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Characteristics and Evolution of China's Carbon Emission Reduction Measures: Leading Towards Environmental Sustainability

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The increasing concentration of carbon emission (CE) in the atmosphere, which causes climate change (CC), has become a priority at the global level. The Chinese govt has enacted a series of CE reduction policies and regulations during the recent decades, which have effectively encouraged the country's green and sustainable growth. For sustainable development and subsequent policy design, it is critical to investigate the features and evolution of CE reduction programs. First, we collected China's national-level CE reduction policy texts from 2007 to 2021 as research objects. Second, using content analysis and NVivo software, a three-dimensional analytical framework of "Policy tools--Development stages--Policy implementation objects" is developed and investigated based on the theory of policy tools. Finally, the CE reduction policy language is coded line by line using empirical analysis, yielding 725 reference points. The results show that 1) The results show that: 1) in the evolution of CE reduction policy, environmental policy tools are the most used, accounting for 51.17%, and the use of supply-based and demand-based policy tools account for 32.28 and 16.55%, respectively; 2) demand-based policy tools need to be strengthened, and the structure of supply-based and environmental policy tools needs to be adjusted; 3) the govt's coordination with research institutions and the public is not sufficient The implementation of policy instruments is insufficient; 4) China's CE reduction policy is gradually developing from a macroscopic single subject policy to a diversified and specific policy with specialized content. Therefore, we recommend optimizing the policy structure in the light of social characteristics and strengthening the government's guiding role in China's CE reduction efforts. It is also recommended to increase financial instruments and enhance the binding force of laws and regulations.

Keywords: carbon emission, environmental policies, characteristic and evolution, climate change, characteristics and evolution

1 INTRODUCTION

Since the 20th century, human activities have increased the atmospheric concentration of CD, which has caused CC that is mainly irreversible in the following centuries (Solomon et al., 2009). Environmental pollution is increasing due to unsustainable practices and poor production processes, which create diseases in society and damage the fauna and flora. Conclusion: there is no doubt that CC is a big challenge for countries around the globe, and United Nations has already taken strict actions and formulated policies to prevent environmental degradation. However, there are also increasing responsibilities on micro levels, such as firms, to cope with CE and protect environmental sustainability by reducing harmful activities in their production and business processes (Palermo et al., 2020). Developing countries use fossil energy excessively in pursuit of development, which creates severe harmful effects on environmental sustainability and further increases global warming (Ali et al., 2019; Jiang et al., 2021). Also, country-level and regional data in the last half-century confirm the criticality of trade to sustainable growth. In the light of the growing importance of trade, measures to actively facilitate it are gaining popularity. Promoting measures that ease trading has become an effective tool to help countries in the Asian region like China because more than half of production plants are working in China, which is damaging to the environmental sustainability and creates pressure on Chinese firms to adopt green practices and sustainable measures to control CE aggressively.

The Circular Economy has great potential for achieving the environmental sustainability. In particular, Circular Economy practices can improve urban waste management for accomplishing environmental performance. According to the UN 2019 Revision of World Population Prospects, four global demographic megatrends will impact both social-economic development and environmental sustainability: population growth, population ageing, migration, and urbanisation (Khanna et al., 2014; Zhao et al., 2021).

The Sustainable Development Goals (SDGs) were put forward as an aftermath of Millennium Development Goals (MDGs) that were designed to reduce communicable diseases like malaria etc., and child mortality rates; to target improved maternal health; to combat HIV/AIDS; to ensure gender equality and women empowerment; to achieve poverty reduction; and to attain higher levels of education for all thereby achieve sustainable development including environmental sustainability through global partnerships (United Nation, 2017). Afterward, the SDGs stated seventeen (17) embedded goals to replace the MDGs, targeted to be achieved by 2030. Schumpeter (1911) asserts that the financial services provided by the intermediaries, banks, etc., are essential for economic development and innovation for which financial education should be focused. Amidžić et al. (2014) also emphasize financial inclusion for individuals and small firms' access to essential financial services. Similarly, the overall goal of sustainable development (SD) is the long-term stability of the economy and environment, only achievable through a mere acknowledgment and integration of social, environmental, and economic dimensions to be achievable vis a financial system.

In 2007, the State Council, the highest state administrative organ in China, promulgated the National Program for Addressing CC in China (Author Anonymous, 2021). In 2011, the State Council proposed an emissions reduction target in the 12th Five-Year Plan to control greenhouse gas emissions, with a 17% reduction in CO_2 emissions per unit of GDP by 2015 compared to 2010 (CHINA, 2021). In 2021, the Chinese govt explicitly stated that it would reach carbon peaking by 2030 and strive to achieve carbon neutrality by 2060 (Zhao et al., 2022).

Many countries have taken legislative action to address CC (Schmidt and Fleig, 2018). Public policies are made by govt agencies and officials (Holt, 2008; Hill and Peter, 2014) and are the basic instruments of govt governance (Hillman, 2003; Pronińska and Księżopolski, 2021). The Small Island State of Malta (SISM) has developed a policy to reduce CO_2 emissions and energy consumption by proactively working with municipalities (Buga and Yousif, 2021). The Korean govt has addressed energy-related environmental issues by adopting various regulations, policies, and standards (Lee and Lim, 2018). The United Kingdom govt's CC Act 2008 set a target to reduce the UK's greenhouse gas emissions by at least 80% from 1990 levels by 2050 (Dawood et al., 2013). To address CC and reduce CO_2 emissions, regional govt departments have introduced a series of policies for different areas (Kong et al., 2020), including pilot construction (Khanna et al., 2014; Qiu et al., 2021), financial investment (Bolton and Foxon, 2015), technology development (Ockwell et al., 2008; Auld et al., 2014; Lee and Mwebaza, 2022), tax incentives (Zhou et al., 2018; Zhu et al., 2020), and regulatory policies (Fan et al., 2017). The policies formulated at different time stages differ slightly in the general direction, from the development of new energy in the early stage to improved energy efficiency in the later stage; the coverage of CE reduction policies has become increasingly broad (Wang and Chang, 2014).

