

Article

The Evolution of Biodiesel Policies in China over the Period 2000–2019

Chao-chen Chung *, Yapeng Zhang, Lina Liu, Yixuan Wang and Ziji Wei

School of Political Science and Public Administration, Wuhan University, Wuhan 430072, China; 2018201150036@whu.edu.cn (Y.Z.); llwork999@163.com (L.L.); 2017302430048@whu.edu.cn (Y.W.); 2017302430001@whu.edu.cn (Z.W.)

* Correspondence: chaochen.chung@gmail.com or 00032104@whu.edu.cn

Received: 9 July 2020; Accepted: 4 August 2020; Published: 6 August 2020



Abstract: The Chinese government launched policies supporting biodiesel production and innovation to meet sustainable energy demands under rapid economic and social development. This study systematically investigates the dynamic transitions of biodiesel policies in China regarding policy contents and policy networks. We performed a content analysis in this study and used NVivo12 software to support the analysis process. The results highlighted some issues. First, the Chinese government supported the development of biodiesel from multiple policy objectives and adopted various policy instruments, eventually transforming biodiesel in China from the first- to second-generation. Second, the State Council was the main institution to promote biodiesel policies, and the National Development and Reform Commission under the State Council burdened most of the responsibilities of policy implementation. Most of the policies were issued at a lower level of administration rather than a higher level of decision-making. Biodiesel policies in China were gradually detailed, and they constantly established a system of technology and product innovation.

Keywords: biodiesel; policy; China; content analysis; policy transitions

1. Introduction

Biodiesel reduces using fossil fuels and considerably decreases the emissions of greenhouse gases (GHG) and became significant for renewable energy [1–4]. First-generation biodiesel, currently in widespread production, is derived from various feedstocks, such as used cooking oil, and second-generation biodiesel, only a few of which are close to large-scale commercialization, is derived from multiple feedstocks and refining technologies, such as algae [5,6]. Since the United Nations Framework Convention on Climate Change in 1992 revealed the principle for the transformation to more sustainable modes of production and consumption, the Kyoto Protocol, which came into force in 2005, required Annex I countries (mostly developed countries) to reduce their GHG emissions to 5% below the levels of 1990. Once the Kyoto Protocol ends in 2020, the Paris Agreement, which came into force in 2016, should continue strengthening the global response to the threat of climate change and keep the global average temperature well below 2 °C above preindustrial levels. Under this agreement, both developed and newly industrialized countries were required to submit emissions reduction targets based on their nationally determined contributions [7]. Therefore, national governments globally accelerated the production and innovation of biodiesel as a solution for reducing GHG emissions [8–12].

China, as one of the newly industrialized countries, launched policies to support biodiesel production and innovation to meet sustainable energy demands under rapid economic and social development [13,14]. This article evaluates biodiesel policies according to the research, technology, development, and innovation (RTDI) policies of biodiesel. Technological Policy of Pollution Control for Diesel Vehicles, introduced in 2003, revealed the starting point at which China's government

formally encouraged the innovation of biodiesel to reduce GHG emissions and mitigate climate change. After the 11th Five-Year Plan for the Development of Biological Industry in 2007, biodiesel was, for the first time, formally included in the long-term national industrial plan for the development of biotechnology. It was also established as a domestic industry to help the country realize opportunities for the innovation of biotechnology. Only after the 12th Five-Year Plan for Bioenergy Development issued in 2012, biodiesel was officially embedded in the specific national long-term plan of bioenergy and synthetically supported as a strategic industry that would speed up technological innovation of bioenergy, optimize energy supply, and achieve a sustainable low-carbon economy. As policy instruments transitioned, the priority of multiple policy objectives for the development of biodiesel evolved. Moreover, the policy networks that implemented these policies also exhibited divergent dynamics in different periods, which are worthy of further exploration [15,16].

This article adopts the content analysis method and systematically investigates the dynamic transitions of biodiesel policies in China. Since no literature synthetically portraying the evolution of China's biodiesel policies exists, we make one of the first attempts to fill the empirical gaps of current research. The theme of this article explores the evolution of policy contents and actors' networks, which incentivized policy change. Therefore, we set up two research questions: (1) How did biodiesel policies transit in China regarding policy objectives and policy instruments? (2) How did policy networks of biodiesel evolve through the transitions of the policies? The method of content analysis was adopted to survey the two research questions through the three phases of preparation, organization, and reporting of results to increase the trustworthiness of our study [16,17]. First, we constructed an analytical framework, involving three dimensions, namely the date of policy promotion, the structural hierarchy within the government and policy types to review the policy texts. Then, to investigate the evolution of policy contents, we encoded the analysis categories based on existing literature. Finally, we discuss our results logically regarding the transitions of policy contents and the evolution of policy networks. The rest of the article is organized into four sections. Section 2 focuses on the research method, Section 3 presents the results of policy transitions, Section 4 portrays the evolution of policy networks, and Section 5 discusses and concludes the article.

2. Research Method and Analysis Processes

This study adopted content analysis as a research method. As described by Elo and Kyngas [18], content analysis is a widely used qualitative research method, and it conceptually describes the empirical phenomenon. Since we want to explain the empirical experiences of China's biodiesel policies based on the fundamental concepts of policy analysis, content analysis is a suitable research method for our study. Following Elo et al. [19], to improve the trustworthiness of a content analysis study, researchers should scrutinize the indications at every phase of the analysis process, including the preparation, organization, and reporting of results. The preparation phase must identify the trustworthiness of the data collection and sampling strategy, the organization phase is concerned with the categorization and interpretation and the reporting phase should report the results systematically and logically. We display the analysis processes of the preparation and organization phases in this section, and we further show the results in Sections 3 and 4.

2.1. Data Collection and Sampling Strategy

First, we collected data by searching for the official websites of the institutions within the central government. These websites included the Communist Party of China Central Committee, the National People's Congress (NPC), and the State Council and its subordinate ministries, including the National Development and Reform Commission, Ministry of Finance, and Ministry of Science and Technology. We obtained publicly promulgated policies since the reform and opening in the 1970s addressing the development of biodiesel by backtracking and searching for the relevant contents in the literal materials and policy texts. Since relatively fewer policies related to specifically biodiesel exist, our search terms included biodiesel and other related terms, such as bioenergy, renewable energy, new energy,

and recycling economy. Finally, we collected the initial data of 63 policies issued by the institutions of the central government from 2003 to the end of 2019.

We purposively sampled our data, ensuring the correctness of the selected policies and rigorously shifted through 63 policies following two principles. First, only the documents whose main contents or at least a part of the contents are closely related to the development of biodiesel were selected. Second, the policy must be a legislative document or a normative document that was officially issued by the government, such as laws, plans, opinions, and notices. We identified 45 samples of effective policies (Table 1).

After we collected policy documents concerning the development of biodiesel in China, we organized the policy texts of 45 policies following the analytical framework originally established by Bai et al. [20]. The policy texts were reviewed by considering three dimensions, namely the dates of policy promotion, the structural hierarchy, and policy types (Figure 1). The policy promotion dates were mainly used to analyze the transitions of policy objectives and policy instruments, and they were divided into different periods, which will be further examined in Section 3. A structural hierarchy was adopted to express the changes of policy networks and displayed the longitudinal governance frameworks for decisions and the implementation of biodiesel policies. Furthermore, policy types were used to analyze the levels between policies, deepening the analysis of policy evolution, and changes of policy networks over time. The analytical framework in practice laid the foundation for the later encoding of policy texts.

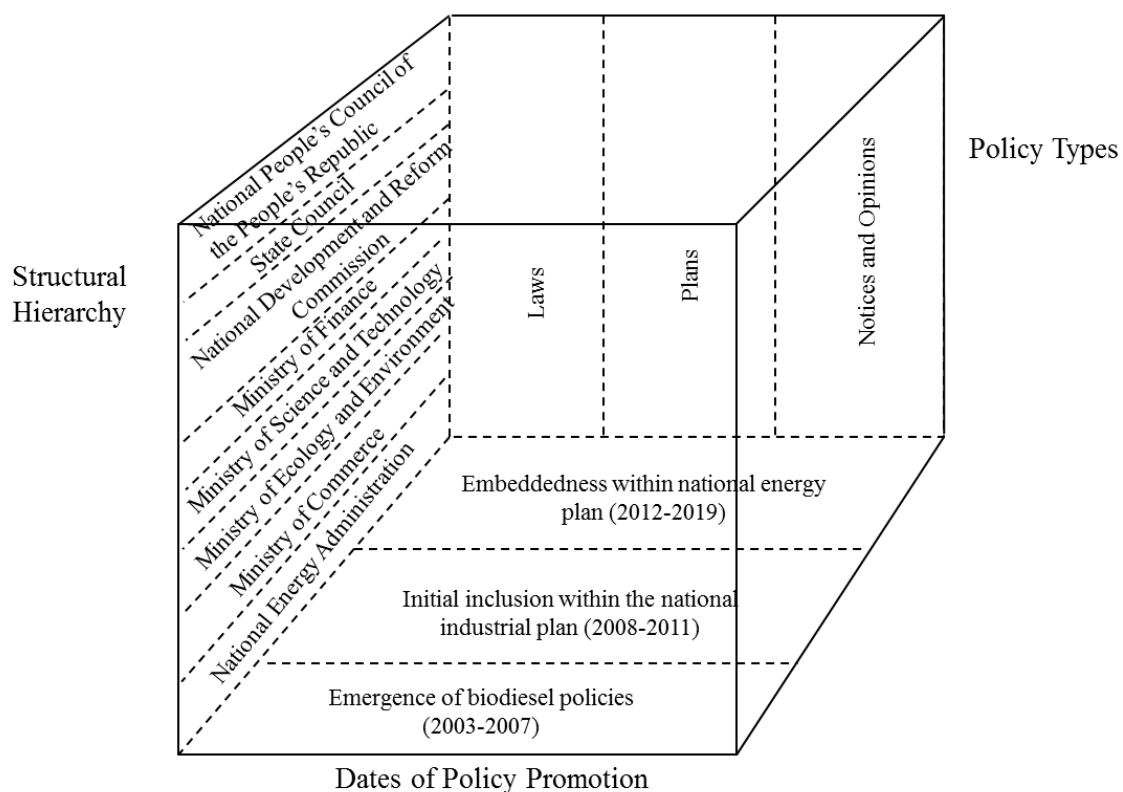


Figure 1. Analytical framework for policy texts.

