

# Research on the Policy of New Material Industry Development from the Perspective of Policy Instruments

Jia Li and Lili Wang

**Abstract**—These Emerging industries can be hardly developed without the support of the governmental policies, especially the new material industry which needs heavy investment on fundamental research in earlier stage and also has a long operation period. This present paper researched China's new material policy issued by the State Council through content analysis method and quantitative analysis method. Moreover, we also analyzed the characteristics of the policies that accelerate the development of the new material industry as well as the loss and abuse phenomenon existing in the selection and construction process of policy instruments in China's new material industry both from the viewpoint of policy instruments and industrial value chain of the new material industry, and herein the corresponding problems were also discussed.

**Index Terms**—New materials, policy instruments, content analysis method.

## I. INTRODUCTION

New materials industry has infiltrated many fields such as national economy, defense and social activities from the global view. Each country pays high attention to the development of new material industry and has carried out a new round of competition on the technological commanding point after the financial crisis. The developed countries, invariably, have taken new materials and energy as the focus of the next stage and issued many special policies for this industry. For instance, US launched Materials Genome Initiative (MGI) in 2011 in an effort to develop material industry and accelerate the development and application of the new materials such as biomaterials, information materials, nanomaterials, materials for extreme environment and so on. Later amounts of projects were carried out soon afterwards, such as 21st Century National Nanotechnology Initiative, Industrial Materials for the Future (IMF), Photoelectron Project, Photovoltaic Project, Advanced Automotive Materials Plan, and Architecture Material Project. In the development of new industries, Japan emphasizes the utility, advance and the coordinated development of resources and environment. Meanwhile Japanese government takes the development of new materials as the second goal of the nation, which also mainly takes environment, resources and energy into consideration and focuses on the development of the materials that coordinates between the resources and the

environment, as well as the recycling materials that can reduce of environmental pollution as the priority goal. The corresponding made projects include Science and Technology Basic Plan, Nanotechnology Initiative, Light of 21st Century, Development Plan of Super-Steel Materials, etc. Europe Union keeps leading edge in some fields such as aerospace materials, the corresponding laid down projects such as EU Nanotechnology Initiative, COST, and European New Materials Research, etc. are included. Each EU member state also has its policy on the development of new materials respectively.

China started the research and development of the new material industry from 1950s mainly in the field of national defense and aerospace aspect. Since 1990s, the development of new materials became market-oriented and more rapid. Chinese's government has continually supported the development of the new material industry ranging from the Twelfth Five-years Plan and the Special Project for New Materials issued during the early period of PRC to the present issued national 863 Project, 973 Project and National Natural Science Foundation of China. Driven by these science and technology policies, the new material industry has been continuously developed from scratch and made significant achievements in system construction, industrial scale, and technical progress.

Due to the significant role of industrial policy in the promotion of technological innovation, the implement, prediction impact as well as analysis evaluation on policy studies are now a hot topic. The present researches abroad mostly measure the effective of one single policy instrument or make comparison of the effective between several policy instruments. For example, Mmuneas *et al.* [1] make comparison between the government investment in science and technology and the tax revenue to discuss the influence on the growth of manufacturing output and the research and development investment. It is found that the government's investment in S&T is an effective policy instrument to improve productivity and stimulate the growth of output, while the tax policy tool can promote the input of R&D. Wallsten *et al.* [2] found that after the implementation of the Small Business Innovation Research method, the new technology-intensive enterprises reduce the expenditure of R&D. Mamoru *et al.* [3] take the electronics industry as an example, this paper compares the contribution of different regions' R & D policies to industrial productivity, and finds that the impact of different industrial development policies vary in different regions. Fengchao Liu *et al.* [4] study the historical evolution path of national science and technology policy from the perspective of the effectiveness and category of innovation policy.

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The paper researched the texts of the new material industry policy through content analysis method [5], which related to the new material policy as analysis samples from the website of the State Council. Herein we established the analysis framework on the basis of policy instrument theory and industrial value chain theory to code the selected texts and to further make frequency statistics and quantitative analysis on the texts [6]. What's more, the article also analyses the existing problems in policy-making process of the new material industry and puts forward the corresponding suggestions on the basis of the statistics result.