In policy formulation, policy tools play an essential role and the ends and means of policy realization (Bali et al., 2021). Kirschen and his colleagues identified more than 40 different types of policy tools (Kirschen, 1964) to inform the development of economic policies in Europe in the 1960s. Later scholars studied policy tools from different perspectives. Houcine et al. studied the effect of unconventional monetary policy tools on the expected inflation rate and showed that changes in the volume of credit on the expected inflation rate were not significant (Houcine et al., 2020). Cheng et al. examined the impact of environmental regulation policy tools on emission reduction and technological progress through empirical analysis (Cheng et al., 2017). Hughes focused on the policy tools used by traditional cities in the United States in developing the application of CC (Hughes, 2020).

Although carbon reduction (CR) policies have been discussed from the perspectives of quantitative evaluation (Zhao and Tang, 2018), analytical frameworks (Li et al., 2013), and policy structures (Luo and Zhu, 2014), fewer studies have analyzed CE policies from the perspective of policy tools. After the Paris Agreement (2015) and the Climate Ambition Summit (2020), the

Chinese govt has enacted many new policies based on the current context of the times, and these policies have not yet been effectively studied (Khan et al., 2021a). Meanwhile, policy research should not only start from a top-level design or an evaluation of the current policy system but should focus on the evolutionary logic of the policies (Fan et al., 2017). Therefore, this paper aims to review the recent development of CE reduction in China and focus on how China's CE reduction policies have developed and evolved from policy tools (Khan et al., 2021b; Khan et al., 2021d). The analysis of China's existing CE reduction policies can explore the direction of China's efforts and the path to achieving sustainable development in recent years and provide a reference for sustainable development in other regions (Khan et al., 2021c). From the perspective of policy tools, the three-dimensional policy analysis framework can help the govt guide subsequent policies and select policy tools (Qin et al., 2020) and provide references for CE reduction efforts and sustainable development in other countries with vital theoretical and practical significance.

This paper attempts to analyze the CE reduction policies enacted in China from the perspective of policy tools. Compared with previous studies by scholars, this paper uses a three-dimensional analysis framework and increases the sample size of policies. The study includes some of the most recent policies enacted by the Chinese government to obtain more advanced and reasonable results. The method of this paper is content analysis, which is based on the idea of constructing a three-dimensional framework for analyzing CR policies with the help of text analysis software. On the one hand, it fills the gap that the latest policy texts have not been studied yet; on the other hand, it expands the two-dimensional analysis method of previous studies and provides a new example for CE reduction policy research.

The paper is organized as follows: **Section 2** introduces the data sources and research methods; **Section 3** constructs a three-dimensional analysis framework, describing the statistical analysis of single and cross-dimensional CE reduction policies; **Section 4** analyzes the evolution of CE reduction policies; **Section 5** summarizes the evolution of CE reduction policies and proposes policy recommendations based on the research findings.

2 METHODOLOGY

2.1 Data Collection

This paper collects policy documents from Chinese govt websites and authoritative legal websites, such as the Ministry of Ecology and Environment of the People's Republic of China, the General Office of the State Council, and Beida Fabio. In the process of selecting policy samples, the research team strictly followed the principles of authority, openness, relevance, uniqueness, and validity: 1) authority means that policy texts are formulated by authoritative bodies such as the General Office of the CPC Central Committee, the State Council, ministries and commissions, and the agencies directly under them; 2) openness means that policy texts must be publicly released, and those that are not publicly available or accessible are not included in the scope of this study; 3) relevance means that the scope of the study covers the policy documents related to CE reduction (e.g., the title of the policy contains "energy conservation and emission reduction," "green," and "environmental protection"); 4) uniqueness means that the collected policy texts are checked, and that duplicate samples are deleted; 5) validity means that the policy texts must be current and valid, and those that are no longer valid are deleted. To ensure the representativeness of the selected policies, the following steps were followed: 1) select the national-level policies related to CE reduction, i.e., those issued by the General Office of the CPC Central Committee, the State Council, ministries and commissions, and the agencies directly under them individually or jointly, while excluding various policy documents promulgated by local govts; 2) initially read the collected policy texts to eliminate policy certifications, approvals, recurring and invalid policy documents; 3) use the citation relationship between policies to retrieve the missing policy documents retroactively. Based on the above search principles and process, 53 CE reduction-related policy documents were collected for this paper, covering the period of 2007–2021.

2.2 Research Technique

Content analysis (Downe - Wamboldt, 1992; Yao et al., 2021) is a systematic and repeatable strategy for dealing with linguistic resources. When statistical methods examine its characteristics, an adequate degree of dependability is frequently achieved (Smith et al., 2000). Morris argues that the content analysis method enables the researcher to avoid distractions due to subjective consciousness and, as a result, to analyze the information (Morris, 1994) better. Policymakers and policy implementers use policy tools to achieve one or more policy goals (Gu, 2006). Based on the analytical perspective of policy tools, current Chinese CE reduction policies' characteristics, patterns, and trends can be understood more deeply (Qin et al., 2020). Therefore, based on the content analysis method, the contents of CE reduction policy texts are analyzed according to the following three dimensions: 1) policy tools, 2) development stages, and 3) policy implementation objects.