Table 1. Policy samples.

Form	Document Number	Name of the Policy Document	Brief Summary and Qualitative Judgment of Policy	Date
Laws	1	Renewable Energy Law of the People's Republic of China	The state encourages the production and use of biological liquid fuels. Petroleum sales enterprises shall incorporate biological liquid fuels that meet national standards into their fuel sales systems in accordance with regulations.	February 2005
	2	Renewable Energy Law of the People's Republic of China (Revision of 2009)	The state encourages the production and use of biological liquid fuels. Petroleum sales enterprises shall incorporate biological liquid fuels that meet national standards into their fuel sales systems in accordance with the State Council's energy regulations.	December 2009
Plans	3	Technological Policy of Pollution Control for Diesel Vehicles	The state encouraging the development of technologies that use biomass and other raw materials to synthesize diesel.	January 2003
	4	The National special Plan for Technical Equipment Development and Major Industrial Technology Development	Focusing on developing key technologies for industrial-scale biodiesel production and process control	February 2005
	5	The Guide For Key Areas of Current Priority Development of High-tech Industrialization	Developing green biodiesel refining and chemical production technology	January 2007
	6	The of State Council 11th Five-Year Plan for the Development of Biological Industry	Supporting the production of biodiesel using agricultural and forestry oil plants as raw materials, and the development of new technologies and new processes for the utilization of waste oils such as catering industry oils and fats. Speeding up the formulation of technical standards. Speeding up the process of industrialization.	March 2007
	7	The Application Guidelines for 2007 Special Topics in the Field of 863 Program Resources and Environmental Technology	Developing unconventional pollution control technology for biodiesel alternative fuel vehicles	March 2007
	8	The Plan of International Science and Technology Cooperation Program for Renewable Energy and New Energy	Focusing on supporting the basic science and applied technology research of biodiesel.	November 2007
	9	The 11th Five-Year Plan for the Renewable Energy	Developing biodiesel production technology using oil plants as raw materials, and build several pilot projects. By 2010, the annual production capacity of biodiesel based on oil plants (crops) will reach 200,000 tons.	March 2008
	10	The 12th Five-Year plan for Science and Technology Development	Focusing on the development of key technologies and equipment such as biodiesel development and utilization, and strengthening the development and deployment of biological liquid fuel in five directions	July 2011
	11	The 12th Five-Year Plan for the Renewable Energy	Promoting the demonstration of biodiesel industrialization, scientifically guiding and standardizing the development of the biodiesel industry that uses catering and waste animal and vegetable fats as raw materials. Carrying out pilot R&D of 1000-ton biodiesel.	August 2012
	12	Energy Development Strategy Action Plan (2014–2020)	Strengthening the research and demonstration of advanced biomass energy technology, focusing on the development of biodiesel, and advancing the development and demonstration of microalgae oil production technology.	June 2014
	13	Biodiesel Industry Development Policy	Scientifically formulating a biodiesel industry plan, gradually forming an industrial pattern, clarifying industry access standards, promoting the application of biodiesel, strengthening technological innovation, providing financial and market support, and strengthening supervision and management.	November 2014
	14	Guidance Catalogue for Foreign Investment Industries (Revised in 2017)	Removing restrictions on foreign investment access in biodiesel production and other fields.	July 2017

Table 1. Cont.

Form	Document Number	Name of the Policy Document	Brief Summary and Qualitative Judgment of Policy	Date
Notices and Opinions	15	Notice on Issuing the Catalogue of Comprehensive Utilization of Resources (Revised in 2003)	Using waste animal and vegetable oils to produce biodiesel and special oils.	January 2004
	16	Notice	Applying biodiesel production technology	October 2005
	17	Notice on Issuing the Interim Measures for the Management of Special Funds for Renewable Energy Development	The focus is to support the development of bioethanol fuel, biodiesel, etc.	May 2006
	18	Notice on Printing and Distributing the Minutes of the Working Conference on Non-Food Biological Liquid Fuels	Carrying out industrialization demonstration. Paying close attention to the formulation of national standards for biodiesel and improve the marketing system of bioliquid fuel.	July 2006
	19	Opinions on the implementation of fiscal and taxation support policies for the development of bioenergy and biochemical	Support the implementation of national fiscal and taxation support policies	September 2006
	20	The Notice on Printing and Distributing Comprehensive Energy Saving and Emission Reduction Work Plan	Accelerating the basic research and preliminary preparation of biodiesel.	
	21	Notice on Interim Measures for the Administration of Non-grain Guided Incentive Funds for Bioenergy and Biochemical	Providing special funds to support biodiesel production expansion demonstration; clarifying fund application standards	May 2007
	22	The Notice on Printing and Distributing Medium and Long-Term Development Plan for Renewable Energy	Focusing on the development of biological liquid fuels. By 2010, the annual utilization of biodiesel will reach 200,000 tons. By 2020, the annual utilization will reach 2 million tons	July 2007
	23	Notice on the release of the Energy Conservation and Emission Reduction National Science and Technology Action Plan	Implementing the projects of technology research and development such as biodiesel development and application	August 2007
	24	Notice on comprehensive utilization of resources and VAT policies for other products	For the self-produced comprehensive utilization of biodiesel, the policy of VAT first collection and then retreat shall be implemented.	September 2007
	25	Notice on Issuing Certain Policies to Promote the Development of the Bio-industry	Promote the development of biodiesel and carry out application pilots in an orderly manner. The state gives appropriate support to biodiesel products.	December 2008
	26	Notice on the Exemption of Consumption Tax on the Production of Pure Biodiesel from Waste Animal and Vegetable Oils	Exemption of consumption tax on pure biodiesel produced using waste animal oil and vegetable oil as raw materials	June 2009
	27	Notice on Clarifying the Scope of Application of Consumption Tax Exemption for the Production of Pure Biodiesel from Waste Animal and Vegetable Oils	Clarifying the applicable scope of exemption of consumption tax for the production of pure biodiesel from waste animal and vegetable oils	December 2010
	28	Notice on Printing and Distributing 12th Five-Year Plan for biotechnology development	Develop common key technologies and special equipment for the manufacturing process of non-grain biodiesel products, and establish demonstrations of large-scale production technologies for bioenergy products.	June 2011

Table 1. Cont.

Form	Document Number	Name of the Policy Document	Brief Summary and Qualitative Judgment of Policy	Date
Notices and Opinions	29	Notice on issuing 12th Five-Year Plan for Energy Saving and Environmental Protection Industry Development	Encouraging the production of biodiesel from kitchen waste oil	November 2011
	30	Notice on Printing and Distributing the 12th Five-Year Plan for the Development of Biomass Energy	Clarifying key tasks such as scale, industrialization, key engineering organizations and technologies, and industrial system construction, providing safeguards and implementation mechanisms, estimating investment, and analyzing social and environmental impacts.	June 2012
	31	Notice on issuing 12th Five-Year Plan for Energy Saving	Promote alternative fuels such as alcohol ether fuel and biodiesel based on local conditions	July 2012
	32	Notice of the State Council on Printing and Distributing the Development Plan of Biological Industry	Building a bioliquid fuel industry chain. Increasing the research and development of cutting-edge technologies such as oil algae biodiesel and aviation biofuels, and promoting the demonstration of industrialization.	August 2012
	33	The Notice on Printing and Distributing Circular Economy Development Strategy and Immediate Action Plan	Encouraging the use of food and kitchen waste biodiesel. Promoting developing R&D technology for the utilization of fast food kitchen waste resources, optimizing the technological process route, and increasing promotion and application.	December 2012
	34	Notice on Clarifying the Purpose of Taxation of Refined Oil on Part of the Import Tax	Consumption tax is levied on biodiesel that meets the regulations, and the tax amount is 0.8 yuan/liter.	January 2013
	35	Notice on Further Promoting the Upgrading of Refined Oil Quality and Strengthening Market Management	Strictly stopping the sale of low-standard biodiesel on time	December 2013
	36	Notice on Printing and Distributing the 13th Five-Year Plan for the Development Biomass Energy	Promoting the application of biodiesel in transportation. To achieve an annual utilization of biodiesel of 2 million tons;	February 2016
	37	Notice on Printing and Distributing the 13th Five-Year Plan for Biological Industry Development	Improving the raw material supply system, orderly developing and utilizing waste oil resources and non-edible oil resources to develop biodiesel. Promoting the research and development of cutting-edge technologies such as cellulose biodiesel and bio aviation fuel, and promoting industrialization demonstration and market application.	October 2016
	38	Notice on Printing and Distributing The 13th Five-Year Plan for Renewable Energy Development	Upgrading and reform biodiesel projects to improve product quality and meeting transportation fuel quality needs. Promoting the industrialization demonstration application of biomass conversion and synthesis of high-grade fuel oil and bio aviation fuel.	December 2016
	39	Notice on Printing and Distributing the 13th Five-Year Plan for Energy Technology Innovation	Establishing a demonstration project of enzyme biodiesel industrialization. Developing key technologies for biojet fuel with complementary oils and sugar-based raw materials.	December 2016
	40	Notice on Printing and Distributing the 13th Five-Year Plan for the Development of Strategic Emerging Industries	Promoting the industrialization of advanced biological liquid fuels. Improving the raw material supply system and developing biodiesel in an orderly manner. Promoting the development and industrialization of cutting-edge technologies such as oil algae biodiesel and bio aviation fuel.	December 2016
	41	Notice on Printing and Distributing Guidance of Energy Work (2017)	Accelerating the introduction of new versions of ethanol gasoline and biodiesel standards for vehicles, and carrying out related upgrades. Achieving full supply of B5 biodiesel.	December 2016

