMAR database, Wingo financial text data platform, and annual reports of enterprises. Finally, a total of 1005 observations are formed, and the continuous variables are winnosed at the level of 1% and 99%.

4.2. Construction of Mediating Effect Model

4.2.1. Model introduction

For the influence of independent variable X on dependent variable Y, if X not only directly affects Y by itself, but also affects Y by influencing variable M, then variable M is regarded as a mediating variable. The role is publicized as follows:

$$Y = cX + e_1 \quad (4)$$

$$M = aX + e_2 \quad (5)$$

$$Y = c'X + bM + e_3 \quad (6)$$

If the variables have been centralized or standardized, the corresponding equation can be used to explain the relationship between the variables. Where c is the total effect on X and Y, ab is the mediating effect through mediating variable M, and c 'is the direct effect. When there is only one mediating variable, the relationship between the effects is as follows:

$$c = c' + ab \quad (7)$$

The mediating effect is measured by c-c '=ab.

4.2.2. Model establishment

According to the above definition of mediating variables, we construct the model as follows:

H1: The development of digital infrastructure can inhibit corporate pollutant emissions.

Model 1:

$$POLLUTION = \beta_0 + \beta_1 DIC + \beta_2 CONTROLS + \alpha + \varepsilon \quad (8)$$

H2: The development level of green finance and green technology innovation can inhibit the emission of corporate pollutants.

Model 2:

$$MECHANISM = \delta_0 + \delta_1 DIC + \delta_2 CONTROLS + \alpha + \varepsilon \quad (9)$$

H3: The level of green finance development and green technology innovation act as intermediary variables to inhibit corporate pollutant emissions.

Model 3:

$$POLLUTION = \theta_0 + \theta_1 DIC + \theta_2 OIC + \theta_3 CONTROLS + \alpha + \varepsilon \quad (10)$$

Where β, δ and θ are the parameters to be estimated, α is the year fixed effect, and ε is the random disturbance term; POLLUTION is the amount of pollutants emitted by enterprises; MECHANISM is the intermediary variable, including the level of green finance development (GF) and green technology innovation (OIC); DIC is digital infrastructure level; CONTROLS are the control variables at the enterprise and regional levels.

4.3. Analysis of Empirical Results

4.3.1. Analysis of mediating utility results

We first conduct a Bootstrap test on the development level of green finance on the panel data of the sample enterprises for 12 consecutive years, and the test results are shown in Table 3.

Table 3. Regression analysis of mediating variable GF

Variables of interest	(1)			(2)			(3)		
	POLLUTION			GF			POLLUTION		
	Coefficient	t	P	Coefficient	t	P	Coefficient	t	P
constant	0.153***	198.179	0.000	1.031***	25.326	0.000	0.147***	193.240	0.000
DIC	0.011***	13.383	0.000	0.429***	10.231	0.000	0.008***	10.533	0.000
Lev	0.001***	4.515	0.000	0.009	0.871	0.384	0.001***	4.478	0.000
ROA	0.000	0.219	0.488	0.150***	2.654	0.008	-0.001	-0.694	0.488
ROE	-0.000	-0.546	0.643	-0.079***	-2.984	0.003	0.000	0.463	0.643
Cashflow	0.002***	4.356	0.000	0.043**	2.279	0.023	0.001***	3.816	0.000
Board	-0.000	-1.224	0.384	-0.013	-1.218	0.223	-0.000	-0.871	0.384
Indep	0.000	0.313	0.789	0.000	0.185	0.853	0.000	0.267	0.789
TOP1	-0.000***	-4.335	0.001	-0.001***	-3.904	0.000	-0.000***	-3.225	0.001
TobinQ	0.000**	2.072	0.001	-0.004***	-3.443	0.001	0.000***	3.393	0.001
ATO	-0.000	-0.529	0.483	0.002	0.402	0.688	-0.000	-0.701	0.483
EDL	0.000***	21.306	0.000	0.000***	19.053	0.000	0.000***	15.556	0.000
IS	-0.000***	-70.031	0.000	-0.022***	-62.904	0.000	-0.000***	-42.506	0.000
MD	0.011***	10.677	0.000	-0.126**	-2.273	0.023	0.012***	12.097	0.000
GF	-	-	0.000	-	-	0	0.006***	30.777	0.000
R2	0.89	-	-	0.85	-	-	0.90	-	-
Adjust R2	0.88	-	-	0.84	-	-	0.89	-	-
F	4764.976	-	-	3448.985	-	-	5030.763	-	-
***p<0.01, **P<0.05, *p<0.10									