NVivo is a qualitative data processing program that excels at handling many sorts of data, making it the greatest tool for qualitative research (Leech and Onwuegbuzie, 2011; Zamawe, 2015). The detailed coding process for the 53 policy documents using NVivo software was as follows: 1) the 53 CE reduction policy documents into NVivo 12 Plus software were imported to create policy instrument, development stage, and policy implementation object tree nodes; 2) corresponding sub-nodes were created under each tree node according to the specific classifications under different dimensions; 3) based on the principle of content analysis, the sample policy in the content was coded line by line and word by word, and a total of 725 reference points was obtained.

The policy samples were logically sorted, and each dimension was then cross-analyzed to explore the development status and characteristics of China's CE reduction-related policies. Some scholars have previously conducted quantitative studies on CE reduction policies, but there are still some shortcomings. First, the

TABLE 1 | Categories of CR policy tools.

Category	Policy tools	Definition and examples
1. Supply-oriented	1.1 Low-carbon information technology	Energy-efficient technologies that reduce CEs and promote carbon sequestration. Examples include advanced energy and manufacturing technologies, efficient transportation technologies, and other aspects
	1.2 Pilot construction	New models for implementing low carbon in certain regions or areas are prioritized. Examples include building low-carbon provinces and cities, low-carbon cities, and carbon trading pilots
	1.3 Infrastructure development	Infrastructure is built to reduce the level of CEs. Examples include building energy-efficient and low-carbon infrastructure
	1.4 Financial input	Special funds and financial resources to support low-carbon development. Examples include increasing the investment in low-carbon technology research and development and pilot construction
	1.5 Cultivation of talents	The cultivation of officials and technicians who promote CR. Examples include building a system of carbon peak and carbon-neutral talents and encouraging relevant disciplines in higher education
	1.6 Carbon trading market	The govt-promoted constructed a carbon trading system and market. Examples include building a CE trading market and developing a general scheme for CEs trading
2. Demand-oriented	2.1 govt procurement	The govt procurement of energy-saving products. Examples include increases in the proportion of energy-saving and the procurement of environmentally friendly products
	2.2 Control of trade	The govt-restricted development of high-emission projects. Examples include controlling fossil energy consumption and limiting credit support
	2.3 International exchange and cooperation	Participation in global climate governance. Examples include developing multi-channel project cooperation and learning from advanced foreign technologies
	2.4 Outsourced Services	CR efforts are outsourced to other professional services by the govt. Examples include regulating CR efforts and developing low-carbon standards
	2.5 Support the low-carbon industry	The govt supports the development of green industries. Examples include developing low-carbon tourism and promoting energy-saving and CR in the service industry
	2.6 Determination criteria	The development of pollutant emission standards and low-carbon standards. Examples include carrying out top-level design and the systematic planning of a system of green standards
3. Economic environment	3.1 Target Planning	Policies for CE reduction development planning. Examples include low-carbon transportation strategic planning
	3.2 Support of finance	Financial support for energy efficiency projects. Examples include diversified financing support for key energy conservation and emission reduction projects
	3.3 Regulatory control	CR efforts through legislation. Examples include the revision of laws regarding air pollution prevention and control
	3.4 Supervision and management	The govt monitors and assessment of energy conservation and emission reduction efforts. Examples include a comprehensive national regulatory system for greenhouse gas emissions control
	3.5 Strategic measures	Various measures are implemented by govt for each industry. Examples include optimizing the energy structure and restructuring the industry
	3.6 Tax incentives	Tax incentives for low-carbon industries. Examples include using tax incentives to promote the application of low-carbon product research and development

Chinese govt has released a considerable number of CE reduction policies in recent years, and previous scholars' studies have not covered this part; second, no relevant studies have analyzed CE reduction policies from the three-dimensional perspectives of policy tools time stages, and implementation targets. Therefore, this study was designed to improve research methods in CR policy texts.

3 THREE-DIMENSIONAL ANALYSIS OF CR POLICY

3.1 Development of a Three-Dimensional Analysis Framework

3.1.1 Policy Tools

Policy tools are the economic and social variables that govts use to influence policy variables, i.e., the means and methods that govts use to achieve policy goals (Schneider and Ingram, 1990). Policy tools have been broadly classified into two models: typology and taxonomy (Smith, 2002). The first classification system, developed by Rothwell and Zegveld, classifies policy tools into supply, demand, and environmental impacts (Hanson, 1982). The second classifies policy tools based on a taxonomy perspective. Policy tools are classified into regulatory instruments, economic and financial instruments, and soft instruments (Borrás and Edquist, 2013). Both classifications explore how the appropriate policy tools for a specific policy objective can be chosen. For this paper, Rothwell and Zegveld classify China's CR policies for 2007–2021 as supply-based, demand-based, or environmental-based, as shown in **Table 1**.

Supply-oriented policy refers to the govt's commitment to implementing CR efforts by providing funds, talents, and technologies to relevant units. Supply-oriented policy tools are divided into six areas according to the needs of the policy text: low-carbon technologies, financial investment, pilot construction, infrastructure development, talent training, and the carbon trading market.

Demand-oriented policies focus on govt regulation and procurement and the development of relevant standards. The govt acts as a third party to monitor and regulate the market,

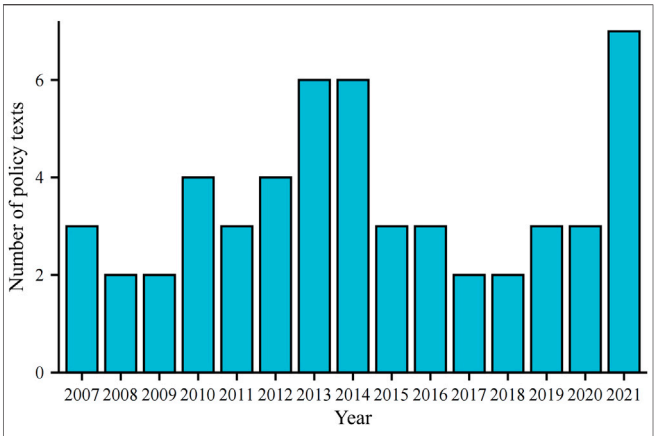

FIGURE 1 | Number of CR policies in 2007–2021.

encourage the production of energy-efficient and low-carbon products, and promote the development of green industries. Demand-oriented policy tools can be divided into govt procurement, trade control, international exchange and cooperation, service outsourcing, support for low-carbon industries, and the recognition of standards.