Table 1. Cont.

Form	Document Number	Name of the Policy Document	Brief Summary and Qualitative Judgment of Policy	Date
Notices and Opinions	42	Notice on Printing and Distributing the 13th Five-Year Special-Plan for Biotechnology Innovation	Focusing on improving biodiesel manufacturing capacity. Developing key technologies for microalgae preparation of biodiesel, and establishing a demonstration base for biodiesel green process production.	February 2017
	43	Notice on Printing and Distributing Guidance of Energy Work (2018)	Increasing the proportion of non-fossil energy in transportation fuels. Improving the refined oil market supervision system and increasing the special spot check of oil quality	April 2017
	44	Notice	Full supply of vehicle diesel (including B5 biodiesel) that complies with the sixth stage of the mandatory national standard VI	February 2018
	45	Notice on Printing and Distributing the Energy Standardization Management Measures and Implementation Rules	Providing management standards for the development and management of biodiesel projects	December 2018
	45	Notice on Printing and Distributing the Energy Standardization Management Measures and Implementation Rules	Providing management standards for the development and management of biodiesel projects	April 2019

2.2. Content Encoding and Categorisation

The analytical categories were organized according to our research questions. As suggested by Hsieh and Shannon [21], a directed approach to content analysis is to validate or extend existing theory or research. Researchers begin coding by identifying key concepts or variables that construct the research questions. While the analytical categories are established depending on the research questions, the operational definitions for each category should be determined based on existing theory or research. Following the suggestions of Hsieh and Shannon [21], we established our analytical categories in two steps. First, we searched for categories based on existing literature. As described by Sabatier and Mazmanian [22] and Howlett [23], the transitions of policies included the evolution of policy objectives and policy instruments. Since our first research question explored the transitions of biodiesel policies in China, we began to search for the proper terms presenting the policy objectives and policy instruments of biodiesel. Second, the RTDI policies of renewables frequently supported biodiesel as a type of renewable energy. The common policy objectives for the development of renewables in most countries, as narrated by Ramos et al. [11], Lipp [24], Horst [25], Winzer [26], and Naylor and Higgins [27], included environmental sustainability, energy supply continuity, industrial development, technology innovation, and rural development. Moreover, following Linden et al. [28], Carley [29], Liao [30], and Amstalden et al. [31], the economic measures (financial support and market configuration) and administrative measures (standard control) were frequently-implemented policy instruments in all governments, aiming at supporting renewable energy projects. Therefore, we adopted the categories referring to economic and administrative policy instruments. Each category, as suggested by Hsieh and Shannon [21], was defined based on existing literature. Table 2 shows the operational definitions for each category.

Table 2. Definitions of analysis categories.

Sort of Categories	Analysis Category	Definition
Policy objectives	Environmental Sustainability	Reduction of GHG emissions, and use biodiesel to replace fossil fuels for environmental protection and climate neutrality [11,24,25].
	Energy Supply Continuity	Expectation that energy supply could be achieved through energy diversity, the deployment of renewables as substitutes for gas or oil [25,26].
	Industrial Development	Growth of the industry in the market [25], or creation of new industry that can lead to job creation and find increasing market to serve [24].
	Technology Innovation	Foster innovation and commercialization of technologies, which are exportable, and the provision of employment [24,25].
	Rural Development	Stimulate the development of dynamic, competitive and sustainable economies in the countryside and tackle poverty in rural areas [24,25].
	Financial Support	The support for relevant market players to generate desired economic behaviors, including fixed feed-in tariffs, investment subsidies, tax exemptions for production costs, and fees or grants for technology innovation [32].
Policy Instruments	Standard Control	The provision of the regulatory environment, which forced market players by laws or policies to encourage the set of behaviors defined acceptable for the state authority. These regulations include technology standards, safety standards and production stops, as well as the technology bands for long-term contracts at a fixed price [27].
	Supervised Evaluation	Evaluation for the permits of market players who have been licensed and active in the market, as well as the review for the effects and effectiveness of policy instruments [24].
	Legal Liability	Punishment for deviant behaviors with negative sanctions, such as a fine, restrictions of trade, and prohibitions [28].
	Market Configuration	Built up a market segment for renewable energies through the establishment of new marketing channels, such as the expansion of footholds [32].
	Sample Engineering	Encouragement for the construction of a significant number of new renewable energy power plants or factories through the direct investments of the government [32].
	Infrastructure	The government establishes R&D labs or other projects, which improve electrical testing and the certification system [30].

Once they were decided, we allocated a code to each category and used the pre-examined codes to encode the 45 selected samples. Table 3 shows the codes from A to L, which were given to match each of the 12 analytical categories. While the codes from A to E revealed the analytical categories of policy objectives, the codes from F to L represented the policy instruments. Table 3 also shows the calculation of the frequency of these codes in the three periods using the software of NVivo12. Figure 2 shows a two-dimensional distribution map of the policy texts, and Table 4 shows the embeddedness of the analysis codes of each policy document. As shown in Figure 2 and Table 4, the texts of 45 policy documents were illustrated following the format of document number–chapter number–clause number. The document number is the number allocated to each policy in Table 1, and the chapter number refers to the appearance of biodiesel in the chapters of each policy document. Moreover, a clause number examines the appearance of biodiesel in the clauses of each chapter. For example, the Renewable Energy Law in 2005 was labeled as Number 1 in Table 1. As Clause 16 of Chapter 4 of the Law appeared in Code B (Energy Supply Continuity), Code G (Standard Control) and Code J (Market Configuration) regarding biodiesel development, the format given to the Renewable Energy Law in Table 4 was 1-4-16BGJ. In Figure 2, the format given to the Renewable Energy Law under Code B, Code G, and Code J in the first period was 1-4-16.

Table 3. Codes and Frequency of each analysis category.

Number	Code	Analysis Category	2003–2007		2008–2011		2012–2019		Total	
			Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Policy Objectives										
1	A	Environmental Sustainability	12	11.54%	4	7.02%	16	7.31%	32	8.42%
2	B	Energy Supply Continuity	11	14.43%	6	15.79%	24	13.24%	41	13.95%
3	C	Industrial Development	6	5.77%	7	12.28%	13	5.94%	26	6.84%
4	D	Technology Innovation	14	13.46%	7	12.28%	25	11.42%	46	12.11%
5	E	Rural Development	8	7.69%	4	7.02%	12	5.48%	24	6.32%
Policy Instruments										
6	F	Financial Support	16	15.38%	7	12.28%	18	8.22%	41	10.79%
7	G	Standard Control	9	8.65%	3	5.26%	24	10.96%	36	9.47%
8	H	Supervised Evaluation	5	4.81%	2	3.51%	28	12.79%	35	9.21%
9	I	Legal Liability	3	2.88%	4	7.02%	10	4.57%	17	4.47%
10	J	Market Configuration	6	5.77%	5	8.77%	14	6.39%	25	6.58%
11	K	Sample Engineering	7	6.73%	4	7.02%	16	7.31%	27	7.11%
12	L	Infrastructure	3	2.88%	1	1.75%	14	6.39%	18	4.74%
Total			104	100%	57	100%	219	100%	380	100%

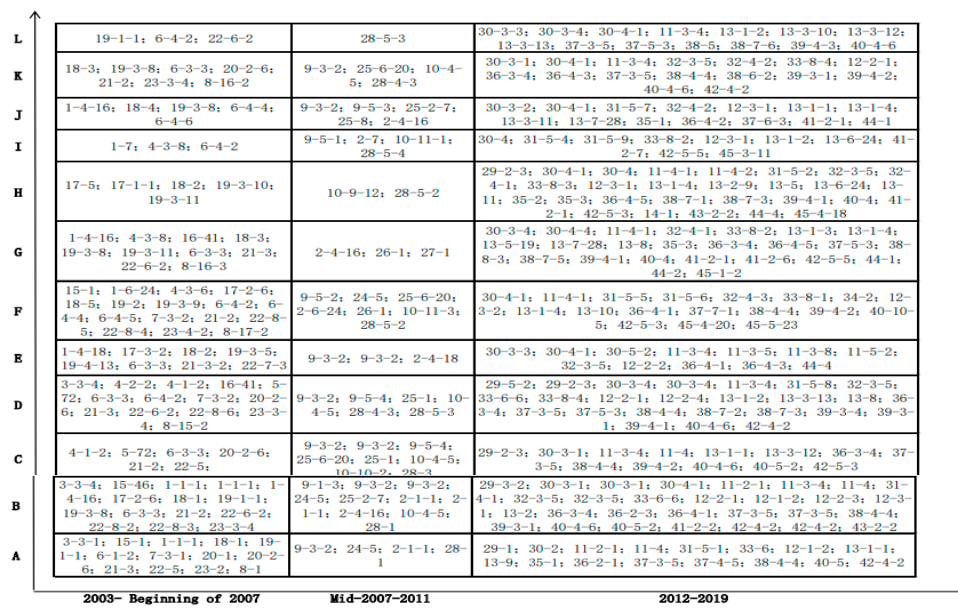


Figure 2. Distribution of policies by form.