According to the results of Model 1, the coefficient of digital infrastructure construction (DIC) shows a positive value, which indicates that the relevant measures to develop digital infrastructure also play a significant role in inhibiting the emission of pollutants of enterprises. Among the control variables, the model at the regional level is significant, which indicates that in the development of each region, the problem of corporate emission reduction has been fully paid attention to, and the balance between economic development and environmental protection has been taken into account.

According to the results of Model 2, the continuous development and progress of digital infrastructure will play a role in promoting green finance. Under the current grand trend of digitalization, the development of green finance industry is inevitable and imperative, and its pace of progress is bound to accelerate with the improvement of digital infrastructure.

Table 4. Analysis of the mediating effect of GF

item	Coefficient	Size of effect	Bootstrap standard error	Confidence intervals at the 95% level
GF indirect effect	-0.0191058	0.0000597	0.00082296	[-0.0206721, -0.0174286]
GF direct effect	-0.00008846	0.0000315	0.00065215	[-0.0014337, 0.001112]
GF total effect	-	0.0000912	-	-

The conclusion shown in Table 4 shows that although the development level of green finance has no mediating effect on the direct effect between digital infrastructure development and enterprise pollutant emissions, the indirect effect reflects a complete mediating effect. Therefore, we believe that green finance development has a complete intermediary effect on corporate pollutant emissions. The report to the 20th National Congress of the Communist Party of China (CPC) proposed that green and low-carbon economic and social development is a key link to achieve high-quality development. In particular, it pointed out that high-end, intelligent and green manufacturing should be promoted, and green environmental protection should be one of the new growth engines of China's economy. While promoting the continuous development of green finance, it also inhibits the emission of corporate pollutants, which is consistent with our experimental results.

4.3.2. Robustness test of mediating effect

The Bootstrap method is a method of repeated sampling from a sample, provided that the sample is representative of the population. The general sampling method is repeated sampling with return. The Bootstrap method does not involve the population distribution and its parameters, and uses the empirical distribution derived from the sample to replace the population distribution, which is a nonparametric method. We conduct Bootstrap test for OIC. The results are shown in Table 5.

Table 5. Regression analysis of mediating variable OIC

(1)			(2)			(3)		
POLLUTION			OIC			POLLUTION		
Coefficient	t	P	Coefficient	t	P	Coefficient	t	P
0.153***	198.179	0.000	0.844***	10.763	0.000	0.152***	197.347	0.000
0.011***	13.383	0.000	0.144*	1.792	0.073	0.010***	13.261	0.000
-	-	0.000	-	-	-	0.001***	13.424	0.000
8496	-	-	8496	-	-	8496	-	-
0.888	-	-	0.413	-	-	0.891	-	-
4764.976	-	-	420.573	-	-	4539.467	-	-

Table 6. Analysis of OIC mediating effect results

item	Coefficient	Size of effect	Bootstrap standard error	Confidence intervals at the 95% level
OIC indirect effect	-0.0059192	7.17×10-6	0.00052225	[-0.0069689, -0.0049536]
OICdirect effect	-0.01327506	-7.45×10-7	0.00092416	[-0.0150133, -0.0113817]
OIC total effect	-	6.43×10-6	-	-

It can be seen from the model results that the GTI carried out by enterprises has a significant role in promoting the development of digital infrastructure. According to the analysis results in Table 6, there is an intermediary relationship between the indirect effect and the direct effect of GTI on the digital infrastructure construction and the pollutant emission of enterprises

$$\frac{OIC\text{indirect effect}}{OIC\text{total effect}} = \frac{7.17 \times 10 - 6}{6.43 \times 10 - 6} = 1.115$$

To sum up, China's green development level has been increasing year by year since 2011. The development of green productivity is the trend of this era, and the development of enterprises is inseparable from the national macro development, and the development of green economy is also the general trend.