Environmentally oriented policy tools refer to the government's indirect influence on CO_2 emissions through financial support and strategic measures to create a favorable economic environment for CE reduction efforts. Environmentally oriented policy tools can be divided into five categories: target planning, financial support, regulatory control, supervision and management, strategic measures, and tax incentives. Strategic measures mainly include a series of policies for high-emission industries such as industry, transportation, and agriculture.

3.1.2 Stages of CE Reduction Policy Development

Matching the policy tools with the stages of CE reduction development provides insight into the policy points and policy trends at each stage of CE reduction development. From a global perspective, China started late with a series of CE reduction measures to address CC. However, the overall development rate is fast, and related policies have been introduced for various high-emission industries. Cheng and Jiang divided the study of low carbon in China into two phases: the start-up period from 2007 to 2010 and the acceleration period from 2011 to 2015 (Chen and Jiang, 2017), which coincides with the time when the Chinese govt formulated its 5-year plan. Therefore, considering that the govt formulates relevant policies according to the time point of the 5-year plan (Wang and Chang, 2014), this paper divides CR policies into phases according to the time stage of China's 5-year plan formulation. Policies issued from 2007 to 2021 are divided into four phases: 2007–2010, 2011–2015, 2016–2020, and 2021–present.

In 2007, the govt issued the China National Program to Address CC, which proposed to develop low-carbon energy and renewable energy through national policy guidance and financial investment. The State Council issued the 11th Five-Year Plan for National Environmental Protection, which encourages the increase of forest coverage. In 2011, China entered the 12th Five-Year Plan period. The 12th Five-Year Plan for controlling greenhouse gas emissions proposed for the first time the construction of a pilot CEs trading system and a regional CEs trading system. In this period, the govt plans to achieve energy savings of 670 million tons of standard coal, and in 2016, the State Council identified high-emission areas such as industry, construction, transportation, and agriculture as

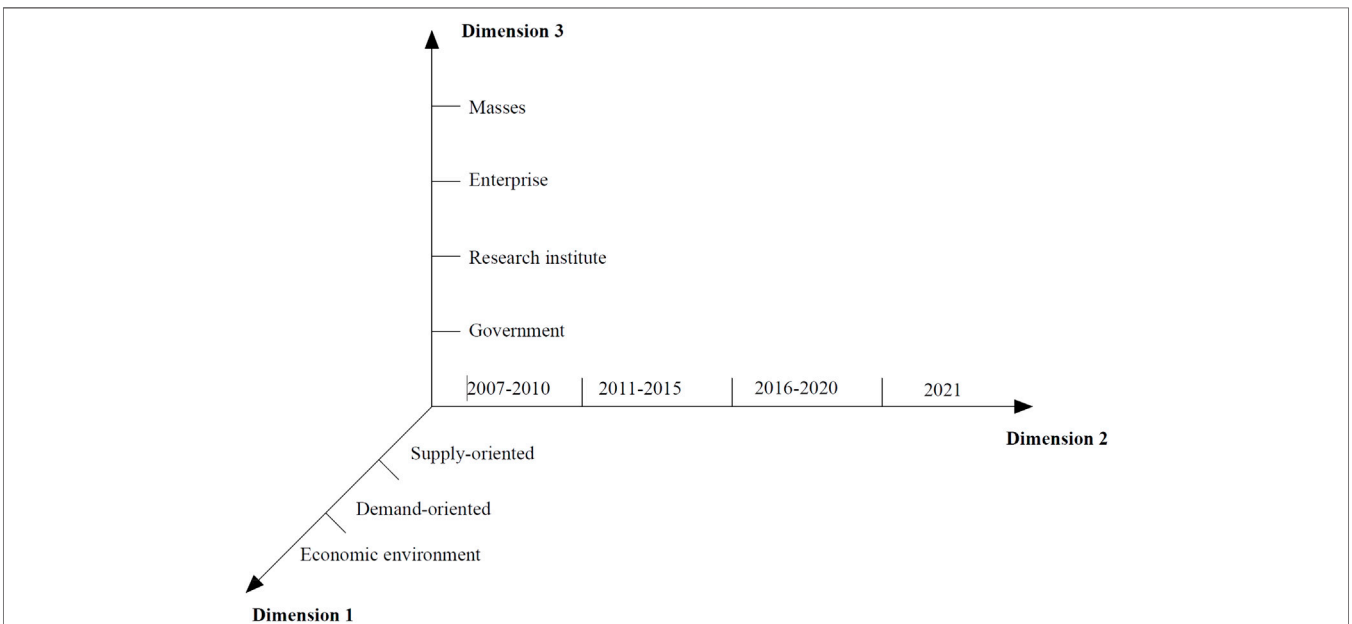

FIGURE 2 | Three-dimensional analysis framework of CR policy.

TABLE 2 | Distribution of policy implementation objects.

Description	2007–2010	2011–2015	2016–2020	2021–Present	Total	Proportion (%)
1. govt	29	37	25	10	101	25.25
2. Research institute	19	26	21	13	79	19.75
3. Enterprise	35	56	32	22	145	36.25
4. Masses	13	32	22	8	75	18.75

crucial emission reduction targets. In 2021, for the first time, the Chinese govt included "carbon peaking" and "carbon neutral" in a govt work report. In 2021, the Chinese govt included "carbon summit" and "carbon neutral" in a govt work report for the first time and formulated the Ten Carbon Summit Actions. A working group has been established to ensure that carbon peaks are achieved by 2030 and that carbon neutrality is achieved by 2060.