Table 4. Embeddedness of analysis codes in policy documents.

Document Number	Name of the Policy Text	Institutions for Policy Implementation	Date	Code Number
1	Renewable Energy Law of the People's Republic of China	National People's Council	February 2005	1-1-1ABB; 1-4-16BGJ; 1-4-18E; 1-6-24F; 1-7I
2	Renewable Energy Law of the People's Republic of China (Revised in 2009)	NPC of the People's Republic	December 2009	2-1-1ABB; 2-4-16BGJ; 2-4-18E; 2-6-24F; 2-7I
3	Technological Policy of Pollution Control for Diesel Vehicles	State Environmental Protection Administration	January 2003	3-3-1A; 3-3-4BD
4	The National special Plan for Technical Equipment Development and Major Industrial Technology Development	National Development and Reform Commission; Ministry of Science and Technology	February 2005	4-2-2D; 4-1-2CD; 4-3-8GI; 4-3-6F
5	The Guide For Key Areas of Current Priority Development of High-tech Industrialization	National Development and Reform Commission; Ministry of Science and Technology	January 2007	5-72CD
6	The 11th Five-Year Plan for the Development of Biological Industry	National Development and Reform Commission	March 2007	6-3-3BCDEGK; 6-1-2A; 6-4-2DFLI; 6-4-4FJ; 6-4-5F; 6-4-6J
7	The Application Guidelines for 2007 Special Topics in the Field of 863 Program Resources and Environmental Technology	Ministry of Science and Technology	March 2007	7-3-1A; 7-3-2DF
8	The Plan of International Science and Technology Cooperation Program for Renewable Energy and New Energy	Ministry of Science and Technology; National Development and Reform Commission	November 2007	8-1A; 8-15-2D; 8-16-2K; 8-16-3G; 8-17-2F
9	The 11th Five-Year Plan for the Renewable Energy	National Development and Reform Commission	March 2008	9-1-3B; 9-3-2ABDEC; 9-3-2DJBK; 9-3-2E; 9-5-1I; 9-5-2F; 9-5-3J; 9-5-4CD
10	The 12th Five-Year plan for Science and Technology Development	Ministry of Science and Technology	July 2011	10-4-5DBCK; 10-10-2C; 10-11-1I; 10-11-3F; 10-9-12H

Table 4. Cont.

Document Number	Name of the Policy Text	Institutions for Policy Implementation	Date	Code Number
11	The 12th Five-Year Plan for the Renewable Energy	National Energy Administration	August 2012	11-2-1AB; 11-3-4E; 11-3-4BLCKD; 11-3-5E; 11-3-8E; 11-4ABC; 11-4-1H; 11-4-1F; 11-4-1G; 11-4-2H; 11-5-2E
12	Energy Development Strategy Action Plan (2014-2020)	State Council	June 2014	12-2-1DKB; 12-1-2AB; 12-2-2E; 12-2-3B; 12-2-4D; 12-3-1BJIH; 12-3-2F
13	Biodiesel Industry Development Policy	National Energy Administration	November 2014	13-1-1JAC; 13-1-2LID; 13-1-3G; 13-1-4JFGH; 13-2-9H; 13-2B; 13-3-10L; 13-3-11J; 13-3-12LC; 13-3-13LD; 13-5H; 13-5-19G; 13-6-24HI; 13-7-28GJ; 13-8DG; 13-9A; 13-10F; 13-11H
14	Guidance Catalogue for Foreign Investment Industries (Revised in 2017)	National Development and Reform Commission	July 2017	14-1H
15	Notice on Issuing the Catalogue of Comprehensive Utilization of Resources (Revised in 2003)	National Development and Reform Commission; Ministry of Finance; State Taxation Administration	January 2004	15-1AF; 15-46B
16	Notice	National Development and Reform Commission	October 2005	16-41DG
17	Notice on Issuing the Interim Measures for the Management of Special Funds for Renewable Energy Development	National Development and Reform Commission	May 2006	17-2-6FB; 17-3-2E; 17-5H; 17-1-1H
18	Notice on Printing and Distributing the Minutes of the Working Conference on Non-Food Biological Liquid Fuels	National Development and Reform Commission	July 2006	18-1AB; 18-2EH; 18-3GK; 18-4J; 18-5F
19	Opinions on the implementation of fiscal and taxation support policies for the development of bioenergy and biochemical	Ministry of Finance	September 2006	19-1-1ABL; 19-2F; 19-3-5E; 19-3-8BGKJ; 19-3-9F; 19-3-10H; 19-3-11GH; 19-4-13E
20	The Notice on Printing and Distributing Comprehensive Energy Saving and Emission Reduction Work Plan	State Council	May 2007	20-1A; 20-2-6ACDK
21	Notice on Interim Measures for the Administration of Non-grain Guided Incentive Funds for Bioenergy and Biochemical	Ministry of Finance	July 2007	21-2CFBK; 21-3GDA; 21-3-2E
22	The Notice on Printing and Distributing Medium and Long-Term Development Plan for Renewable Energy	National Development and Reform Commission	August 2007	22-6-2B; 22-6-2LDJ; 22-5CA; 22-7-3E; 22-8-2B; 22-8-3B; 22-8-5F; 22-8-4F; 22-8-6D
23	Notice on the release of the Energy Conservation and Emission Reduction National Science and Technology Action Plan	Ministry of Science and Technology	September 2007	23-2A; 23-3-4DBK; 23-4-2F
24	Notice on comprehensive utilization of resources and VAT policies for other products	Ministry of Finance; State Taxation Administration	December 2008	24-5FAB
25	Notice on Issuing Certain Policies to Promote the Development of the Bio-industry	State Council	June 2009	25-2-7BJ; 25-6-20FKC; 25-8J; 25-1CD
26	Notice on the Exemption of Consumption Tax on the Production of Pure Biodiesel from Waste Animal and Vegetable Oils	Ministry of Finance; State Taxation Administration	December 2010	26-1FG

Table 4. Cont.

Document Number	Name of the Policy Text	Institutions for Policy Implementation	Date	Code Number
27	Notice on Clarifying the Scope of Application of Consumption Tax Exemption for the Production of Pure Biodiesel from Waste Animal and Vegetable Oils	Ministry of Finance	June 2011	27-1G
28	Notice on Printing and Distributing 12th Five-Year Plan for biotechnology development	Ministry of Science and Technology	November 2011	28-4-3DK; 28-5-2FH; 28-5-3DL; 28-5-4I; 28-1AB; 28-3C
29	Notice on issuing 12th Five-Year Plan for Energy Saving and Environmental Protection Industry Development	State Council	June 2012	29-3-2B; 29-5-2D; 29-2-3C; 29-2-3D; 29-2-3H; 29-1A
30	Notice on Printing and Distributing the 12th Five-Year Plan for the Development of Biomass Energy	National Energy Administration	July 2012	30-2A; 30-3-1B; 30-3-1CKB; 30-3-3EL; 30-3-4DL; 30-3-4G; 30-3-4D; 30-3-2J; 30-4-1H; 30-4-1B; 30-4-1EF; 30-4-4G; 30-4-1JK; 30-4-1L; 30-4IH; 30-5-2E
31	Notice on issuing 12th Five-Year Plan for Energy Saving	State Council	August 2012	31-4-1B; 31-5-1A; 31-5-2H; 31-5-4I; 31-5-5F; 31-5-6F; 31-5-7J; 31-5-8D; 31-5-9I
32	Notice of the State Council on Printing and Distributing the Development Plan of Biological Industry	State Council	December 2012	32-3-5BE; 32-3-5BDKH; 32-4-1HG; 32-4-2JK; 32-4-3F
33	The Notice on Printing and Distributing Circular Economy Development Strategy and Immediate Action Plan	State Council	January 2013	33-6-6BD; 33-6A; 33-8-1F; 33-8-2IG; 33-8-3H; 33-8-4DK
34	Notice on Clarifying the Purpose of Taxation of Refined Oil on Part of the Import Tax	Ministry of Finance	December 2013	34-2F
35	Notice on Further Promoting the Upgrading of Refined Oil Quality and Strengthening Market Management	National Development and Reform Commission	February 2016	35-1AJ; 35-2H; 35-3HG
36	Notice on Printing and Distributing the 13th Five-Year Plan for the Development Biomass Energy	National Energy Administration	October 2016	36-3-4BCGKD; 36-2-3B; 36-2-1A; 36-4-1BEF; 36-4-2J; 36-4-3EK; 36-4-5HG
37	Notice on Printing and Distributing the 13th Five-Year Plan for Biological Industry Development	National Development and Reform Commission	December 2016	37-3-5ABC; 37-3-5DKLB; 37-4-5A; 37-5-3DGL; 37-6-3J; 37-7-1F
38	Notice on Printing and Distributing The 13th Five-Year Plan for Renewable Energy Development	National Development and Reform Commission	December 2016	38-4-4CDKB; 38-4-4AF; 38-8-3G; 38-5L; 38-6-2K; 38-7-1H; 38-7-2D; 38-7-3H; 38-7-3D; 38-7-5G; 38-7-6L
39	Notice on Printing and Distributing the 13th Five-Year Plan for Energy Technology Innovation	National Energy Administration	December 2016	39-3-4D; 39-3-1BDK; 39-4-1HGD; 39-4-2KFC; 39-4-3L
40	Notice on Printing and Distributing the 13th Five-Year Plan for the Development of Strategic Emerging Industries	State Council	December 2016	40-4-6BDCKL; 40-4HG; 40-10-5F; 40-5A; 40-5-2BC
41	Notice on Printing and Distributing Guidance of Energy Work (2017)	National Energy Administration	February 2017	41-2-1JGH; 41-2-6G; 41-2-2B; 41-2-7I
42	Notice on Printing and Distributing the 13th Five-Year Special-Plan for Biotechnology Innovation	Ministry of Science and Technology	April 2017	42-4-2ABDKB; 42-5-3FHC; 42-5-5GI

