
The Mechanism for Hindrances of Coal-to-Gas Switching Policies in China

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Abstract: To improve air quality, Chinese governments issued a series of policies to carry out the coal-to-gas transition. However, the implementation of these policies has been hindered in practice, which has caused a series of negative effects. Therefore, this paper aims to analyze the mechanism for hindrances of the implementation of coal-to-gas switching policies in China by using the archival research method. A systematic review of existing literature in Chinese coal-to-gas transition is used to select documents. The systematic review finds a total of 154 research articles from Google Scholar and CNKI and finally selects 20 articles based on the inclusion criteria regarding relevance to the research question, quality assessment, writing language, and accessibility. These articles are analyzed through frequency analysis to identify the importance of hindrances. The most frequent hindrance being mentioned in research articles is the insufficient gas infrastructure which is a common problem across many provinces in China. Economic issues including high prices and shortage funds are the second and third significant hindrances. Both of them are particularly common for Sichuan and Chongqing provinces. Local governments' excessive implementation belongs to the political issue, which is particularly serious in the Beijing-Tianjin-Hebei area. The policy issue of one-size-fits-all ranks at the fifth most important position, which is also especially serious in the Beijing-Tianjin-Hebei area. Finally, several political issues containing inadequate incentives for the target group, energy security and underdevelopment of natural gas are specific hindrances for Xinjiang province, although less being mentioned, also significant.

Keywords: Coal-to-gas, Policy Implementation, Hindrances, Systematic Review, Frequency

1. Introduction

At present, a natural gas revolution is taking place worldwide. The regional atmospheric pollution characterized by PM_{2.5} not only affects the quality of life and public health, but also poses a threat to economic and social stability and sustainable development. Coal burning is considered as one of the main sources of pollution. Therefore, On September 10, 2013, the State Council issued the "Air Pollution Prevention and Control Action Plan", officially unveiling the coal-to-gas reform with official documents. The coal-to-gas transition refers to an energy revolution in which natural gas (including conventional and unconventional natural gas, coal gas, etc.) is used as the heating source in residential life and the process of industrial production to replace coal with low energy efficiency and high pollution emissions [1]. Therefore, The Party Central Committee and governments issued a series of policies to promote the process of coal-to-gas transition.

This essay aims to answer the question that what are the hindrances in the implementation of coal-to-gas switching policies in China. These policies seem to be reasonable and beneficial for reducing air pollution; however, there are various problems, such as large-scale gas shortage, potential safety hazards, high heating costs, and so on, being caused by inappropriate implementing methods [2]. Therefore, it is necessary to explore the hindrances that cause these problems.

Compared with previous studies that use case studies, analyze effects of the coal-to-gas transition, and explore factors affecting the feasibility of coal-to-gas switching policies, this essay turns to focus on the hindrances of the implementation of coal-to-gas switching policies. To identify the mechanism for hindrances stated in existing literature systematically and completely, the systematic review is used to give a scientific analysis. Moreover, the frequency analysis is selected as the research method to identify significant hindrances. When discussing the results of the analysis, not

only factors existing in the whole range of China but also specific factors for each area and province are analyzed separately. This fills the gap in previous studies that merely focus on an individual case.

The paper is organized as follows: Section 2 reviews existing literature to find out the gaps and makes it clearer how this paper fills these gaps. Section 3 discusses the research design and the reasons for making this design. Section 4 conducts the research study, shows the results and discusses the results. Section 5 presents the conclusions.

2. Literature Review

2.1. Existing Literature Written in English

Studies on the coal-to-gas transition written in both English and Chinese are included, since I need both China's domestic and international perspectives to give a more complete analysis. Firstly, 'coal-to-gas China' was used as a search term in "Google Scholar" for studies written in English in this field. 'Coal-to-gas' is used to exclude studies unrelated to our research topic. 'China' is also included in the search term to limit the focus of searching results to China, because this energy reform in China has its own characteristics. Since the 1990s, studies [3] about factors influencing coal-to-gas enforcement highlighted the role of environmental constraints and economic factors, such as investment, high cost of gas production, and the price mechanism in shaping Chinese energy development. After the 2000s, several national circumstances including a rapidly growing population, urbanization, industrialization were considered in energy development [4]. In recent ten years, insufficient storage and transportation infrastructures have been paid more attention [5]. Besides, political considerations were also included in the mechanism for influential factors, such as governments' strict control, unreasonable distribution, and energy security issues [6].