5. Conclusions and Suggestions

5.1. Conclusion

5.1.1. Cognitive status

The importance of digital infrastructure construction for the development of green productivity and energy efficiency optimization of intelligent manufacturing enterprises is gradually being recognized and accepted. With the new wave of information technology, more and more people realize the importance of digital infrastructure to reduce carbon, digital infrastructure can help enterprises achieve more efficient energy use, thus reducing pollution emissions. By monitoring production data in real time and optimizing energy use, intelligent manufacturing enterprises can manage energy consumption more accurately and reduce their carbon footprint. More people recognize and support the use of digital technology, which can comprehensively monitor and optimize the intelligent manufacturing production chain, reduce waste and energy loss, thus reducing the negative impact on the environment.

Business managers also recognize that digital infrastructure is essential to improve the efficiency of production and management of enterprises. Through digital technology, enterprises can realize automatic and intelligent production and improve the efficiency and flexibility of production lines. At the same time, it can realize real-time data monitoring and analysis, help enterprises find problems in advance and deal with them in time, and reduce costs.

People hold a positive attitude towards digital infrastructure construction in reducing pollution, reducing carbon and improving efficiency of intelligent manufacturing enterprises. Most people can realize that the construction of digital infrastructure can help intelligent manufacturing enterprises achieve efficient production management. Through big data monitoring, intelligent analysis and prediction, enterprises can better optimize the production process, improve production efficiency, reduce resource waste, so as to reduce pollutant emissions and achieve the goal of pollution and carbon reduction.

5.1.2. Effect mechanism of new infrastructure on enterprise energy efficiency optimization

The digital infrastructure in the new infrastructure can collect and analyze a large amount of environmental data, enabling enterprises to have a more accurate understanding of their own pollution and carbon emissions, so as to realize intelligent environmental management and decision-making, and take targeted measures to reduce pollution and carbon emissions.

Through intelligent energy management system and advanced information technology, it helps enterprises optimize energy allocation, improve energy efficiency, reduce unnecessary energy consumption and corresponding pollutants and carbon emissions.

New infrastructure will drive the development of related industries, encourage enterprises to adopt more environmentally friendly and low-carbon technologies and processes, accelerate the upgrading and transformation of traditional high-pollution and high-carbon industries, cultivate green emerging industries, and reduce pollution and carbon emissions at the source.

5.2. Suggestions

5.2.1. Government level

As policy makers, the government should issue special policies and development plans to clarify the goals, tasks and roadmaps for the coordinated development of new infrastructure and intelligent manufacturing enterprises. In addition, special funds can be set up to formulate relevant technical standards and specifications to ensure that the coordinated development of new infrastructure and intelligent manufacturing enterprises is scientific and reasonable. It can also organize relevant enterprises and scientific research institutions to establish exchange and cooperation platforms

to promote information sharing, technical exchanges and project cooperation.

5.2.2. Enterprise level

Actively invest in the introduction and upgrading of new infrastructure related technologies and equipment, such as intelligent energy management system, advanced environmental monitoring equipment, etc., and use new infrastructure to improve their own pollution reduction and carbon reduction capacity. Through the data platform built by the new infrastructure, we can better understand our energy consumption and emissions, so that we can accurately formulate and implement pollution and carbon reduction strategies. Digital infrastructure construction is crucial for manufacturing enterprises to reduce pollution and emissions and optimize energy efficiency. Continue to carry out technological research and development and innovation, and take advantage of the opportunities brought by new infrastructure to continuously enhance the competitiveness and sustainable development capacity of enterprises in the development of green productivity.

5.2.3. Individual level

Human capital is an important driving force for the digital economy to empower the manufacturing industry to improve the energy efficiency of the manufacturing industry. We should not only pay attention to the cultivation of high-end technical personnel, but also pay attention to the digital skills training of medium and low skilled labor, so as to better adapt to the needs of the development of the manufacturing industry. This paper analyzes the problems existing in the digital skills training of the medium and low skilled labor, and puts forward corresponding countermeasures. In addition, individual residents should do a good job in the supervision of intelligent manufacturing enterprises, so that the green development of intelligent manufacturing enterprises continues.

To sum up, the construction of digital infrastructure is of great significance to the pollution reduction and emission reduction and energy efficiency optimization of manufacturing enterprises.

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