Table 4. Cont.

Document Number	Name of the Policy Text	Institutions for Policy Implementation	Date	Code Number
43	Notice on Printing and Distributing Guidance of Energy Work (2018)	National Energy Administration	February 2018	43-2-2BH
44	Notice	National Development and Reform Commission; National Energy Administration;	December 2018	44-1JG; 44-2G; 44-4EH
45	Notice on Printing and Distributing the Energy Standardization Management Measures and Implementation Rules	National Energy Administration	April 2019	45-1-2G; 45-3-11I; 45-4-18H; 45-4-20F; 45-5-23F

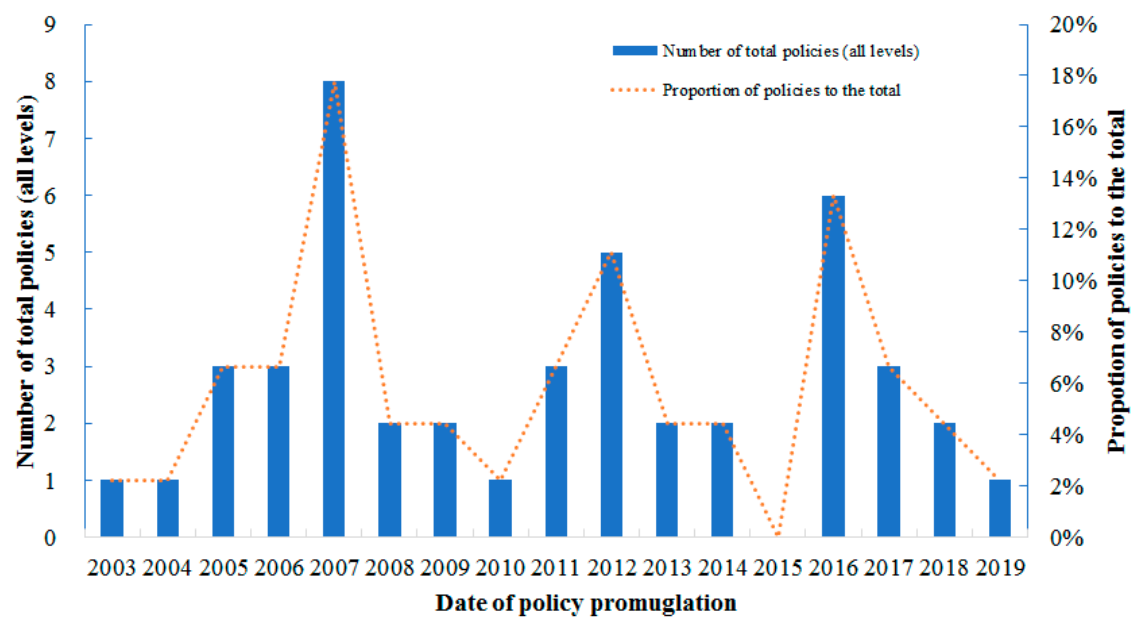
3. Results of Policy Transitions

We adopted 2003, 2007, and 2012 as three milestones in which to divide the transitions of biodiesel policies in China. Accordingly, policy transitions were divided into three periods: the emergence of biodiesel policies (2003 to the beginning of 2007), initial inclusion within the national industrial plan (mid-2007 to 2011), and embeddedness within the national bioenergy plan (2012 to 2019). Figure 3a shows that the change of total policy volumes increased from 9 policies between 2003 and the beginning of 2007 to 19 between 2012 and 2019. Most policies as shown in Figure 3b were on the low level of notices and opinions. Table 5 displays the annual production of biodiesel in China. The policy transitions are further discussed below.

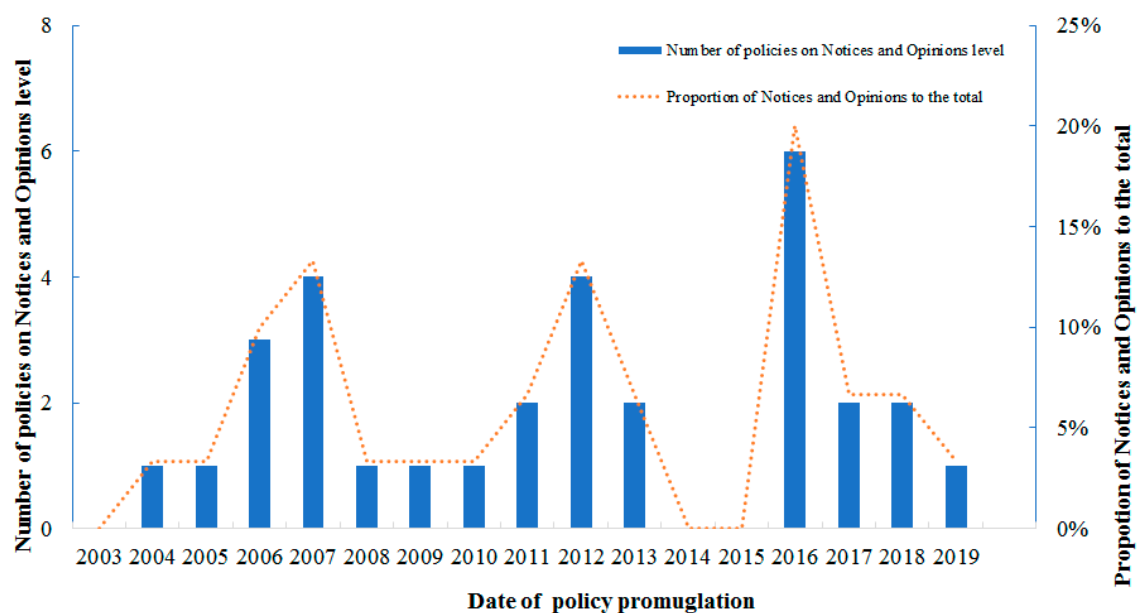
Table 5. Annual production of biodiesel in China.

Calendar Year	Production (Million Liters)
2006	273
2007	352
2008	534
2009	591
2010	568
2011	738
2012	927
2013	1079
2014	1133
2015	787
2016	909
2017	1043
2018	834
2019	900

Sources: United States Department of Agriculture (USDA)'s Gain Reports [33,34].



(a) Changes in the number and proportion of total policies.



(b) Changes in number and proportion of policies on the level of notices and opinions.

Figure 3. Changes in the number and proportion of relevant policies.

3.1. Transitions of Policy Objectives and Policy Instruments

3.1.1. The Emergence of Biodiesel Policies (2003 to the Beginning of 2007)

The Technological Policy of Pollution Control for Diesel Vehicles launched in 2003, labeled the emergence of the first national biodiesel policies in China. The policy, jointly promoted by the Ministry of Ecology and Environment, Ministry of Commerce, and Ministry of Science and Technology, was a short-term plan for the development of biodiesel. It only revealed the policy objectives to encourage technology innovation of diesel made from biomass to control air pollution and achieve environmental sustainability. Afterward, the Renewable Energy Law, legislated in 2005 by the National People's Congress (shortened to be NPC), provided the first legal foundation to legitimize the policy support for

biodiesel. The main policy objectives of the law were to encourage the development and innovation of renewable energies. Since biodiesel is considered part of renewable energy, the government should foster domestic technological innovation and industrial development of biodiesel to increase energy supply and achieve environmental sustainability. Among the nine policies issued between 2005 and the beginning of 2007 (Figure 3), policy objectives for the development of biodiesel (Table 2) concentrated on energy supply continuity (14.43%), technology innovation (13.46%), and environmental sustainability (11.54%). Technology innovation, as guided by the law and other policies, focuses on first-generation biodiesel produced from used cooking oil, waste animal, and vegetable oils and non-edible energy crops. For example, the Notice on Issuing the Catalogue of Comprehensive Utilization of Resources issued in 2004 gave tax exemptions for the supply of biodiesel produced from waste animal and vegetable oils. Furthermore, the Opinions on the Implementation of Fiscal and Taxation Support Policies for the Development of Bioenergy and Biochemical issued in 2006 also subsidized the cultivation of non-edible energy crops, such as tung tree and *Pistacia chinensis*.