Furthermore, several research studies focus on the effects of the coal-to-gas transition. In 2010, A study compared industrial efficiency of coal and natural gas, and concluded that after the transition, boilers and industrial resources were more effectively controlled [7]. In the recent 5 years, a life-cycle comparison of water consumption and greenhouse gas emissions between coal and gas were made [8]. It was concluded that this transition is a good chance to deliver climate benefits with proper methane leakage control [9]. Then effects on economic activities, prices, and consumption were evaluated. And it was found that the key determinant is the assumption about growth rates in electricity generation from renewables [10].

2.2. Existing Literature Written in Chinese

In addition to English literature, Chinese words meaning coal-to-gas were used to search for Chinese domestic research studies in "CNKI" which is the largest academic resource sharing platform in China. The reason for using this search term is that it is the most frequent term being used in this field of studies according to the statistics of CNKI. Almost all the

studies no matter the subject it belongs to were analyzed in this section, since I need a more comprehensive perspective to learn about the coal-to-gas transition. The research focus of studies in this field changed from the effects of the coal-to-gas transition on environmental protection and economy to its effects on energy structure and residential life.

Several scholars paid attention to the environmental and economic effects of the coal-to-gas transition. The economic benefits of the coal-to-gas transition in Nanchong City were analyzed by using the method of cost comparison [11]. Through quantitative empirical method, it was concluded that reducing NOx emissions is the key to the treatment of PM2.5, and cogeneration coal-to-gas transition measures cannot significantly reduce NOx emissions, instead, it will increase the amount of natural gas, resulting in conflicts in gas consumption [12]; the Beijing coal-to-gas project was taken as a typical case to investigate financial pressures and its effect on welfare [13].

In the field of public policy, scholars focus more on the evaluation of policy implementation. For example, the effect of the implementation of coal-to-gas switching policies in Chongqing was evaluated from the perspective of environmental protection and economy [14]. It is believed that this policy is highly feasible, but it lacks fairness, operability, and sustainability. There was also an official analysis released by the Clean Energy Action Office analyzed the case of Beijing industrial boiler coal-to-gas, by using cost-effectiveness methods, with considerations about energy, urban development, mass life, enterprise production level, technological progress, etc., to summarize the successful and unsuccessful experience of policy implementation [15]. In addition to the effectiveness, several researchers also studied coal-to-gas switching policies from the perspective of policy tools. For example, Zhao employed Rothell and Zegveld's three types of policy tool theory and the clean energy industry chain as an analytical framework, using content analysis and statistical analysis as a method to identify the problems in the selection and use of policy tools in Chinese energy policies [16].

With the practical advancement of coal-to-gas projects, several studies recently paid more attention to the impact of coal-to-gas on energy structure. A study predicted the development prospects of the LNG point supply industry [17]; natural gas supply which is highly related to energy security was also studied [18]. The game theory was employed to analyze the inter-government relationships and tensions between the market and planned system, which caused by insufficient comprehensive coordination, unilateral advancement, and excessive implementation [19].

2.3. Summary

Research studies on China's coal-to-gas transition date back to the 1990s. They focus on this transition's environmental and economic effects [14], and political, economic, and technical factors affecting the feasibility of the policy [3]. Although there have been a large number of studies in this field, several gaps still exist in previous studies. First, the previous academic research has primarily focused on

evaluating the impacts or the feasibility of coal-to-gas switching policies rather than the hindering factors of the policy implementation. Second, most of these articles use case studies based on the analysis of public documents and local data [13]. The results of these studies are susceptible to the case selection approach. And their results are not universal. Furthermore, there has not been any critical appraisal on the quality of the evidence base. Moreover, quantitative methods are also rarely used. In addition, the focuses of previous studies are usually limited to a single area; thus, there is a lack of study covering the whole China range. Therefore, this paper explores the mechanism for the hindrances of the implementation of China's coal-to-gas switching policies. The archival research is employed. By using a systematic review, this paper critically appraises the quality of the evidence. The frequency analysis is chosen to identify the importance of hindrances. Significant hindrances of the policy implementation are found out.