## II. CONSTRUCTION OF THE TWO-DIMENSIONAL ANALYSIS FRAMEWORK ON THE NEW MATERIAL INDUSTRY POLICY

Science and technology policy instrument is a basic component of Public science and technology policy. Various science and technology policies are applied comprehensively and systematically in the constituting process of science and technology policy; however, any kind of science and technology policy has its limitations in application. Thus a wide variety of policies should be extensive applied and combined so that they can enlarge the effect of the science and technology policy, and meanwhile avoid the abusive or independent application of one or several policies. Therefore, only by combination of various science and technology policies, can the industry be better developed.

One of the most representative studies on the analysis of policy instrument is the research of Rothwell and Zegeveld [7]. Based on their policy classification method, texts of the new material industry can be categorized into supply-based, demand-based and environment-based policy [8], as shown in Fig. 1.

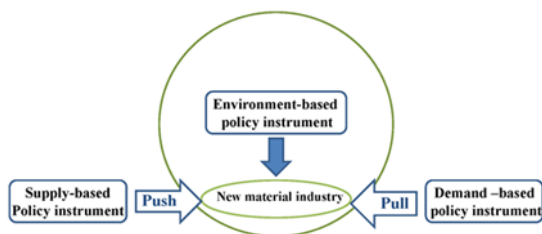


Fig. 1. Policy instruments of new material industry.

- 1) Supply-based policy instrument is the support that the government provides in various aspects such as talents, information and technology and so on to expand the technological supply and promote the development of the industry directly. What's more, it can be categorized into education and training, scientific and technological information support, scientific and technological infrastructure construction, as well as the public service, etc.
- 2) Demand-based policy instrument is the measures which the government takes such as purchasing and trade control to reduce the uncertainty of the market and enlarge the market of the new material industry. Furthermore, it can be divided into Public technology procurement, subsidy to the consumers, outsourcing

service and trade control, etc.

- 3) Environment-based policy instrument, manifesting as the indirect influence on the new material industry of the policy, is a series of policies that the government issues to influences the environment for the development of the industry and provide a favorable policy environment for the industry innovation. It can be subdivided into goal programming, financial support and tax preferences, etc.

However, the study of the new material industry policy cannot merely be categorized by the basic types of policies, its own patterns of activity and the characteristics should also be taken into consideration. The new material industry can be divided into R & D, investment, production and consumption on the basis of laws of industrial life cycle and value chain. Eventually, the analysis framework of the new material policy comes into being based on policy instruments by combing the policy instruments and the value chain theory.

## III. SAMPLE SELECTION AND ANALYSIS OF POLICY TEXTS OF NEW MATERIAL INDUSTRY DEVELOPMENT

To guarantee the effectiveness of the research, the selected texts must be accurate and representative. Accordingly, the texts in this article are all selected from documents on new material industry issued by the official site of the State Council, while policies on local industries, industry association documents, and industry standards are not taken into consideration. Ultimately 33 texts on new material policies are selected (As listed in Table I).

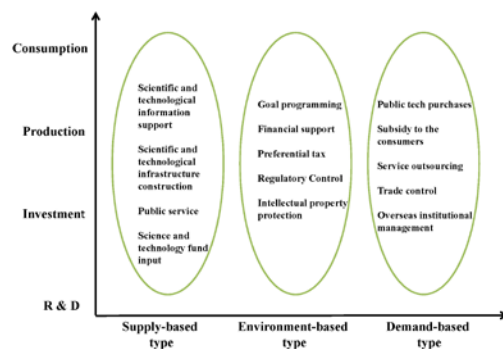


Fig. 2. Two-dimensional analysis framework on the new material industry policy.

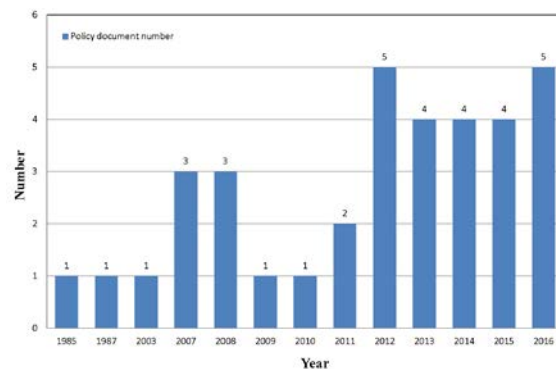


Fig. 3. Distribution of state-level new material industry policy texts issued by the state council.