The policy instruments complemented the policy objectives. Financial support (15.38%) was the most frequently used policy instrument in the period. Financial support included subsidies, tax exemptions, and loans with low-interest rates for the individuals and private companies that invested in the production and innovation of biodiesel. Farmers' cultivation of non-edible energy crops was also subsidized. Standard control (8.65%) regulated the technical norms adopted for the production of biodiesel. Sample engineering (6.73%), which was fully funded by the government but operated by private companies, was constructed near the origins of non-edible energy crops to represent the standard processes of biodiesel production. In the first period, as biodiesel only initially emerged in China (Table 5), policies emphasized the increase in the supply of biodiesel. As the policy objectives aimed to encourage technological innovation of biodiesel to fulfill the visions of energy supply continuity and environmental sustainability, the policy instruments of financial support, standard control, and sample engineering were used to encourage private involvement in the standard production of biodiesel. However, as the industry of biodiesel only initially germinated, the policy instruments, shaping the market demands of biodiesel, such as market configuration, were supplementary at the time.

3.1.2. Initial Inclusion within the National Industrial and Energy Plan (Mid-2007 to 2011)

The 11th Five-Year Plan for the Development of Biological Industry in mid-2007 included biodiesel in the long-term national plan for the first time. As a general industrial plan for biotechnology-related industries, biodiesel was a new industry based on biotechnology and supported biopharmaceuticals to contribute to biotechnology innovation of the country. The National Development and Reform Commission was the sole ministry to implement the long-term plan and encouraged first-generation biodiesel by subsidizing the cultivation of non-edible energy crops and process innovation of used cooking oil. Afterward, the 11th Five-Year Plan for the Renewable Energy issued in 2008 further included biodiesel in the long-term national plan of renewable energies, and it supported biodiesel along with wind and solar energies. The National Development and Reform Commission, which implemented the long-term energy plan, recognized biodiesel as part of renewable energy that contributes to energy supply and environmental sustainability. Additionally, the Commission announced the first detailed landmark that, by 2010, the annual production capacity of biodiesel should reach 200,000 tonnes, most of which should be made by non-edible energy crops, including *Jatropha curcas*, tung tree, and *Pistacia chinensis*. Next, the policy objectives of the 16 policies launched from mid-2007 to 2011 emphasized energy supply continuity (15.79%) and technology innovation (12.28%). However, as biodiesel was considered part of biotechnology-related industries, the priority of industrial development (12.28%) increased, while environmental sustainability (7.02%) continued to be a critical objective for the development of biodiesel (Table 2). The technological innovation of biodiesel focused on first-generation biodiesel produced from used cooking oil and non-edible energy crops. However, the Chinese government gradually noticed the establishment of the innovation system of biodiesel and

encouraged technology transfer from universities to industry rather than solely supported technology innovation within the industry. For example, the 12th Five-Year Plan for Science and Technology Development, launched in 2011 by the Ministry of Science and Technology, established innovation systems of new energy technologies, including biodiesel.

The policy instruments were implemented to fulfill the policy objectives. Financial support (12.28%) was still the most frequently used policy instrument, allocated to universities as research funding and private companies through subsidies and tax exemptions. Since industrial development emerged as a critical policy objective, market configuration (8.77%) was adopted as an essential policy instrument to expand the points of sale for biodiesel. As the involvement of private companies in the production of biodiesel increased, legal liability (7.02%) was strengthened to impose fines for unqualified biodiesel products sold in the market. Furthermore, standard control (5.26%) revealed the minimum quality of biodiesel products, and sample engineering (7.02%) was used to represent the standard processes of biodiesel production. In other words, policy instruments were synthetically operated to establish the overall system of biodiesel innovation and production. As the outputs of biodiesel increased and the market for biodiesel gradually formulated, policy instruments were used to control the supply of biodiesel through financial support, standard control, and sample engineering and to shape market demands by market configuration and legal liability.

3.1.3. The Embeddedness within National-Specific Bioenergy Plan (2012–2019)

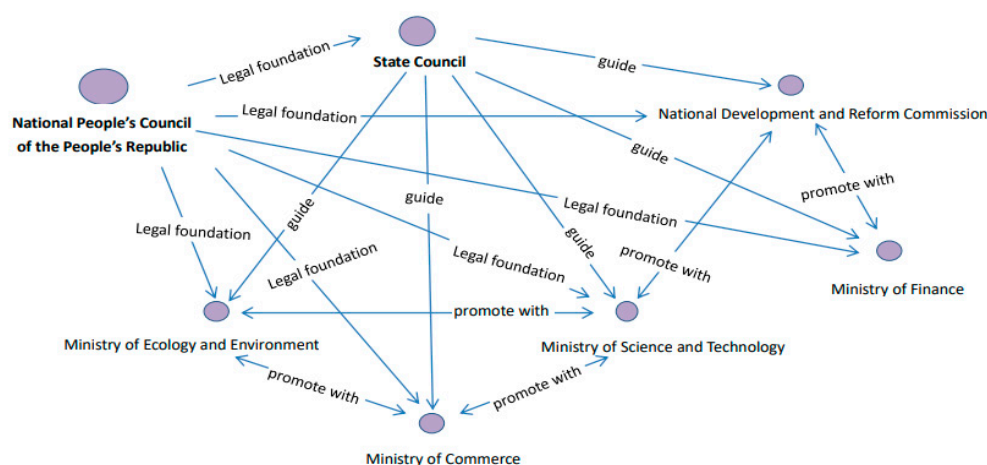
Since 2012, the long-term national plan of bioenergy embedded biodiesel. The 12th Five-Year Plan for Bioenergy Development, issued in 2012, was the first national plan targeting the development of bioenergy, and biodiesel was officially recognized as a strategic industry of bioenergy. It was synthetically supported with bioethanol and biogas to serve the national purposes of technology innovation of bioenergy, energy supply, and environmental sustainability. The National Energy Administration under the National Development and Reform Commission was the main institution to implement the plan, and it supported the production of first-generation biodiesel based on used cooking oil and non-edible energy crops and the innovation and commercialization of second-generation algal biodiesel. Later on, the 13th Five-Year Plan for Bioenergy Development issued in 2016, reconfirmed the inclusion of biodiesel in long-term national bioenergy development. The government would encourage the expansion of first-generation biodiesel based on non-edible energy crops, especially woody energy plants such as *Jatropha curcas*, and concurrently, the process innovation and mass production of algal biodiesel at low costs. The main policy objectives for the development of biodiesel at the time were energy supply continuity (13.24%), technology innovation (11.42%), and environmental sustainability (7.31%). Technology innovation fostered the innovation system of biodiesel, especially the innovation of algal biodiesel, and energy supply continuity emphasized the supply of biodiesel to aviation fuel. For example, in 2016, the Notice on Printing and Distributing the 13th Five-Year Plan for Renewable Energy Development announced the increase in biodiesel usage in transportation, especially aviation. Additionally, the notice revealed that the annual production of biodiesel should achieve 2 million tonnes by 2020.

The priority of policy instruments changed during this period. As the involvement of private companies steadily increased, supervised evaluation (12.79%) emerged as the most frequently used policy instrument regulating the licenses of market entry. Only private companies fulfilling the standards for production and the quality of products were licensed. However, these licenses were evaluated regularly, and the companies that could not maintain the standards could no longer manufacture and sell biodiesel products. Standard control (10.96%) was adopted to both manage the processes of production and the quality of biodiesel products. While private companies needed to follow the technical norms to produce BD 100 biodiesel, since 2019, only B5 biodiesel complying with the mandatory national standard could be sold in the market. Moreover, financial support (8.22%) remains the critical policy instrument to fund universities and research institutes for research of new species of microalgae and non-edible energy crops and allocate subsidies and tax exemptions

to private companies participating in the standard production of biodiesel. Sample engineering (7.31%) was used to construct representative factories for the production of second-generation biodiesel based on algae. In conclusion, as the production of and market for first-generation biodiesel were gradually established, policy instruments were synthetically applied to optimize the supply of biodiesel. Supervised evaluation and standard control were used to banish the unqualified products, and financial support and sample engineering fostered the system of biodiesel innovation to move forward to the innovation and production of second-generation biodiesel from algae.