3. Research Design

3.1. Research Process

This essay uses the research process onion concept to design the research. In this concept, the research process is divided into 6 stages: research philosophy, approach, strategy, choice, time horizon, technique, and procedure [20]. In this way, the scientific path from general philosophy to specific research methods can be designed step by step and clearly shown. With regards to philosophy, this essay prefers positivism than interpretivism, since it works with observable social reality instead of individual perceptions, and the end product is expected to be generalisation. The approach in this essay is inductive, because hindrances need to be summarized from data. This study is conducted on the basis of secondary data, to be more specific, archival research is applied. Most of the previous studies [4, 13] use case studies, the results of which are susceptible to case selection and are not universal. By contrast, archival research can identify the factors more completely and systematically. Among research choices, to identify hindrances and deal with numerical data, this essay uses a quantitative method to analyze panel data. The research question of this essay covers the whole geographical range of coal-to-gas switching policies in China. Therefore, studies no matter which area or province they focus on are included. To identify hindrances, the frequency analysis is employed. This method shows how widespread the finding is in the sample and whether or not factors identified for one policy implemented in a particular evaluation and context are present for the same policy in other evaluations and contexts [21]. Since most existing literature uses the case study to research hindrances in a specific province or area, thus, after analyzing all the hindrances for the whole China, I discuss the importance of these hindrances for different regions based on specific characteristics of each region and province to fill the gap in the existing literature.

As for the analytical technique, this essay requires a method

that can evaluate the evidence base comprehensively and systematically. Thus, systematic review which can synthesis findings of intervention and can draw conclusions based on the relatively high-quality evidence seems to be appropriate for this essay.

3.2. Systematic Review

There are eight stages in a systematic review [22].

Review questions and boundaries: what are the hindrances in the implementation of coal-to-gas switching policies in China?

Selection of systematic review type: To answer the research question, a method that can analyze hindrances comprehensively would be appropriate. This is the reason for realist synthesis that focuses on underlying mechanisms of interventions under certain contexts being chosen [23].

Comprehensive search: As a result of limited time and resources, the review boundaries are quite narrow. Search terms are 'coal-to-gas China' in Google Scholar & 'coal-to-gas (written in Mandarin)' in CNKI. After scoping review, these journals feature prominently in discussing coal-to-gas switching policies in China.

Journals: Energy Economics, China Energy, Journal of China West Normal University Energy Policy, Macroeconomic Research, International Petroleum Economy, IEA, Energy Research and Utilization, Climate Policy, Oxford Energy Forum, City, Cleaner Production, Natural Gas Industry B, Youth and Society, Zhejiang Social Sciences, Journal of Cleaner Production, Environmental Science & Technology; Government websites: Chinese State Council, National Department of Ecological Environment Protection.

These journals are chosen due to their high quality of studying energy policy. Government websites are also included to read the original document of policies and officials' public speeches.

Inclusion criteria: highly related to the research question (including hindrances); can pass the study quality assessment scale; written in Mandarin and English (so that I can understand); are freely accessible online.

Quality assessment:

The quality of documents is assessed mainly from two perspectives: whether the policy implementation and evaluation are clearly explained; the perspective of peer review and regulatory compliance. In this way, both the perspectives from the researcher herself and professional evaluation from other scholars are contained to ensure the quality of the data source.

"4 points: Has the process for policy implementation been clearly explained?" Each with 1 point: Have details about policy implementer, policy design, how and why implementation been given?

"4 points: Has the process of policy evaluation been clearly explained?" Each with 1 point: Have details about policy evaluator, how evaluated, policy impacts and policy success been given?

"2 points: Has the document been peer-reviewed or independently verified?" Each with 1 point: Has the document

been peer-reviewed by a reputable expert or by two or more than two reputable experts?

“2 points: Are their statements of copyright, regulatory compliance, and possible conflicts of interest present?”

“1 point: Does the author/publishing organization have a track record in the area?”

“1 point: Where percentages are given, are the totals given?” [21]

Documents can only be included when gaining half of the total scores i.e. 7 scores. Because only when over this score, I can make sure the document meets at least half of the requirements for researching.

Data/information extraction: To extract data for each document systematically, an excel spreadsheet containing the results of the filtering process needs to be used in this stage.

Table 1. Document quality assessment score.

Document	Score
China's clean energy investment and financing dilemma and outlet research	8
Energy development and environmental constraints in China	10
Sustainable energy development and climate change in China	12
Coal-to-oil, gas and chemicals in China	7
Searching for Natural Gas Demand in the Next Decade	8
Air Pollution and Control in Different Areas of China	12
Can switching from coal to shale gas bring net carbon reductions to China?	11
The national and international impacts of coal-to-gas switching in the Chinese power sector	11
City coal to gas action plan policy case study in Nanchong	10
Large-scale coal to gas is not suitable for China's national conditions	8
The coal-to-gas project should be carefully implemented: based on the investigation and analysis of Beijing coal-to-gas project	7
Coal to gas policy research in Chongqing	13
Analysis of China's clean energy development policy from the perspective of policy tools	10
Coal to gas is the main reason for the rapid rise in natural gas consumption	11
The game under the gas shortage	7
Discussion on the development of coal to gas in Beijing-Tianjin-Hebei region	9
Failed coal to gas: an environmentally friendly battle	9
Can natural gas-fired power generation break through the dilemma in China? A system dynamics analysis	9
Natural gas and energy revolution: A case study of Sichuan- Chongqing gas province	10
Analysis report on coal-to-gas policy in Urumqi	11