Policy development for reducing CEs and social and economic development (**Figure 1**). There are 11 policies related to CE reduction from 2007 to 2010, 22 from 2011 to 2015, 13 from 2016 to 2020, and 7 from 2021 to the present.

3.1.3 CE Reduction Policy Implementation Objects

The govt implements its strategies through specific instruments, and the policy implementation object is also an important research aspect. Man used the policy implementation object as the third dimension in analyzing the policy of marine pasture construction, and its policy subjects were divided into enterprises, universities, research institutes, and intermediaries (Qin et al., 2020). During the systematic analysis of China's low-carbon policy and low-carbon transition, policy subjects were divided into govt, enterprises, and civil society organizations (Qian and Zhang, 2011). The subjects involved in implementing a series of CE reduction measures by the Chinese government include govt departments, scientific research institutions, enterprises, and the public.

3.2 Three-Dimensional Policy Analysis Framework

Policy tools, as output mechanisms of the govt's role, are means to achieve one or more policy goals (CNKI, 2021). Many policies themselves are also policy tools, so the study of policy tools is also the study of policy (Bjärstig and Sandström, 2017).

Policy tools are a scientific and effective method for studying policies, and policy tools for national policy analysis have been evolving in recent years. Therefore, establishing a framework for CE policy analysis based on the policy tool perspective can provide a deeper grasp of China's CE policy system's characteristics, laws, and trends. The basic idea of policy instrument analysis is to take policy structuredness as the fundamental theoretical basis, highlight the structural characteristics of the policy, and consider that policy is constructed by a series of essential unit tools reasonably organized and matched and can reflect the public policy values and concepts of policymakers.

The three-dimensional analysis framework of CR policy and its elements in each dimension are shown in **Figure 2**.

3.2.1 The Use of Policy Tools in Different Time Intervals

The 53 policy documents were coded from Dimension 1 through NVivo 12 Plus software, creating 725 reference points for 18 of the three types of policy tools. The magnitude of the numbers in **Table 2** reflects the frequency of use of the different policy tools. The usage rate of supply-based policy tools was 32.28%, the usage rate of demand-based policy tools was 16.55%, and the usage rate of environmental new policy tools was 51.17%. The results indicate that the govt prefers environment-based policy tools and pays less attention to demand-based policy tools during the study period. To further investigate the use of carbon abatement policy tools in different periods, the matrix coding function of NVivo12 Plus software was borrowed. A cross-tabulation analysis of the policy tools and different phases of CE reduction policies was conducted to obtain a two-dimensional matrix distribution table (**Table 3**).

During the study period, the Chinese govt relied heavily on the use of environment-based policy tools for CR efforts (**Figure 3**). The Chinese govt introduced CE reduction policies late in the early 20th century, while more initiatives were used to reduce sulfur dioxide emissions. Therefore, govt departments used economic and environmentally oriented policy tools to advocate the development of a circular economy to provide a favorable environment for CE reduction development and to secure resource supply. Strategic measures account for the highest proportion among the environmental policy tools, with an overall inverted U-shaped curve development trend. In the early stage of development, the government's focus is on adjusting the industrial structure and optimizing the energy structure. In 2011, the 12th Five-Year Plan proposed a series of corrective measures for, e.g., industry, construction, transportation, and agriculture and encouraged the promotion and application of low-carbon technologies. However, the policy does not cover enough scope in transportation, and the relevant content of road maintenance policy can be added appropriately (Madhopur and El-Diraby, 2021). Regulatory policy tools are distributed in different development stages, mainly including laws and regulations promulgated by the government and the formulated supervision and assessment system.

On the one hand, the relevant laws and regulations are improved, and the Action Plan for Energy Conservation and Low Carbon Development 2014–2015 proposes to promote the revision of the Energy Conservation Law and the Air Pollution Prevention and Control Law to provide a legal basis for CE reduction work. On the other hand, energy conservation and emission reduction statistics and a monitoring and assessment

TABLE 3 | Two-dimensional distribution table of Dimension one and Dimension two matrices.

Indicators	Description	2007–2010	2011–2015	2016–2020	2021–Present	Total	Proportion (%)	
1. Supply-oriented	1.1 Low carbon information technology	22	26	10	8	66	9.10	32.28
	1.2 Pilot construction	13	31	16	5	65	8.97	
	1.3 Infrastructure development	2	12	1	9	24	3.31	
	1.4 Financial input	8	15	7	2	32	4.41	
	1.5 Cultivation of talents	8	9	4	4	25	3.45	
	1.6 Carbon trading market	0	12	5	5	22	3.03	
2. Demand-oriented	2.1 govt procurement	2	5	2	2	11	1.52	16.55
	2.2 Control of trade	10	8	5	5	28	3.86	
	2.3 International exchange and cooperation	11	13	7	3	34	4.69	
	2.4 Outsourced Services	0	0	0	0	0	0.00	
	2.5 Support the low-carbon industry	1	5	7	2	15	2.07	
	2.6 Determination criteria	7	13	8	4	32	4.41	
3. Economic environment	3.1 Target Planning	12	13	6	5	36	4.97	51.17
	3.2 Support of finance	7	12	8	2	29	4.00	
	3.3 Regulatory control	22	21	16	4	63	8.69	
	3.4 Supervision and management	19	23	20	5	67	9.24	
	3.5 Strategic measures	35	56	40	27	158	21.79	
	3.6 Tax incentives	4	8	4	2	18	2.48	
Total	183	282	166	94	—	—	—	—
Proportion (%)	25.24	38.90	22.90	12.97	—	—	—	—