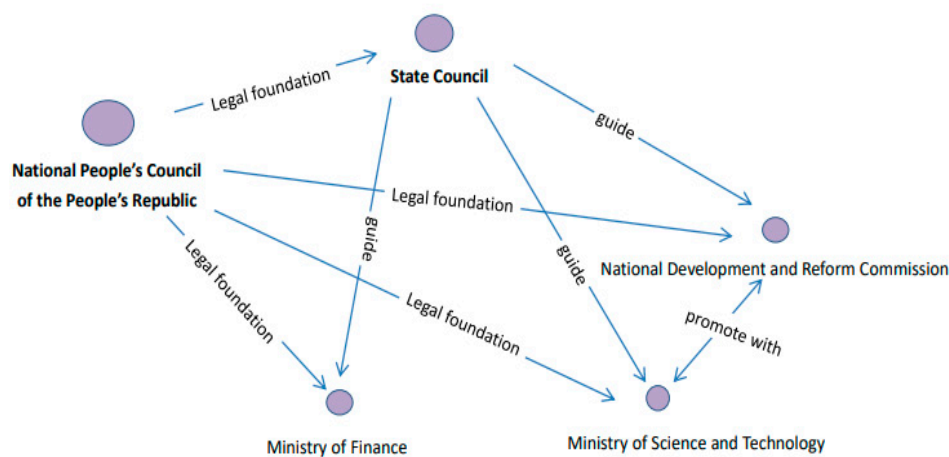
4. Evolution of Policy Networks

The dynamics of the policy networks that implemented biodiesel policies in China evolved with the transitions of policy contents. Figure 4 shows that throughout the three periods, the State Council, which guided the policymaking processes, was the important node, and the National People's Council, which legitimized legal foundations, was essential in the first and second periods. Table 6 displays institutions and text composition of policies on the development of biodiesel. As shown in Table 6, the National People's Council only issued two policies, namely the Renewable Energy Law (2005) and the Revision of the Law (2009), weighting 4.44% of the overall policies. However, the Law guided the implementation of subordinate policies on the levels of plans and notices and opinions within the State Council. The State Council burdened the promotion of most of the policies (43 policies weighted 95.56%). The ministries under the State Council in practice actively participated as responders to the National People's and State Council. The National Development and Reform Commission, Ministry of Science and Technology, and Ministry of Finance were the three main ministries implementing the policies on the levels of plans and notices and opinions. However, the division of labor between the three ministries changed with time.

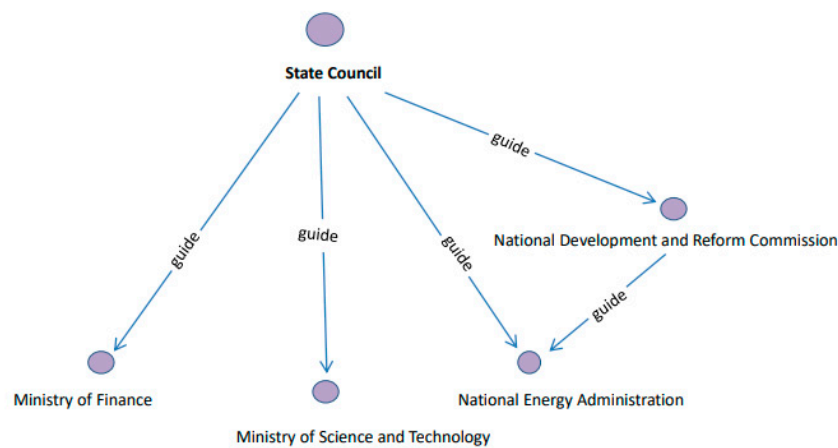


(a) Policy networks of the first period.

Figure 4. Cont.



(b) Policy networks of the second period.



(c) Policy networks of the third period.

Figure 4. Policy networks of biodiesel policies.**Table 6.** Institutional and text composition of policies on the development of biodiesel.

Institutional Composition	National Peoples' Council	State Council	Relevant Ministries of the State Council					Total
			National Development and Reform Commission	Ministry of Finance	Ministry of Science and Technology	Ministry of Ecology and Environment	National Energy Administration	
Quantity	2	8	14	6	6	1	8	45
Percentage/%	4.44%	20.00%	31.11%	13.33%	13.33%	2.22%	15.56%	100.00%
Text Composition	Laws		Plans		Notices and Opinions		Total	
	Quantity		Quantity		Quantity		Quantity	
Quantity	2		12		31		45	
Percentage/%	4.44%		26.67%		68.89%		100.00%	

During the first period, the National People's Council legislated the Renewable Energy Law that guided further policymaking processes, and the State Council was the main institution for the implementation of biodiesel policies. Within the State Council, the Ministry of Ecology and Environment, and Ministry of Commerce, which jointly issued the first biodiesel policy, the Technological Policy of Pollution Control for Diesel Vehicles, with the Ministry of Science and Technology in 2003, no longer

implemented other biodiesel policies afterward. The National Development and Reform Commission accepted the main responsibility of promoting biodiesel (six of nine policies). Furthermore, the Ministry of Finance and Ministry of Science and Technology also contributed to launching biodiesel policies (two of nine policies each). The coordination between ministries was relatively frequent. The National Development and Reform Commission twice jointly issued policies with the Ministry of Science and Technology and once with the Ministry of Finance.

By revising the Renewable Energy Law in the second period, the National People's Council continuously provided the legal foundation, and the State Council continued as the main institution for the implementation of biodiesel policies. However, the roles of inferior ministries under the State Council switched. The National Development and Reform Commission, Ministry of Science and Technology, and Ministry of Finance shared equal responsibilities in the network as the main responders for the promotion of biodiesel policies. Each of the three ministries issued 3 of 16 policies. In practice, compared with the first period, the Ministry of Science and Technology and Ministry of Finance played more active roles, while the National Development and Reform Commission took less responsibility in the implementation of biodiesel policies. Furthermore, the Ministry of Ecology and Environment and Ministry of Commerce were no longer involved in the policy network of biodiesel policies. While the National Development and Reform Commission and Ministry of Science and Technology still jointly issued policies, the Commission did not issue policies with the Ministry of Finance in the second period.

The State Council continued as the main institution to implement biodiesel policies in the third period, and the National People's Council, which no longer provided a legal foundation for the development of biodiesel, faded from the policy network. Under the State Council, the roles of inferior ministries changed again. The National Development and Reform Commission became the most essential ministry to launch biodiesel policies. The National Energy Administration under the Commission emerged within the network as the critical institution subordinate to the ministry. The Commission itself issued six policies, and the National Energy Administration also launched six policies. While the National Development and Reform Commission in sum promoted 12 of 19 policies, weighting approximately 63% of the overall policies in the period, the Ministry of Science and Technology and Ministry of Finance only implemented one policy each and played minor roles in the biodiesel policy network. Thus, the implementation of biodiesel policies was concentrated in the National Development and Reform Commission, and the coordination between ministries at the same time reduced. The National Development and Reform Commission did not jointly issue any policy with other ministries in the period but allocated the responsibilities of policy implementation to the National Energy Administration.

5. Discussion and Conclusions

This article analyzed the transitions of biodiesel policies in China using the content analysis method. In Section 1, we set up two research questions and portrayed the policy transitions and policy networks in Sections 3 and 4. Considering the research questions proposed at the beginning of this article, in this section, we further explored the two research questions based on our empirical results and concluded the article with our empirical contributions and suggestions for future research.

The first research question is the following: How did biodiesel policies transit in China regarding policy objectives and policy instruments? The policy objectives of China's biodiesel policies evolved. Energy supply continuity was the most important policy objective throughout the three periods and was steadily followed by technology innovation and environmental sustainability. Only in the second period did industrial development emerge as one of the most essential policy objectives. Next, the policy objectives shifted with the innovation of technologies. In the first period, as first-generation biodiesel initially emerged, the policies emphasized the increase in the supply of biodiesel. While the production of first-generation biodiesel constantly increased, the policy objectives strengthened the development of the industry and enlarged the market demand to build the system of innovation

of biodiesel. Until the third period, with the emergence of second-generation algal biodiesel, policy objectives again focused on biodiesel supply. Nevertheless, the supply of biodiesel in the third period focused on second-generation rather than first-generation biodiesel. Besides, rural development continued as the supplementary policy objective over the three periods. Contrary to Horst's [25] analysis that rural development is one of the main objectives of biomass energy policies in the United Kingdom, in the experiences of China, rural development received minor priority compared with energy supply continuity and other policy objectives. Moreover, policy instruments changed with the transitions of policy objectives. When the supply of first-generation biodiesel was the main policy purpose in the first period, financial support, standard control, and sample engineering were used to accelerate the production of biodiesel. Once industrial development became one of the critical policy concerns in the second period, market configuration became the essential policy instrument. As policy objectives focused on the supply of second-generation biodiesel in the third period, financial support, standard control, and sample engineering were used again as the critical policy instruments, along with supervised evaluation, to manage the market entry of first-generation biodiesel to upgrade the quality of biodiesel products in the market.

The second research question is the following: How did policy networks of biodiesel evolve through the transitions of policies? The dynamics of policy networks in China changed with the evolution of policy contents. The National People's Council provided the legal foundations to guide the principal direction for the development of biodiesel, and the State Council continuously significantly influenced the promotion of biodiesel development. Nevertheless, the participation of different ministries under the State Council switched over time. Next, the Ministry of Ecology and Environment and Ministry of Commerce only issued the first biodiesel policy but were no longer involved in policy networks in the later periods. Contrastingly, the National Development and Reform Commission extensively burdened the responsibilities for the implementation of biodiesel policies throughout the three periods. Only in the second period, when market configuration was used as the main policy instrument to fulfill the objective of industrial development, the Commission equally shared responsibilities with the Ministry of Science and Technology and Ministry of Finance. The supply of biodiesel was a significant policy purpose in the first and third periods, and the National Development and Reform Commission continued as the dominant ministry to implement biodiesel policies. Additionally, because the implementation of biodiesel policies was concentrated within the Commission, the burden of the Commission even increased in the third period. The National Energy Administration under the Commission immediately emerged in the network as the main subordinate institution to launch biodiesel policies. Furthermore, the Ministry of Science and Technology and Ministry of Finance, which were once important nodes within the policy networks in the first and second periods, gradually faded in the third period. As long as biodiesel was embedded within the long-term national bioenergy plan, allocating the National Energy Administration to set up overall synthetic policies to support the development of biodiesel, the two ministries reduced coordination with the Commission, and they gradually stepped away from the policy network.