TABLE I: STATISTICS FOR THE POLICY TEXTS ON NEW MATERIAL INDUSTRIES

No	Name of Policy	No	Name of Policy
1	Guiding Opinions of the General Office of the State Council on Creating Sound Market Environment to Promote the Structural Transition and Profit Increase of Nonferrous Metals No. 42 Document of State Council [2016]	21	commission and other departments on accelerating the cultivation of new competitive edges in international cooperation. No. 32 Document of State Council [2012]
2	Guiding Opinions of the General Office of the State Council on Promoting the Stable Increase, Structural Adjustment and Profit Increase of Building Materials Industry No. 42 Document of State Council [2016]	22	Opinions of the State Council on further supporting the sound development of Micro and Small Enterprise No. 14 Document of State Council [2012]
3	Guiding Opinions of the General Office of the State Council on Promoting the Stable Increase, Structural Adjustment and Profit Increase of Building Materials Industry No. 28 Document of State Council [2016]	23	Announcement of the State Council on issuing the Quality Development Outline(2011-2020) No. 9 Document of State Council [2012]
4	Announcement of the State Council on Approving and Relaying the Opinions of the National Development and Reform Commission on Key Work for Deepening the Reform of the Economic System in 2016 No. 21 Document of State Council [2016]	24	Announcement of the State Council on issuing Industrial Transformation and Upgrading Plan No. 47 Document of State Council [2011]
5	Guiding Opinions of general office of the state council on accelerating maker space development to serve the entity economic transformation and upgrading No. 7 Document of State Council [2016]	25	Opinions of the State Council on Division of Work for Departments for the Implementation of Key Work in the "Government Work Report" (2014) No. 7 Document of State Council [2011]
6	Announcement of general office of the state council on issuing development planning of national standardization system construction (2016-2020) No. 89 Document of State Council [2015]	26	Decision of the State Council on Accelerating the Fostering and Development of Strategic Emerging Industries No. 32 Document of State Council [2010]
7	Announcement of the State Council on Issuing the "Made in China (2025)" No. 28 Document of State Council [2015]	27	Several Opinions of the State Council on Further Promoting the Development of Small- and Medium-sized Enterprises No. 36 Document of State Council [2009]
8	Announcement of the General Office of the State Council on Issuing the Action Plan for Implementing the Quality Development Outline in 2015 No. 19 Document of State Council [2015]	28	Announcement of the General Office of the State Council on forwarding Guiding Opinions of the development and reform commission and other departments on Some policies of promoting the Research Achievement of independent innovation No. 128 Document of State Council [2008]
9	Opinions of the State Council on Division of Work for Departments for the Implementation of Key Work in the "Government Work Report" (2014) No. 14 Document of State Council [2015]	29	Announcement of the State Council on Issuing No. 18 Document of State Council [2008]
10	Opinions of the general office of the state council on promoting the healthy development of domestic trade circulation No. 51 Document of State Council [2015]	30	Announcement of the State Council on Issuing the Major Tasks for 2008 No. 15 Document of State Council [2008]
11	Guiding opinions of the general office of the state council on speeding up the development of producer services and promoting the adjustment of industrial structure upgrade No. 26 Document of State Council [2014]	31	Announcement of the General Office of the State Council on Forwarding the "11th five" Plan of the National development and Reform Commission and Other Departments on National Innovation Basic Capacity No. 7 Document of State Council [2007]
12	Announcement of the General Office of the State Council on Issuing the Action Plan in 2014 for Implementing the Outline for Quality Development No. 18 Document of State Council [2014]	32	Announcement Issued by the Business Department and Forwarded by the General Office of the State Council on Several Opinions on Further Implementing the Strategy of Developing Trade by Technology No. 92 Document of State Council [2003]
13	Opinions of the State Council on Division of Work for Departments for the Implementation of Key Work in the "Government Work Report" (2014) No. 15 Document of State Council [2014]	33	Announcement Issued by the State Planning Commission and Forwarded by the General Office of the State Council on Attracting Foreign Investment No. 76 Document of State Council [1987]
14	Announcement of the State Council on Issuing the Medium and Long-Term Plan for Key National Technology Infrastructure Construction (2012-2030) No. 8 Document of State Council [2013]		Announcement Issued by the State Planning Commission and Approved and Forwarded by the State Council on the Report of Technical Policies and Technical Reconstruction Problems during the Seventh Five-Year Plan No. 24 Document of State Council [1985]
15	Opinions of the General Office of the State Council on Strengthening the Dominant Position of Enterprise Technological Innovation to Comprehensively Improve Innovation Capabilities of Enterprises No. 8 Document of State Council [2013]		
16	Announcement of the State Council on Issuing the Announcement Economy Development Strategy and Near-Term Action Plan No. 5 Document of State Council [2013]		
17	Announcement of the State Council on Issuing the "12th five-year plan" national Independent innovation ability construction plan No. 4 Document of State Council [2013]		
18	Guiding Opinions of the General Office of the State Council on promoting technological transformation of enterprises No. 44 Document of State Council [2012]		
19	Announcement of the General State Council on Issuing the "12th five-year" national strategic emerging industry development plan No. 28 Document of State Council [2012]		
20	Announcement of the General Office of the State Council on forwarding Guiding Opinions of the development and reform		