system were constructed, and the energy conservation management, monitoring, and service "trinity" of the energy conservation management system was gradually completed to achieve data sharing. In the construction of a system, the recommendations of a policy should refer to research literature for more detailed implementation of that policy (Deetjen et al., 2018). Promoting enterprises to reduce CO_2 emissions implies technological upgrades and increased production costs. Among the economy-based policy tools, financial support and tax incentives account for the lowest percentage, indicating that current policies do not pay enough attention to these two policy tools. This is mainly reflected in the lack of corresponding supporting policies and specialized policy contents. Financial support mainly includes credit support for low-carbon technologies and products, but no specific document will be issued until 2021. The document entitled "Opinions on Comprehensively Implementing the New Development Concept to Achieve Carbon Neutrality" proposes establishing a "CE reduction currency" and a national low-carbon transition fund to guide banks and other financial institutions to provide long-term financial institutions, low-cost funds for green and low-carbon projects. This series of measures can provide long-term and stable financing support for achieving carbon peaking and carbon neutrality.

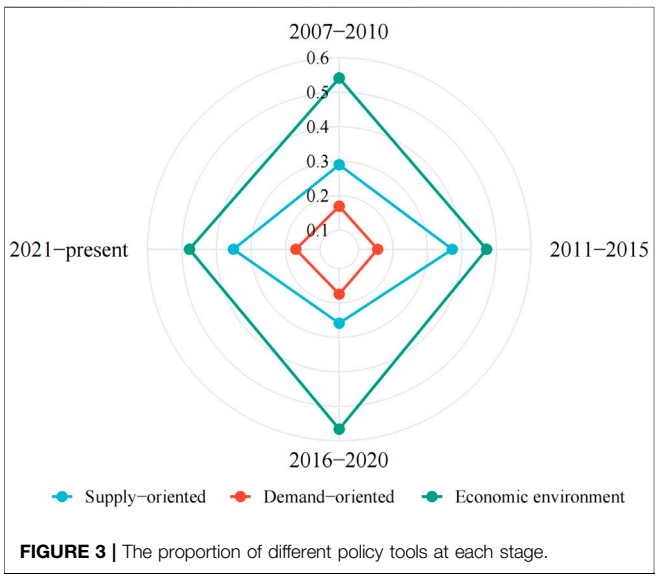

FIGURE 3 | The proportion of different policy tools at each stage.

The Chinese govt also frequently uses supply-based policy tools when promoting CR efforts. Among them, low-carbon information technology and pilot construction are used most frequently. The govt acts as a leading force to promote the development and diffusion of low-carbon technologies across industries; it encourages regions to build low-carbon pilots. At the same time, the govt pays attention to low-carbon and intelligent infrastructure development. However, it mainly focuses on the transportation industry, logistics, parks, and urbanization. China's Policies and Actions to Address CC in 2021 propose leading rural revitalization with green development and conducting demonstrations of ultra-low energy consumption in certain areas. The countryside is also an important area for implementing CR, and this initiative makes up for the ambitious blueprint of a region-wide layout. Talent is the key to accomplishing low-carbon targets. Cultivating scientific and innovative talents can enhance the R&D capability of low-carbon technologies. The Chinese govt has been advocating the strengthening of

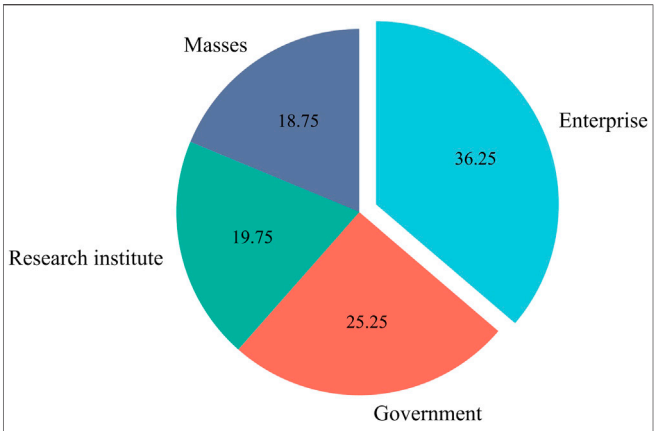

FIGURE 4 | The proportion of policy implementation objects.

the talent pool through education and training since 2007, but there is a lack of targeted policy guidance. Financial investment has mainly been used for technology R&D and pilot construction, but the current policy lacks a transparent financial support system. Implementing a series of CE reduction measures will undoubtedly increase the production costs of enterprises, while carbon peaking and carbon neutrality require long-term adherence to low-carbon construction in various industries. Therefore, the policy should introduce a systematic financial support policy to attract more corporate investment.

Demand-oriented policy tools can help reduce market uncertainty and open up the CE reduction market, thus promoting CE development. Therefore, demand-oriented policy tools play a pivotal role in CE reduction. Regarding the number of uses of policy tools, the importance of the policy tools does not significantly match the number of uses. Govt procurement mainly includes green office supplies, and its procurement scope must be expanded to other aspects; additionally, the use of policy combinations can be increased (Yang et al., 2021a). Among these demand-oriented policy tools, the govt mainly focuses on developing low-carbon standards and the regulation of high-emission industries. In addition to curbing the blind development of high-energy-consuming and high-emission projects, the govt should also develop international cooperation to support the "going out" and "coming in" of energy conservation and environmental protection industries. The next step focuses on how others can learn from the CR experience of developed countries and how developing countries can be driven to carry out CR work.