Synthesis of findings: quantitative analysis is used to answer the research question, followed by a systematic review of findings. As mentioned above, the frequency analysis is applied to analyze the significance of factors mentioned in previous studies.

Factor Frequency Threshold:

1) High Frequency: ≥ 5 evaluations

2) Low Frequency: < 5 evaluations

The level of ‘5’ evaluations as the threshold is determined inductively by examining the overall average frequency of discussion of each factor in the systematic review sample [24].

Dissemination of findings: this step is not necessary for this essay.

4. Results and Discussion

4.1. Results

Hindrances refer to certain negative factors that hinder the implementation of policies, causing poor execution and even a complete deviation from policy objectives. To identify the mechanism for hindrances, 20 documents including written in English and Mandarin are analyzed. All of these 20 documents are fully used. Hindrances are extracted, and their frequencies are also calculated to measure their relevant importance.

Table 2. The mechanism for hindrances.

Category	Hindrances	Explanation
Policy issue	Inappropriate objective	The target of the energy transition is simply understood as the increase in the share of renewable energy. However, the long-term and complicated nature of energy transformation is not emphasized [25].
Policy issue	Lack of supporting policies	There is a lack of supporting policies, such as financial investment, credit, taxation, supervision and management [26].
Policy issue	One-size-fits-all	The one-size-fits-all policy cannot satisfy various needs and solve all problems in different areas.
Political issue	The contradictions between governments and industries	The state government is cautious about energy security, while industries and local governments regard this switch as a chance to gain subsidies, and as a result, a large number of projects are pushed during a short time.
Political issue	Excessive implementation	Under the bureaucratic system, the incentive effect of instructions is gradually enlarged level by level; as a consequence, local governments rush into implementation [27].
Political issue	Unreasonable allocation of gas	The gas market is still under the control of the central government which allocates gas supplies to ensure key sectors like industrial sectors, while prohibits use in other sectors, such as residential heating systems [28].
Political issue	Lack of monitoring	At present, the implementation of policies lacks effective supervision, and there is no specific

Category	Hindrances	Explanation
Target group issue	Poor participation of the target group	feedback channel for public opinions. The target group does not participate in the process of policymaking, which leads to low-level policy awareness [29].
Target group issue	Inadequate incentives	Most residents care subsidies far more than environmental protection.
Energy resource issue	Underdevelopment of natural gas	In China, only a small part of natural gas is developed and utilized, due to remote distance, low motivations and poor technologies [6].
Energy resource issue	Energy security	As a result of the increasing demand, Chinese external dependence on natural gas rose to 31.8% in 2015 [30].
Energy resource issue	Uneven distribution of resources	China's natural gas resources are concentrated in the western region, while resources in regions with high demands in the east are scarce [12].
Economic issue	High prices	Compared with coal, gas has less competitiveness in price. In 2017, the price of natural gas was US\$8.3/MMBtu, while coal was mere US\$3 [31].
Economic issue	Shortage of funds	The investment and financing channels are single and insufficient, mainly from Chinese governments [32].
Infrastructure issue	Insufficient infrastructure	The transportation network of gas is incomplete, and the transport capacity of pipelines cannot meet the consumer demands. Furthermore, the load capacity of infrastructure is insufficient [33].

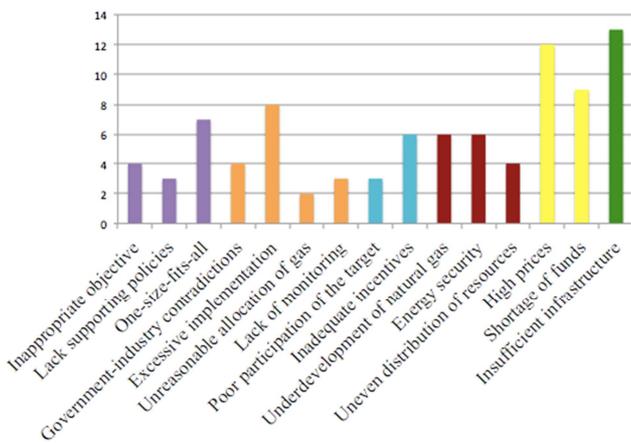


Figure 1. Frequency.