The time span of the above listed policies ranges from 1985 to 2012 (See Fig. 3). However, a large majority of the policies are issued after 2012, accounting for about 66.7%. Since the implement of the 12th Five-Year Plan, the State Council has accordingly made decision to accelerate the cultivation and development of new strategic industries. New material industries entered into a golden decade under the guidance of national policy planning, furthermore forming as the major supporting industries for new strategic industries. The continuous issue of these policies would undoubtedly play an extremely important role especially on entry into the Independent Innovation era of the new material industries' development.

The above-listed 33 texts are encoded in this paper by the "policy-chapter-specific clause", consequently forming the

Code of Content Analysis Unit of the Policy Texts on new material policies based on policy instruments (See Table II).

followed by supply-based policies (22.2%), while demand-based policies are least (5.6%).

TABLE II: CODE OF CONTENT ANALYSIS UNIT OF POLICY TEXTS

Name of Policy	Content Analysis Unit of New Material Industry Texts	Code
Guiding Opinions of the General Office of the State Council on Promoting the Stable Increase, Structural Adjustment and Profit Increase of Building Materials Industry	Develop new materials. Focus on the fine processing of nonmetallic minerals like graphite, Kaolin, Bentonite, Diatomite. Enhance research on mineral homogenization, refining, ultra pulverized fly ash, level allocation. Promote the development and application of nonmetal-based mineral; expand the production scale of new material.	2-3-12
Guiding Opinions of the General Office of the State Council on Promoting the Stable Increase, Structural Adjustment and Profit Increase of Building Materials Industry	Establish the base for industrialization of scientific achievements. Aim at strategic new industries like energy saving & environment protection, new generation information technology, biotechnology, advanced equipment production, new energy, new material and new energy vehicles. Establish national demonstrative area of independent innovation and a group of bases for the industrialization of scientific achievements. Direct the scientific achievements towards the demand of characteristic industries, and nurture new economic growth points.	3-2-3-10
...	...	...
Announcement Issued by the Business Department and Forwarded by the General Office of the State Council on Several Opinions on Further Implementing the Strategy of Developing Trade by Technology	Facilitate the exportation of high-tech products and promote the systematic construction. Further expand international market. Support the exportation of electronic and information technology, biological medication, new materials and eco-friendly high-tech products. Adjust the Exportation Catalog of Chinese High-tech Products according to the development of high-tech industries, and give priority to the products listed in the Catalog.	31-2-4
Announcement Issued by the State Planning Commission and Forwarded by the General Office of the State Council on Attracting Foreign Investment	Encourage foreign investment on any of the following projects: those that can produce new equipment and new materials which satisfy the need of domestic and foreign markets and which cannot be in China yet.	32-5-1
Announcement Issued by the State Planning Commission and Approved and Forwarded by the State Council on the Report of Technical Policies and Technical Reconstruction Problems during the Seventh Five-Year Plan	Improve the quality of raw materials. For raw materials for industry and mining, enhance the development and application for new materials for metallurgy, oil, chemical industry and electronic component. Establish a complete production and supply system of special raw materials, and actively make use of foreign resources at the same time.	33-5-4

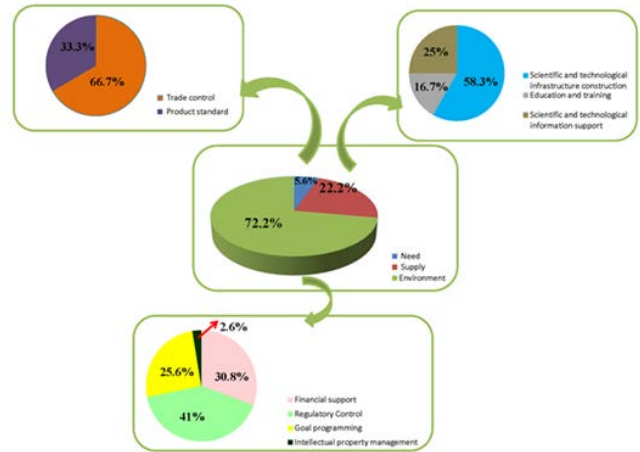


Fig. 4. Pie graph of basic policy tools.