3.2.2 Implementation Subjects in Different Time Intervals

In order to improve the effectiveness of policy implementation, the govt enacted specific policies with differences for different subjects. **Table 3** shows the distribution of implementation targets in different time intervals. Among them, enterprises and govt departments account for most of the policies, with 36.25 and 25.25%, respectively. Scientific research institutions and the public show similar percentages, 19.75 and 18.75%, respectively (**Figure 4**). The govt guides enterprises and the public to carry out a series of energy-saving and low-carbon actions to promote CE reduction. For example, in 2014, the Notice on the Organization of Low-carbon, Energy-saving, and Green Circulation Actions proposed to guide public institutions to carry out "resource recycling, look to me" actions to reduce the number of disposable items used. However, there is a lack of responsible persons for each action, and no complete accountability mechanism has been established. Until 2021, China's Policies and Actions to Address CC announced the establishment of the Leading Group for Carbon Neutrality to guide and coordinate the work on carbon peaking and carbon neutrality. Guiding the public to develop a low-carbon lifestyle is another essential element, such as promoting the "135″ green travel mode (walking within 1 km, cycling within 3 km, and taking public transportation around 5 km). However, the policy content is unclear in terms of division of labor and responsibility, and most of the content is proposed and recommended, making the policy not very operable. In the next step, the govt needs to develop a targeted and clear division of labor policy contents for the characteristics of govt departments, research institutions, enterprises, and people involved in the policy.

4 EVOLUTION OF CE REDUCTION POLICIES

China's CE reduction policy system is gradually improving, but many policies are still biased toward the macro level. There is a lack of policy guidance and regulation for different industries and entities. This is an issue that the Chinese govt will focus on. This paper compares the CE reduction policies issued by the Chinese govt from 2007 to the present and divides them into four development stages according to the time when China formulated its 5-year plan.

The early policies from 2007 to 2010 mainly reformed the energy supply industry from the macro-level to reduce CO_2 emissions. The policy themes focused on the formulation of relevant laws and regulations and promoting advanced technology development. After signing the United Nations Framework Convention on CC, China adopted a series of policies and measures to address CC. For example, the Law of the People's Republic of China on Energy Conservation was revised to establish a strict energy conservation management system. Meanwhile, funds have been invested in engineering carbon sequestration, renewable energy, and new energy development and utilization technologies (Wang and Chang, 2014). For agriculture, forests, and other ecosystems, overall development directions are proposed to determine the importance of a solid ecological state. Second, reducing CO_2 emissions requires the participation of all members of society. Based on the principle of joint participation, China has put forward advanced concepts such as implementing the scientific concept of development and adhering to the path of sustainable

development. The public and cadres of the authorities are constantly guided to establish an awareness of energy conservation, create a favorable environment for low-carbon development, and mobilize the public as much as possible.

2011–2015 is the 12th 5-year planning period in China. The number of CE reduction policies has increased rapidly, and the content of the policies has gradually developed towards diversification. In 2012, the State Council issued the 12th Five-Year Plan to control greenhouse gas emissions, in which the establishment of a CEs trading market was proposed for the first time, providing policy guidelines for CEs reduction trading. At the same time, to more accurately account for CD emissions, the govt has adjusted the scope of the energy statistics survey and refined the energy statistics classification standards to ensure that the data is true and accurate. With the responsibility and commitment of great power, China has actively participated in multilateral processes related to CC. The National Plan for Addressing CC (2014–2020) puts forward matters related to international exchanges and cooperation.

On the one hand, it promotes cooperation with developed countries and introduces advanced climate-friendly technologies and successful experiences from developed countries. On the other hand, it supports capacity building in developing countries and enhances in-kind support for relevant developing countries to cope with CC. The Chinese govt has started to consider how to promote CE reduction from an international perspective.

From 2015 to 2020, the content of CE reduction policies has become more specialized, and the policy system has been improved. From the previous single subject to multiple specific policies. The Chinese govt plans to achieve carbon peaking by around 2030, and the 13th Five-Year Plan to Control Greenhouse Gas Emissions has proposed specific programs for various sectors and industries. For example, it will reduce the intensity of CEs and support regions with the conditions to achieve the first CEs peak by 2020. The development of low-carbon development pilot demonstration provides construction experience for regional low-carbon development (Zhao and Wang, 2021). The 13th Five-Year Plan for Energy Conservation and Emission Reduction proposes corrective measures for industry, transportation, and agriculture to reduce CD emissions. For example, it restricts the purchase of traditional cars and promotes new energy vehicles to reduce CD emissions (Yang et al., 2021b). The Three-Year Action Plan for Winning the Blue Sky Battle supports the construction of low-carbon pilot projects and the guidance of universal participation in energy conservation and emission reduction, mobilizing broad participation from the whole society. The 14th Five-Year Plan and 2035 Vision for National Economic and Social Development propose to adhere to the concept of green water and green mountains and to promote the comprehensive green transformation of economic and social development, from rapid development to high-quality development.

Carbon peaking and neutrality were written into the document as major strategic decisions in 2021. The Action Plan for Carbon Peaking by 2030 and the Comprehensive Implementation of the New Development Concept for Carbon Peaking and Carbon Neutral Work clearly define the objectives of China's CE reduction work and develop carbon peaking implementation plans for energy, industry, urban and rural construction, transportation, agriculture, and rural areas, and other sub-sectors and industries. The first is to reduce the total amount of CD emissions; the second is to strengthen the capacity of ecosystems to sequester carbon. In terms of finance, a "CE reduction currency" will be established to provide financial support for low-carbon projects. At the same time, we will pay attention to international exchanges and cooperation, promote the construction of green "one belt and one road," take new energy and other green low-carbon technologies and products out of the country, and improve the level of green low-carbon development in the open world. The Program for Improving the Dual Control of Energy Consumption Intensity and Total Volume will curb the blind development of high-energy-consuming and high-emission projects as an essential element to grasp the work of carbon peaking and carbon-neutral and gradually form a set of perfect institutional systems and regulatory systems. Ensuring the completion of the carbon peak and carbon-neutral target will become an essential part of the Chinese government's future CR work.