This article is one of the first attempts to analyze the evolution of biodiesel policies in China systematically. We adopted the research method of content analysis to explore the transitions of policy contents and the dynamics of policy networks. Lastly, future research could use more synthetic qualitative or quantitative research methods to improve the analysis of the effectiveness of biodiesel policies, resolve the limitations of the content analysis method, and further explore the underlying contexts driving the policy change of biodiesel in China.

Author Contributions: Funding acquisition, C.-c.C.; Investigation, Y.Z.; Methodology, C.-c.C.; Software, L.L.; Supervision, C.-c.C.; Visualization, Y.W. and Z.W.; Writing—original draft, C.-c.C. All authors have read and agreed to the published version of the manuscript.

Funding: This project was funded by Wuhan University (600460001).

Conflicts of Interest: The authors declare no conflict of interest.

References

- Kim, D.S.; Hanifzadeh, M.; Kumar, A. Trend of biodiesel feedstock and its impact on biodiesel emission characteristics. *Environ. Prog. Sustain. Energy* **2018**, *37*, 7–19. [\[CrossRef\]](#)
- Ayoub, M.; Zuhairiabdullah, A. Critical review on the current scenario and significance of crude glycerol resulting from biodiesel industry towards more sustainable renewable energy industry. *Renew. Sustain. Energy Rev.* **2012**, *16*, 2671–2686. [\[CrossRef\]](#)
- Manaf, I.S.A.; Embong, N.H.; Khazaai, S.N.M.; Rahim, M.H.A.; Yusoff, M.; Lee, K.T.; Maniam, G.P. A review for key challenges of the development of biodiesel industry. *Energy Convers. Manag.* **2019**, *185*, 508–517. [\[CrossRef\]](#)
- Garg, S.; Das, P. High-grade activated carbon from pyrolytic biochar of Jatropha and Karanja oil seed cakes—Indian biodiesel industry wastes. *Biomass Convers. Biorefin.* **2018**, *8*, 545–556. [\[CrossRef\]](#)
- Harvey, M.; Pilgrim, S. The new competition for land: Food, energy, and climate change. *Food Policy* **2011**, *36*, S40–S51. [\[CrossRef\]](#)
- Anuar, M.R.; Abdullah, A.Z. Challenges in biodiesel industry with regards to feedstock, environmental, social and sustainability issues: A critical review. *Renew. Sustain. Energy Rev.* **2016**, *58*, 208–223. [\[CrossRef\]](#)
- Energy and Climate Change*; International Energy Agency: Paris, France, 2015.
- Abdullah, A.Z.; Salamatinia, B.; Mootabadi, H.; Bhatia, S. Current status and policies on biodiesel industry in Malaysia as the world's leading producer of palm oil. *Energy Policy* **2009**, *37*, 5440–5448. [\[CrossRef\]](#)
- Padula, A.D.; Santos, M.S.; Ferreira, L.; Borenstein, D. The emergence of the biodiesel industry in Brazil: Current figures and future prospects. *Energy Policy* **2012**, *44*, 395–405. [\[CrossRef\]](#)
- Ng, J.-H.; Ng, H.K.; Gan, S. Recent trends in policies, socioeconomy and future directions of the biodiesel industry. *Clean Technol. Environ. Policy* **2010**, *12*, 213–238. [\[CrossRef\]](#)
- Ramos, M.; Dias, A.P.S.; Puna, J.F.; Gomes, J.; Bordado, J.C. Biodiesel production processes and sustainable raw materials. *Energies* **2019**, *12*, 4408. [\[CrossRef\]](#)
- Dias, M.A.D.P.; Vianna, J.N.D.S.; Felby, C. Sustainability in the prospective scenarios methods: A case study of scenarios for biodiesel industry in Brazil, for 2030. *Futures* **2016**, *82*, 1–14. [\[CrossRef\]](#)
- Xu, Y.-J.; Li, G.-X.; Sun, Z.-Y. Development of biodiesel industry in China: Upon the terms of production and consumption. *Renew. Sustain. Energy Rev.* **2016**, *54*, 318–330. [\[CrossRef\]](#)
- Yang, C.-Y.; Fang, Z.; Long, Y.-F. Review and prospects of Jatropha biodiesel industry in China. *Renew. Sustain. Energy Rev.* **2012**, *16*, 2178–2190. [\[CrossRef\]](#)
- Teets, J. The power of policy networks in authoritarian regimes: Changing environmental policy in China. *Governance* **2018**, *31*, 125–141. [\[CrossRef\]](#)
- Zheng, H.; Jong, M.D.; Koppenjan, J. Applying policy network theory to policy—Making in china: The case of urban health insurance reform. *Public Adm.* **2010**, *88*, 398–417. [\[CrossRef\]](#) [\[PubMed\]](#)
- Assaroudi, A.; Nabavi, F.H.; Armat, M.R.; Ebadi, A.; Vaismoradi, M. Directed qualitative content analysis: The description and elaboration of its underpinning methods and data analysis process. *J. Res. Nurs.* **2018**, *23*, 42–55. [\[CrossRef\]](#)
- Elo, S.; Kyngas, H. The qualitative content analysis process. *J. Adv. Nurs.* **2007**, *62*, 107–115. [\[CrossRef\]](#) [\[PubMed\]](#)
- Elo, S.; Kõõriõinen, M.; Kanste, O.; Pölkki, T.; Utriainen, K.; Kyngäs, H. Qualitative content analysis: A focus on trustworthiness. *SAGE Open* **2014**, *4*, 1–10. [\[CrossRef\]](#)
- Bai, Y.; Zhou, W.; Guan, Y.; Li, X.; Huang, B.; Lei, F.; Yang, H.; Huo, W. Evolution of policy concerning the readjustment of inefficient urban land use in China based on a content analysis method. *Sustainability* **2020**, *12*, 797. [\[CrossRef\]](#)
- Hsieh, H.-F.; Shannon, S.E. Three approaches to qualitative content analysis. *Qual. Health Res.* **2005**, *15*, 1277–1288. [\[CrossRef\]](#)
- Sabatier, P.; Mazmanian, D. The conditions of effective implementation: A guide to accomplishing policy objectives. *Policy Anal.* **1979**, *5*, 481–504. [\[PubMed\]](#)
- Howlett, M. Governance modes, policy regimes and operational plans: A multi-level nested model of policy instrument choice and policy design. *Policy Sci.* **2009**, *42*, 73–89. [\[CrossRef\]](#)
- Lipp, J. Lessons for effective renewable electricity policy from Denmark, Germany and the United Kingdom. *Energy Policy* **2007**, *35*, 5481–5495. [\[CrossRef\]](#)

25. Horst, D.V.D. UK biomass energy since 1990: The mismatch between project types and policy objectives. *Energy Policy* **2005**, *33*, 705–716. [CrossRef]
26. Winzer, C. Conceptualizing energy security. *Energy Policy* **2012**, *46*, 36–48. [CrossRef]
27. Naylor, L.R.; Higgins, M. The political economy of biodiesel in an era of low oil prices. *Renew. Sustain. Energy Rev.* **2017**, *77*, 695–705. [CrossRef]
28. Linden, A.-L.; Carlsson-Kanyama, A.; Eriksson, B. Efficient and inefficient aspects of residential energy behaviour: What are the policy instruments for change? *Energy Policy* **2006**, *34*, 1918–1927. [CrossRef]
29. Carley, S. The era of state energy policy innovation: A review of policy instruments. *Rev. Policy Res.* **2006**, *28*, 265–294. [CrossRef]
30. Liao, Z. The evolution of wind energy policies in China (1995–2014): An analysis based on policy instruments. *Renew. Sustain. Energy Rev.* **2016**, *56*, 464–472. [CrossRef]
31. Amstalden, R.W.; Kost, M.; Nathani, C.; Imboden, D.M. Economic potential of energy-efficient retrofitting in the Swiss residential building sector: The effects of policy instruments and energy price expectations. *Energy Policy* **2007**, *35*, 1819–1829. [CrossRef]
32. Enzensberger, N.; Wietschel, M.; Rentz, O. Policy instruments fostering wind energy projects: A multi-perspective evaluation approach. *Energy Policy* **2002**, *30*, 793–801. [CrossRef]
33. China-Peoples Republic of Biofuels Annual 2015. Available online: <https://www.fas.usda.gov/data/china-biofuels-annual-1> (accessed on 27 June 2020).
34. China-Peoples Republic of Biofuels Annual 2019. Available online: <https://www.fas.usda.gov/data/china-biofuels-annual-5> (accessed on 27 June 2020).



© 2020 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).