As shown in the internal structure of different types of policies, among environment-based policy instruments, industry management and financial support occupy the largest percentage, with 35.9% and 30.8% respectively; goal programming makes up 25.6%, while regulatory control and intellectual property are the minority, with 5.1% and 2.6% respectively. Among supply-based policy tools, scientific and technological infrastructure construction shares the largest percentage of 58.3%, followed by scientific and technological information support with 25%, and educational training occupies the least with 16.7%. In contrast, demand-based policies are relatively monotonous. The two categories, namely product standard and trade control, occupy 66.7% and 33.3% respectively. Therefore, extra attentions are further needed on demand-based policies in future policy-making.

Based on the coding of content analysis unit of policy instruments on new material industries development, the index of industry value chain was added to form the two-dimensional distribution graph of new material industry policies (shown in Fig. 5). A statistical table of the distribution of each section in the value chain of new material industries was drawn based on the statistical analysis of the above two-dimensional graph.

Based on the coding unit, the application of basic policy instruments can be classified according to the theories of Rothwell and Zegveld [7], the result of which is shown in the pie graph (in Fig. 4).

Generally speaking, the above 33 policies on the development of new material industries have covered policy instruments of supply-based type, environment-based type, and demand-based type, which promote the development of new material industries from various aspects. Statistics show that environment-based policies occupied most (72.2%),

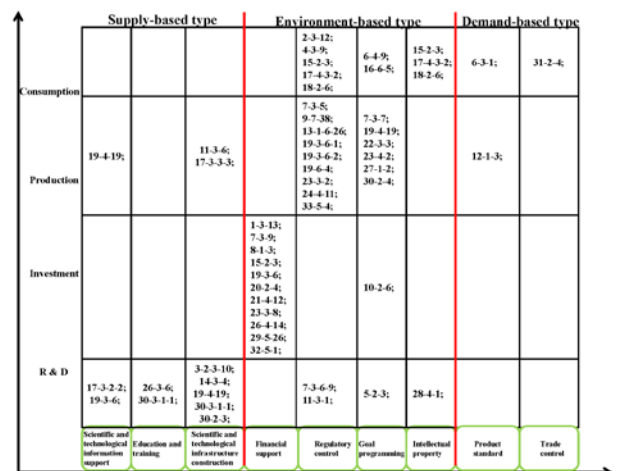


Fig. 5. Two-dimensional distribution of new material industry policies.

According to the above statistic result, the 33 policy texts cover all the aspects of the value chain including research and development, investment, production and consumption. Production occupies the largest proportion (35.8%), indicating that much more efforts have been made on policy instruments by the government to promote the production in new material industries. Research and development follows close behind (24.5%); because new material industries are a kind of long time consuming prophase fundamental research, thus strengthening support is increasingly needed during the research and development period. While policies on investment and consumption, respectively, make up 22.7% and 17%.

#### IV. U PROBLEMS IN POLICY INSTRUMENTS

Based on the two-dimensional distribution of new material industry policies, environment-based policy instruments have been excessively used. Statistic result show that the majority of policy instruments involved in new material industry policy texts are environment-based type (72.2%), where in policies of regulatory control occupies the largest about 41%, while policies on intellectual property only accounts for about 2.6%. There are two reasons for the excessive use of regulatory control policies. Firstly, majority of the previous issued policies have not been effectively implemented, however given that these policies are indispensable, consequently they are repeatedly made in the following policy-making. Secondly, there is still a lack of foresightedness during the policy implementation. Due to the environmental changes, the policies cannot achieve the predetermined goal during implementation, consequently resulting in the excessive use of policies for constantly reiterated emphasis in follow-up policy making. The lack of intellectual property protection policies, on the other hand, would undoubtedly undermine the new material industries,

which greatly emphasize basic research achievements.

Demand-based policy instruments, which can expand the applications and market prospect of new material industries and thereby facilitate their development, are severely insufficient. Among all the above-mentioned policies, only three of them are demand-based type making up 5.6% of the total policy instruments. The severe insufficiency of policies in this aspect demonstrates that the pivot of future policy-making should be placed on demand-based policies.