5 CONCLUSION AND POLICY RECOMMENDATIONS

The govt plays a vital role in guiding and supervising the work of promoting CE reduction. A comprehensive and targeted policy is a vital tool to guarantee the implementation of CE reduction efforts and a necessary tool to promote sustainable development. This paper proposes a new research perspective and designs a three-dimensional analytical framework for CE reduction policies. It focuses on how China's CE reduction policies have developed and evolved under the perspective of policy tools. This paper collects CE reduction-related policies promulgated by the Chinese govt from 2007 to 2021 from authoritative legal websites. NVivo software was used to conduct word frequency statistics on policy texts to identify policy topics initially. The policy texts are divided here into policy tools, development stages, and policy implementation objects based on content analysis, and the development characteristics and evolutionary logic of CE reduction policies are explored from three dimensions and cross-dimensions. The conclusions of this paper are combined with the actual context to provide policy recommendations.

5.1 Conclusion

This paper examines 53 CE reduction policies issued by the Chinese govt since 2007. The evolution of CE reduction policies is divided into four stages according to the points in time when China formulated its 5-year plans: the 11th 5-year plan period (2007–2010), the 12th 5-year plan period (2011–2015), the 13th 5-year plan period (2016–2020), and the 14th 5-year plan period (2021–present). The number of govt policies on CE reduction increased during the 12th Five-Year Plan period and then entered a slow development phase. In 2021, the Guidance of the State Council on Accelerating the Establishment of a Sound Economic System of Green, Low-Carbon, and Circular

Development proposed to improve the production, distribution, and consumption system of green, low-carbon, and circular development placing increasing emphasis on CE reduction. The number of CE reduction policies promulgated by the govt per year is also increasing.

In the evolution of CE reduction policies, the govt used the most environment-based policy tools, which accounted for 51.17% of the total. Supply-based and demand-based policy tools accounted for 32.28 and 16.55%, respectively. In practice, the govt tends to use push and pull strategies to achieve its goals. The govt-issued 260 key energy-saving technologies in 13 industries, including coal, electricity, and steel. It also strengthened energy conservation regulations and standards constraints and issued and implemented more than 340 national energy conservation standards to implement a double degree of control over energy consumption intensity and total volume. In industry, transportation, and construction, among others, CD emissions are strictly controlled.

On the one hand, the govt is trying to reduce the amount of CO_2 as much as possible; on the other hand; it is enhancing the ecological carbon sequestration capacity to implement CE reduction efforts from various aspects to remove the potential impact of CO_2 on China's sustainable development goals. However, demand-based policy tools account for a relatively small proportion of the total, and the govt should play a leading role in CR efforts to increase the use of demand-based policy tools.

The percentages of enterprises, govt departments, research institutions, and the public in the targets of policy implementation are 36.25, 25.25, 19.75, and 18.75%, respectively. The govt encourages certain enterprises to participate in domestic CEs trading and guides enterprises and the public to carry out energy-saving and low-carbon actions. Although the policy prohibits new projects in overcapacity industries, specific penalties have yet to be introduced for high-energy-consuming enterprises. Based on many regulatory policies, penalties and incentives should be added to form a solid procedural constraint on the target of implementation

5.2 Policy Recommendations

Based on the above analysis of policies related to CE reduction and some of the conclusions found, this paper provides the following three recommendations for future policy formulation.

1) Decompose CO_2 emission reduction targets. China has committed to peak CO_2 emissions by 2030 and achieving carbon neutrality by 2060. The govt should adopt more robust policies and measures in key emission sectors such as energy, industry, urban and rural construction, transportation, and agriculture and rural areas to help promote high-quality development. It should set specific CE reduction targets for different industries and design an overall implementation path of "carbon peaking" and "carbon neutrality" to achieve appreciable low-carbon and sustainable development.
2) Increase financial instruments and strengthen the formulation of laws and regulations. In the study area of this paper, the State Council and the Central Committee of the Communist Party of China have mainly proposed advocacy and regulatory measures at the macro level. These groups should promote the market-oriented reform of CEs, build a carbon trading system and market, and increase the scope of tax incentives. In addition, the govt should strengthen the introduction of relevant laws to produce more substantial legal constraints on the production and activity behavior of enterprises, the public, and other subjects.
3) Enrich demand-oriented policy tools and increase the portfolio of policy tools. The govt tends to use recognition standards, trade controls, and international exchange and cooperation to motivate all social actors' willingness to implement CR. However, these three policy tools have limited demand incentives, and policy content is insufficient. The govt should increase the number of demand-oriented policy tools. For example, it can set up an outsourcing program to allow only low-carbon and economic enterprises to compete, or it can increase procurement to guide green consumption and promote green products, thus promoting technological upgrading and lifestyle changes. Through these measures, the govt can improve its policy tools and guide all of society to participate in CE reduction efforts.

5.3 Future Research Work

This paper analyzes the CE reduction policies enacted in China based on a three-dimensional analytical framework; however, this area still needs to be further explored. 1) This paper focuses on the supply-based, demand-based, and environment-based analysis of CE reduction policies. Research on CE reduction from the perspective of regulatory, financial, and soft instruments is still needed. 2) The govt's policy formulation is a process that evolves with time, and policymakers will make new adjustments to the content of policies based on experience, so the latest trends of the Chinese govt's CR policy should be continuously followed. 3) This paper uses a qualitative approach to analyze CE reduction policies, but what is the specific impact of the enacted policies on local CO_2 emissions? It is necessary to construct a mathematical model and conduct an in-depth study with actual data.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

All of the authors contributed to the study. Conceptualization: WZ and CZ; software: CZ and SW; supervision: QZ and AR; writing (original draft): WZ, CZ, and AS; writing (review and editing): WZ and CZ All authors have read and agreed to the published version of the manuscript.

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