4.2. Discussion

There are 15 factors being mentioned in total. These factors are divided into 6 categories. First, the policy issue category which refers to the factors related to the policy content including the appropriateness and feasibility of policies. There are 3 factors that fall into this category. The second category is related to the political issue which refers to problems relevant to government behaviors, such as allocation of resources, supervision, and so on. There are 4 factors belonging to the political issue category. The third one is called the target group issue that includes the factors related to the target group of the policy. As for coal-to-gas switching policies, inhabitants and industries being forced to change their heating source from coal to natural gas, are the target group. There are 2 factors belonging to this issue. Then, the energy resource issue mainly referring to the causes of natural gas shortage is another category. 3 factors are related to this issue. In addition, there are 2 economic factors that mainly include insufficient funds and high prices. And the final one is an infrastructure issue, which may affect the transportation and storage of gas. The frequency analysis indicates that the most frequently discussed factor is “insufficient infrastructures” which was presented in 13 documents, taking up to 65%. Economic factors including “high prices” and “shortage of funds”

presented 12 (60%) and 9 (45%) respectively, are also emphasized. According to existing literature, the fourth important factor is excessive implementation. Its frequency is 8, indicating that 40% of documents discussed it. However, other political hindering factors, such as “unreasonable allocation of gas” and “lack of monitoring” are merely mentioned in two and three times.

According to the threshold, significant hindrances in documents include “one-size-fits-all”, “excessive implementation”, “inadequate incentives”, “underdevelopment of natural gas”, “energy security”, “high prices”, “shortage of funds”, and “insufficient infrastructure”.

Coal-to-gas switching policies are implemented in many areas in China. One of these is the Beijing-Tianjin-Hebei area that is located in the Northern area. Xinjiang province also conducts this energy transition. Besides, Sichuan and Chongqing are also included in the scope of this policy. Among these hindrances, “energy security”, “high prices” and “insufficient infrastructures” are common across these provinces, many of them are due to political and marketing system in China. For Beijing-Tianjin-Hebei, “excessive implementation” and “one-size-fits-all” are unique and important hindrances; while for Sichuan and Chongqing, “shortage of funds” is the most important factor. “Underdevelopment of natural gas” is the most significant factor worried by Xinjiang province, since although there is quite much natural gas in Xinjiang, it has not been utilized.

5. Conclusion

To figure out the mechanism for hindrances, 20 documents discussing the coal-to-gas switching policies in China covering three main areas are analyzed to calculate the frequency of hindrances. Significant hindrances of the implementation of coal-to-gas switching policies include the policy issue of one-size-fits-all (especially for Beijing-Tianjin-Hebei area); local governments’ excessive implementation (This problem is also particularly serious in the Beijing-Tianjin-Hebei area); inadequate incentives for the target group; energy security, and underdevelopment of natural gas (this issue is specifically for Xinjiang province);

high prices and shortage funds (particularly for Sichuan and Chongqing); insufficient infrastructure.

The contributions of this paper can be discussed in terms of empirically and methodologically. Empirically, this paper provides the first systematic review of the coal-to-gas switching policies evaluation evidence base. The systematic review has national coverage. The central part of this paper is the identification of the key hindrances of policy implementation. Under government resource constraints, the findings are useful for identifying where limited resources should be channeled in order to prevent policy failure. One of the central arguments of this paper is that previous studies have primarily focused on the impacts of coal-to-gas switching policies, rather than the hindrances of the implementation and the research has contributed towards filling this knowledge gap. Methodologically, this paper further develops the theory and practice of using systematic reviews in energy policy research, particularly the practical application of the realist synthesis approach. In addition, this approach develops a scale for critically appraising the quality of the evidence base, which could be applied to research the policy and program mechanisms of other energy and climate policies.

The coal-to-gas switching policies play a very important role in the energy transition in China. It is implemented in an increasing number of provinces in China. The identification of the mechanism for hindrances can help policymakers conduct policy decision-making in further stages. This study has some limitations. For example, because of limited time and resources, the number of sample documents is not large enough. Furthermore, frequency analysis might not be enough for the identification of the relative significance of hindrances. Therefore, more documents should be included, and the analysis method is supposed to be enriched. A weighting analysis of factors needs to be introduced.

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