Supply-based policy instruments only cover three kinds of scientific and technological policy instruments, namely scientific and technological information support, scientific and technological infrastructure construction and educational training. However scientific and technological fund input and public service are absent. This vacancy should be filled by future policies in the subsequently policy-making process.

From the perspective of industry value, policies on the production aspect ranks first with 33.9%, while policies on research, investment and consumption are relatively fewer, with 23.2 %, 21.4% and 21.4% respectively, as shown in Table III. These statistic results also indicate an unreasonable distribution of policies. Currently, china's new material industries are poor in independent developing capability and the research of key materials, as well as with low effect of industrial cluster [9]. Therefore, more increasingly policies support should be directly strengthened on the R&D aspect, and policies on investment and consumption should also be increased to promote the expansion of the industry and the market. Too many policies on the production aspect can easily cause the overcapacity of some new materials, thus the development of new material industries should be oriented towards the market. On another hand, the blind pursuit of too much production will definitely result in a serious waste of resources due to the overall relatively low technological level of China [10].

TABLE III: STATISTICAL TABLE OF THE DISTRIBUTION OF NEW MATERIAL INDUSTRY POLICIES

	Scientific and Technological Information Support [policies]	Education Training [policies]	Scientific and technological infrastructure Construction [policies]	Financial Support [policies]	Regulatory Control [policies]	Goal Programming [policies]	Intellectual Property [policies]	Product Standard [policies]	Trade Control [policies]	Total [policies]	Percentage [%]
Consumption	0	0	0	0	5	2	3	1	1	12	21.4
production	1	0	2	0	9	6	0	1	0	19	33.9
Investment	0	0	0	11	0	1	0	0	0	12	21.4
R&D	2	2	5	0	2	1	1	0	0	13	23.2

#### V. POLICY SUGGESTIONS

##### A. Figures and Combining Environment-Based, Demand-Based and Supply-Based Policy Instruments

Based on the current related policies, steps should be quickening to carry out implementation details and implement the regulatory to bring these policies into effect. In addition, the efforts of implementation and policy-making on aspects such as education and training, public service, tax preference, public tech purchase and overseas institution management should be enhanced according to the difficulties of the new material industry.

- 1) The development of science and technology calls for the support from talents. Without the cultivation of talents, related industries can hardly develop [11]. New material industry, especially as a new-type industry, needs a long time for fundamental research and is difficult to make some achievements, which is particularly in need of the supply of talents. Therefore, increasingly support from the government should be strengthened to guide universities and scientific institutions to cultivate science and technology talents, which could consequently guarantee the talents for the development of China's new material industry.
- 2) The production capacity of new material is bottlenecked



by independent research and development of core technology; thus more public service policies should be provided by the government. In addition, science and technology information platforms, relying on National Innovation Demonstration Zones, National Hi-tech Zones as well as universities and scientific institutions information, also should be built to integrate and share Information resources, which could promote the research on new material industry and avoid repetitive researches, a great waste of production resources and loss of development opportunities due to misinformation and the lack of information.

- 3) There are issues with lower transferring rate of sci-tech achievement and over capacity in new material industry. Therefore, the government should establish a compensation mechanism, broaden financing channels, adapt fundamental researches according to the market demands and promote market-oriented researches on new materials.
- 4) The above policy texts are not involved preferential tax policies, which, in one hand, play an important part in the development of the new industry and support of newly established companies. In the other hand, it brings about effective results for market promotion, sales and production. Herein related policies should be made to compensate for the current deficiency of tax policies.

#### B. Focusing on the Driving Force of Demand-Based Policy Tools

Demand-based policy instruments, including outsourcing, public tech purchases and trade controls, have a positive effect in boosting the development of the industries. However, the current deficiency and the unreasonable combination of policies would affect the sustainable development of industries. Thus the purchase of public technology should increase to support scientific institutions researches for the new material industry. While as for those key technology that has not yet successfully developed, outsourcing can be applied to eliminate technical bottlenecks; meanwhile preferential policies related to the import and export of new material should be also adopted to encourage companies to work on overseas research and development, production and market expansion so as to promote the development of new energy [12].

#### C. Making Sure Scientific Policies are Forward-Looking and Supporting

Currently, there are lots of problems such as lack of the supporting enforcement and implementation policies due to the overcapacity phenomenon, the repetitive and inconsistent policies in goal programming policies and regulatory control

policies. Therefore, systematic and forward-looking industrial policies should be made to better combine fundamental research and development, production, investment and consumption through the optimization and combination of policies during future policy-making.

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